PreIB Chemistry
Workbook and Past Exam questions 2020-21

The world’s first Chemistry textbook, written by a Babylonian woman called Tapputi 3300 years ago, to learn more, click here.

NAME: ___________  English Name: _____________________
Class: ___________  Teacher: ___________________________
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1 Introduction to the Course and the Course Materials

1.1 FUNDAMENTAL – What the 4 different levels used here mean
There are 4 different levels that each activity has been labelled as within this workbook. Learning about these 4 categories of activities is considered FUNDAMENTAL, so everyone is expected to read this :o)

FUNDAMENTAL – This is the most basic ideas and most important things to do before you try to do anything else. If you are struggling in this subject these FUNDAMENTAL activities are the most important things to concentrate on to allow you to progress on towards the higher grades. If you only do the fundamental parts of the course you are unlikely to get above a C grade.

ESSENTIAL – This refers to activities that you should do if you are aiming for a B or an A grade. These are the kinds of things that you should be doing before you attempt any of the harder activities.

EXTENSION – Anything that is marked with this is considered to be really important for those students who are on track for getting an A* and who intend to stay on track.

EXCEPTIONAL – These are things that you can do that are unlikely to have much impact on your final grade, so only the ablest students who regularly achieve over 90% in assessed activities should attempt these. They are important because they will help broaden your mind and give you a depth of understanding that will be particularly important if you are finding the work extremely easy and would like to stretch and challenge yourself. These kinds of experiences and ideas are especially important to help make a good application for the best universities.

1.2 FUNDAMENTAL – How to use this workbook
Each chapter of this book will have a Keyword list, or Glossary, a Classroom activities section, a Past Exam questions section, a Mark Scheme section, Assessed Activity section and a Stretch and Challenge Section. It is recommended that you read ahead in the textbook so that you already have answers, but most importantly, questions about the topic we are studying. This is what your textbook is for. The Classroom Activities and the Assessed Activities SHOULD NOT be completed in advance, but you can read through them if you would like. The Past Exam questions should only be attempted when you feel able to do them successfully, which may be after you have read through the textbook and already worked through the activities there, but often it will only be after you have been taught the material in class. It is better that you answer the questions well on your first attempt and put all of your energy into doing as well as you can on the current topic, especially before the end of topic test. Only a very small number of students will benefit from getting too far ahead of the class, most will simply have covered more material less well and this will be reflected in disappointing grades and test scores.

1.3 For Parents Section of Smashing Science
There is a page dedicated to explaining the iGCSE course and the resources which is specifically to help your parents better understand what you are learning. You will need to get them to scan the QR codes below and then sign this page to show that they have seen this page and are aware of the additional online resources that have been created specifically for you.

Name of Parent or Guardian: _____________________________ Signature: _____________________________

Date: ________________
## 1.4 FUNDAMENTAL – Explaining the different sections of each chapter

<table>
<thead>
<tr>
<th>Section title</th>
<th>What is in it</th>
<th>How and why it can help you</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keywords</td>
<td>Keywords for the topic auto translated into Chinese. These words are essential to be able to understand and answer questions about the the science of the topic.</td>
<td>If you are struggling with the language this is the most important section, you will not be able to do well in much else if you don’t understand the keywords in English. For <strong>exceptional students</strong> I would be very appreciative of a better electronic translation.</td>
</tr>
<tr>
<td>Extension keywords</td>
<td>Keywords that are at the edges of the syllabus.</td>
<td>These are not essential to get an A grade, but they will help you to better understand where the syllabus ends. They are also useful in expanding your academic vocabulary and particularly useful for <strong>exceptional students</strong>.</td>
</tr>
<tr>
<td>Essential Exam Questions</td>
<td>Past exam questions from previous exam papers that assess the topic.</td>
<td>Understanding the science is only a part of being a successful science student, you also need to be able to read and answer exam questions in a way that will allow you to get enough marks. The best practice for anything nearly always is doing the thing you hope to become good at. The difference between an A* student and an A grade student often has very little to do with how much science they understand, but A* students understand very deeply good exam technique and the patterns in exam questions. This understanding takes a great deal of practice. Some students may not finish all of these questions. <strong>Exceptional students</strong> will not only finish these questions but will also go on the websites shown here and download and work on the additional exam questions.</td>
</tr>
<tr>
<td>Mark Schemes</td>
<td>The answers to the exam questions. This is not the mark scheme actually used by examiners when these questions were in real exams, however, but a simplified version.</td>
<td>Understanding the difference between a correct, but incomplete answer and a correct and complete answer is at the heart of excellent exam technique. Looking at how mark schemes change over time (they always get harder!) is also a useful exercise in understanding what the examiners think is the most important aspect of an idea. <strong>Exceptional students</strong> will make notes of the marks they have lost and work on other questions until the number of marks they lose in a given topic is reduced to a very small number, ideally 0.</td>
</tr>
<tr>
<td>Fundamental Assessed Activities</td>
<td>Test on the keywords for the course</td>
<td>These should only be attempted by those students who are struggling with the topic and the course. Most students are not expected to try these, but it is up to you to decide which assessed activity you try based on how you feel about the topic.</td>
</tr>
<tr>
<td>Essential Assessed Activities</td>
<td>Straightforward activities that test your progress in the course.</td>
<td>These are not going towards your GPA. You have access to all of them, but it is in your best interest to give them a fair go in class because the score is important: if you get very high scores on these, but very low scores on your End of Topic tests than it is obvious that you are not properly preparing for those tests because you have shown an ability already in this topic. It is far better to score badly in these, learn from those poor scores and revise properly for the end of topic tests, which sometimes will go towards your GPA.</td>
</tr>
<tr>
<td>Extension Assessed Activities</td>
<td>These are harder questions and there are a lot more of them.</td>
<td>These will test your ability to work to tight timelines, which is essential for a good A*. You will complete these after you have completed the Essential Assessed Activities.</td>
</tr>
<tr>
<td>Stretch and Challenge Activities and Additional Reading</td>
<td>Questions, further reading and links to additional resources that go beyond the syllabus.</td>
<td>You can use the advice and information in here to better understand the topic, but also there is an optional activity where you are able to give a presentation to the class about something loosely connected to this topic.</td>
</tr>
</tbody>
</table>
1.5  FUNDAMENTAL Student Survey Introducing yourself

Please complete this brief introduction to yourself and your background and what you hope to study later on and why.

Name, English and Chinese (in pinyin): ________________________________ Class: __________

Email address: ______________________________________________________

<table>
<thead>
<tr>
<th>iGCSE Subject</th>
<th>Target grade</th>
<th>iGCSE Subject</th>
<th>Target grade</th>
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<tbody>
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</table>

Top 5’s – What are your goals for the following

<table>
<thead>
<tr>
<th>Rank</th>
<th>University course</th>
<th>University (&amp; country it is in)</th>
<th>Career</th>
<th>How you want to be remembered by others</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<tr>
<td>5</td>
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</tbody>
</table>
Goals for your time at Ulink

Which activities (at school or outside of school, like music or sport) have you done before?

______________________________________________________________________________________________________________________________________________________________________________________

Which co-curricular activities do you intend to do, or would like to do?

______________________________________________________________________________________________________________________________________________________________________________________

What are your targets for the first few weeks of term?

______________________________________________________________________________________________________________________________________________________________________________________

Academic Targets for this term (and how will you achieve them?):

______________________________________________________________________________________________________________________________________________________________________________________

Life (non-academic) targets for this term (and how will you achieve them?):

______________________________________________________________________________________________________________________________________________________________________________________

If you have studied chemistry before, what do you think is easiest and hardest about the subject?

Easiest: __________________________________________________________________________________________________________________

Hardest: ________________________________________________________________________________________________________________

Most interesting: __________________________________________________________________________________________________________

Least interesting: __________________________________________________________________________________________________________

Can you think of anything that has happened in science recently in the news that you thought was amazing?

______________________________________________________________________________________________________________________________________________________________________________________

______________________________________________________________________________________________________________________________________________________________________________________
1.6 FUNDAMENTAL – Electronic Resources Available
An electronic version of this book is available by scanning the QR code below:

This book contains some past exam questions, but for even more practice go to one of the websites below, the larger of the two is the first one, but is only accessible through a VPN. Either website offers thousands of pages of resources to help you practice and learn about this subject as well as other subjects.

There is also advice on things you can do to Expand your Mind which will help broaden your horizons and give you ideas on things that might be of interest, especially to the ablest students. In addition, there is advice and guidance on applying to university and the kinds of things that the best universities tend to look for in students that they offer places to.

Videos explaining the science in the course in English can be found on this webpage here:
https://www.smashingsciencecn.org/igcse-chem-videos,

1.7 FUNDAMENTAL – How Your Course Will be Assessed at Ulink College Shanghai
For MOST topics you will have 2 Assessed Activities that will be carried out in the classroom. These WILL NOT go towards your Grade Point Average, but they will help you learn how you are progressing within the topic before the End of Topic Test. Some of your End of Topic Tests will go towards your GPA. This will be explained in advance. You will also have an End of Semester Exam in January, an End of Year Exam and your external iGCSE Exams in May.
# 1.8 Fundamental Command Terms used in the questions taken from CAIE iGCSE Chemistry
(on which this course is based)

<table>
<thead>
<tr>
<th>Command word</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Define</td>
<td>(the term(s) ...) is intended literally, only a formal statement or the same idea in slightly different language is acceptable. Often these questions lose marks over time, so the same answer is expected, but will carry fewer marks making it more difficult to get full marks.</td>
</tr>
<tr>
<td>What do you understand by/ What is meant by</td>
<td>(the term(s) ...) normally suggests that a definition should be given, together with some relevant comment on the significance or context of the term(s) concerned, especially where two or more terms are included in the question. The amount of supplementary comment intended should be interpreted in the light of the indicated mark value.</td>
</tr>
<tr>
<td>State</td>
<td>implies a short and complete answer with little or no supporting information (e.g. a numerical answer that can readily be obtained ‘by looking at it’).</td>
</tr>
<tr>
<td>List</td>
<td>requires a number of points, generally each of one word, with no further information. Where a given number of points is specified only that number of points should be given, so don’t give more answers than is required or they may not be counted, or they may, if they are incorrect, be used to deduct marks from your total.</td>
</tr>
<tr>
<td>Explain</td>
<td>may require reasoning or some reference to theory, depending on the context. It is another way of asking candidates to give reasons. The candidate needs to leave the examiner in no doubt why something happens. These questions will usually include the hardest mark, which is normally the 2nd or 3rd mark that will differentiate between A and A* students.</td>
</tr>
<tr>
<td>Give a reason/Give reasons</td>
<td>is another way of asking candidates to explain why something happens.</td>
</tr>
<tr>
<td>Describe</td>
<td>requires the candidate to state in words (using diagrams where appropriate) the main points. Describe and explain may be given in the same command, as may state and explain. Usually much easier than the Explain aspect of the question.</td>
</tr>
<tr>
<td>Discuss</td>
<td>requires the candidate to give the essential information of the points involved.</td>
</tr>
<tr>
<td>Outline</td>
<td>implies brevity, so a short response (i.e. limiting the answer to giving just the essentials).</td>
</tr>
<tr>
<td>Predict</td>
<td>implies that the candidate is expected to make a prediction not by remembering a fact (recall) but by making a logical connection between other pieces of information. For instance, predict the properties of a compound with unfamiliar elements, based on understanding lighter elements in the same group in the periodic table.</td>
</tr>
<tr>
<td>Deduce</td>
<td>implies that the candidate is not expected to produce the required answer by recall but by making a logical connection between other pieces of information. Normally in chemistry this involves being shown a compound that contains unfamiliar elements, but which belong to a group of familiar elements, e.g. Deduce the formula of hydrogen selenide. Answer: Selenium is in the same group as oxygen, and hydrogen oxide is H₂O, so H₂Se is the expected response.</td>
</tr>
<tr>
<td>Suggest</td>
<td>is used in two main contexts, i.e. either to imply that there is no unique answer (e.g. in chemistry, two or more substances may satisfy the given conditions describing an ‘unknown’), or to imply that candidates are expected to apply their general knowledge of the subject to a ‘novel’ situation, one that may be formally ‘not in the syllabus’ – many data response (for instance where information is given in a table about different substances) and problem solving questions are of this type.</td>
</tr>
<tr>
<td>Find</td>
<td>is a general term that may interpreted as calculate, measure, determine, etc.</td>
</tr>
<tr>
<td>Calculate</td>
<td>is used when a numerical answer is required. In general, working should be shown and clearly labelled especially where more than one step is involved.</td>
</tr>
<tr>
<td>Measure</td>
<td>implies that the quantity concerned can be directly obtained from a suitable measuring instrument (e.g. length using a rule, or mass using a balance).</td>
</tr>
<tr>
<td>Determine</td>
<td>often implies that the quantity concerned cannot be measured directly but can be worked out from a graph or by calculation.</td>
</tr>
<tr>
<td>Estimate</td>
<td>suggests that a statement that is only very roughly close to the real value (within a factor of 10) or calculation of the quantity concerned. Normally assumptions will need to be made based on points of principle and values of amounts not given in the question.</td>
</tr>
<tr>
<td>Sketch</td>
<td>when applied to graph work, implies that the shape and/or position of the curve need only be roughly (or qualitatively) correct, but candidates should be aware that, depending on the context, some quantitative aspects may be looked for (e.g. passing through the origin, having an intercept). In diagrams, sketch implies that simple, freehand drawing is acceptable; nevertheless, care should be taken over proportions and the clear labelling of important details or equipment.</td>
</tr>
</tbody>
</table>
1.9 ESSENTIAL How the PreIB Course Will be Assessed

All candidates take exam papers at the end of the year. These will be created based on questions taken from Cambridge Assessment International Education, which is a part of the University of Cambridge.

You will NOT actually sit the CAIE exam in May!

You will complete a modified course that will allow us to focus on preparing you best for the IB which has a variety of unique aspects that are not found in the CAIE A Level program, but which need to be completed to allow you the best chance of success at IB Level.

Your exams will contain questions from these exam papers, but the course may not end with 3 exams (there’s a chance that you will instead sit for fewer exams):

<table>
<thead>
<tr>
<th>Extended candidates take:</th>
<th>and Extended candidates take:</th>
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<tbody>
<tr>
<td>Paper 2</td>
<td>Paper 4</td>
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<tr>
<td>Multiple Choice</td>
<td>Theory</td>
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<tr>
<td>40 marks</td>
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<td>40 four-choice multiple-choice questions</td>
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<td>Questions will be based on the Extended subject content (Core and Supplement)</td>
<td>Short-answer and structured questions</td>
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The Periodic Table of the Elements

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*58-71 Lanthanoid series
190-103 Actinoid series

**Key**
- **a** = relative atomic mass
- **b** = proton (atomic) number

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).
# FUNDAMENTAL

Recording your scores and keeping track of your performance

<table>
<thead>
<tr>
<th>Test name</th>
<th>Topic #</th>
<th>Mark (out of)</th>
<th>% Score</th>
<th>Target grade: _______</th>
<th>Target Score _______ %</th>
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<td>10-Aug</td>
<td>Mon 10 to 14 G1 &amp; PreA Students Orientation Week&lt;br&gt;Tue 11th All teachers back in office&lt;br&gt;Fri 14th Full staff meeting/Department meeting Welcome Buffet&lt;br&gt;Sun 16th C6 AS &amp; A2 students registration&lt;br&gt;Sun 16th UCS Opening Ceremony All Staff am: G1, G2 &amp; PreA, pm AS, A2 &amp; IB1/2</td>
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<td>17-Aug</td>
<td>Mon 17th Teaching Begins</td>
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<td>24-Aug</td>
<td>Fri 28th Dead Line for G1, ASD and IB1 to change options&lt;br&gt;Tue 26th Activities Fair&lt;br&gt;Wed 26th-30th Student Union Elections</td>
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<td>7-Sep</td>
<td>Fri 11th G1 and PreA Parents consultation day&lt;br&gt;Fri 11th Dead Line for A2 Students to drop options</td>
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<td>14-Sep</td>
<td>Fri 18th Dead Line for A2 Predicted grades&lt;br&gt;Fri 18th IB2 Parents' consultation day&lt;br&gt;Fri 11th Open day for G1 and PreA parents</td>
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<td>6</td>
<td>21-Sep</td>
<td>Sat 26th Make up day (Tuesday)</td>
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<td>7</td>
<td>28-Sep</td>
<td>Thur 1st Oct First day of National Holiday</td>
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<td>5-Oct</td>
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<td>10th Oct Last day of National Holiday&lt;br&gt;Sun 11th Make-up Day (Friday’s timetable)</td>
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<td>12-Oct</td>
<td>SAT 17 Make-up Day (Sports Day) (or Wednesday if weather is bad)</td>
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<td>19-Oct</td>
<td>Fri 23rd International Mole day</td>
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<td>26-Oct</td>
<td>Wed 28th Alternative sports day&lt;br&gt;26th-30th Art Week</td>
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<td>2-Nov</td>
<td>Fri 6th Deadline for 1st observation for returning teachers</td>
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<td>9-Nov</td>
<td>Mon 9th to Fri 13th IB2 MS EXAMS&lt;br&gt;Wed 11th Physics Day&lt;br&gt;Fri 13th CAIE Winter Session Begins&lt;br&gt;Fri 13th DeadLine for inputting marks for Mid Sememster Reports</td>
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<td>23-Nov</td>
<td>Mon 23rd G1,2 PreA, AS and A2 Reports&lt;br&gt;Fri 27th AS, A2 and IB1 Parents Consultation&lt;br&gt;Fri 27th Completion of the first Student Survey&lt;br&gt;Sat 28th Makeup day G1, G2, PreA and Pre IB Parents Consultation day</td>
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<td>14-Dec</td>
<td>13th CAIE Winter session ends</td>
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<td>Sun 3rd Jan Last day of Xmas holiday&lt;br&gt;Mon 4th to Sat 9th End of Semester Exams&lt;br&gt;Sat 9th Jan make up day</td>
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<td>Mon 18th Deadline for input of all makrs in SIMS for EOS Reports&lt;br&gt;Fri 22nd Annual Party &amp; Long Service Awards Celebration</td>
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<td>Mon 25th G1,2, PreA, AS and A2 reports issued&lt;br&gt;Thur 28th IB1, AS and A2 Parents Consultation Day (PM only)&lt;br&gt;Fri 29th G1,2 PreA, PreIB Parents Consultation Day (Whole day)&lt;br&gt;Sat 30th Spring Festival Holiday begins</td>
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<td>Chinese New Year Holiday&lt;br&gt;Sat 20th Winter Holiday ends&lt;br&gt;<strong>Sun 21st AM All students and form tutors in school for registration</strong>&lt;br&gt;<strong>Sun 21st PM Students Assembly</strong></td>
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<td>Mon 22nd Semester 2 Teaching begins&lt;br&gt;Sun 28th New spring classes in school for registration</td>
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<td>Tue 2nd to Fri 12th IB2 Mock Exam&lt;br&gt;Wed 3rd Graduation Picture Day (Weather permitting)</td>
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<td>Fri 12th End of IB2 Mock&lt;br&gt;Fri 12th G2 and preA Optional Course Information Day&lt;br&gt;Fri 12th Completion of 2nd Student survey</td>
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<td>Mon 15th Deadline for G2, PreA, AS and A2 End of Year Exam Papers to AAO for printing</td>
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<td>Mon 22nd Guided Revision Starts&lt;br&gt;Wed 24 UCS Spring Concert&lt;br&gt;Fri 26th Teaching of G2, PreA AS, A2 syllabi completed&lt;br&gt;Fri 26th Deadline for all Observations</td>
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<td>Mon 29th- Thur 1st April CAIE Oral English Exam&lt;br&gt;Thur 1st Guided Revision Ends&lt;br&gt;<strong>Fri 2nd April QingMing Holiday Begins</strong> (3 days)&lt;br&gt;Wed 31st Drama Class End of Year Performance</td>
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<td>Mon 5th EOY (G2, PreA, AS &amp; A2) begins</td>
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<td>Thur 29th IB External Exams Begin</td>
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<td>3-May</td>
<td>Mon 3rd CAIE Summer Session Begins</td>
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<td>Deadline All marks G3, PreA, AS and A2 into SIMS</td>
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<td>Mon 24th to Fri 28th G1 EoY Exams</td>
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<td>31-May</td>
<td>Mon 31st Deadline for payment of student tuition and dormitory fees</td>
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<td>Fri 4th G2, PreA, AS and A2 reports issued</td>
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<td>Fri 4th Deadline for inputting G1 marks into SIMS</td>
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<td>Fri 4th PreIB Parents consultation day</td>
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<td>Wed 9th IB Parents Consultation Day</td>
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<td>Fri 11th CAIE summer session ends</td>
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<td>Sat 12th A2 &amp; IB2 Graduation Ceremony</td>
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<td>Mon 7th-9th G1 Students Social Studies</td>
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<td>Wed 9th G1 Reports issues</td>
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<td>Fri 11th G1 Parents Consultation Day</td>
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<td>14-Jun</td>
<td>Mon 14th-16th EoY Reflection Days (All staff must attend)</td>
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### 1.13 ESSENTIAL Teaching order

This is the approximate order that these topics will be taught and if they are going to be taught by me. There may be changes depending on special events or lessons that are missed for other reasons, especially because this is the first year that this course has been offered.

Notice that the textbook that is used, Complete Chemistry for Cambridge IGCSE (3rd Edition, Oxford 2014) follows a different order than the CAIE topic order, which we will follow almost exactly, with some slight changes. **Exceptional students** will not only be following the topic being taught outside of class but also preparing for the next topic.

The main difference between our course and CAIE is that we will cover about 20% less of the course than the iGCSE due to time restrictions (we have fewer lessons per week than PreA level classes) and to allow us to better prepare for the IB group 4 subject you chose to do (which may be Chemistry either HL or SL).

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1.14 EXCEPTIONAL Stretch and Challenge - Basics to delivering an effective presentation

At the end of each topic there will be a chance for the most interested students to give a presentation about anything they found particularly interesting. It can be about anything, but it will help develop your public speaking skills, your confidence and allow you to demonstrate subject passion, which is the most important quality that the best universities in the UK are interested in.

This exercise is voluntary but open to all students.
1.15 EXTENSION How grade thresholds have changed across the years

GRADE THRESHOLDS FOR EXTENDED CHEMISTRY 0620 FROM JUN2019 TO JUN2014 A*-C WITH THE PROPORTION OF STUDENTS AWARDED AN A*

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1.15.1 Reflection:

What do you think this graph shows? How can you use this information to make sure you achieve the A*?
1.16 ESSENTIAL Study Timetable – Use this to assign blocks of time to different subjects and regular activities

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## 1.17 ESSENTIAL Revision Timetable – Use this to help you start to organise your revision time

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Learning to learn

2.1 ESSENTIAL Critical reading techniques

1. Critical reading techniques
2. Use an efficient approach
3. Active reading

Active reading simply means reading something with a determination to understand and evaluate it for its relevance to your needs.

Simply reading and re-reading the material isn't an effective way to understand and learn. Actively and critically engaging with the content can save you time. Most OU study books and websites include in-text questions and self-assessed questions. Use these as built-in cues to make your study active.¹

![Critical reading techniques](https://help.open.ac.uk/active-reading)

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¹ [https://help.open.ac.uk/active-reading](https://help.open.ac.uk/active-reading)

2.2 FUNDAMENTAL Active Reading Advice

Active reading strategy

S Q 3 R

SURVEY
Skim the text and find the main ideas.
What can I learn from the text?

QUESTION
Think about what you already know about the topic
What do I hope to learn from the text?

READ
Look for answers to your questions.

RECITE
Consider what you want to remember from the

RECALL
Reread your notes and link the information with your own experience.

2.3 EXTENSION Active Reading Advice


Active Reading Strategies

Choose the strategies that work best for you or that best suit your purpose.

- **Ask yourself pre-reading questions.** For example: What is the topic, and what do you already know about it? Why has the instructor assigned this reading at this point in the semester?

- **Identify and define any unfamiliar terms.**

- **Bracket the main idea or thesis of the reading, and put an asterisk next to it.** Pay particular attention to the introduction or opening paragraphs to locate this information.

- **Put down your highlighter. Make marginal notes or comments instead.** Every time you feel the urge to highlight something, write instead. You can summarize the text, ask questions, give assent, protest vehemently. You can also write down key words to help you recall where important points are discussed. Above all, strive to enter into a dialogue with the author.
- Write questions in the margins, and then answer the questions in a reading journal or on a separate piece of paper. If you’re reading a textbook, try changing all the titles, subtitles, sections and paragraph headings into questions. For example, the section heading “The Gas Laws of Boyle, Charles, and Avogadro” might become “What are the gas laws of Boyle, Charles, and Avogadro?”

- Make outlines, flow charts, or diagrams that help you to map and to understand ideas visually. See the reverse side for examples.

- Read each paragraph carefully and then determine “what it says” and “what it does.” Answer “what it says” in only one sentence. Represent the main idea of the paragraph in your own words. To answer “what it does,” describe the paragraph’s purpose within the text, such as “provides evidence for the author’s first main reason” or “introduces an opposing view.”

- Write a summary of an essay or chapter in your own words. Do this in less than a page. Capture the essential ideas and perhaps one or two key examples. This approach offers a great way to be sure that you know what the reading really says or is about.

- Write your own exam question based on the reading.

- Teach what you have learned to someone else! Research clearly shows that teaching is one of the most effective ways to learn. If you try to explain aloud what you have been studying, (1) you’ll transfer the information from short-term to long-term memory, and (2) you’ll quickly discover what you understand — and what you don’t.

See other side of page for sample diagrams →

Sample diagrams:
2.4 How to get the most from your textbook

The best way to learn most efficiently is the most important thing that you will learn about yourself and about learning. To discover better ways of learning will need you to try them out. Hopefully you have already started to notice certain patterns in all textbooks, like the way they are set out. Normally one idea or concept is covered in either a single page or a double page spread, helping to break down a larger topic into smaller parts which are easier to manage. They will also have questions after idea has been explained which are designed to reinforce your learning and require you to think about the ideas and make use of what you have just learnt. This is a part of a process known as Active Learning. Solving past exam questions is another way to learn by activity. Also effective is teaching another student who is struggling with a particular part of the course.

Active reading requires you to really think about what you are reading and make notes, underline and reflect on the ideas. If you follow the instructions that follow when you are working through the textbook, especially if you are reading ahead of the classes (use the calendar and ask your teacher to find out which topic or Chapter is next)

2.4.1 Important points to note about the textbook

Like any textbook it will contain information that is relevant, but not always necessary for the topic it covers. For instance, some of the uses of chemicals it lists are accurate, they really are used in those processes, but they are not always included in mark schemes for CAIE IGCSE Chemistry, which in addition to valuing what is true, also requires from it’s A* students what is most relevant. E.g. if you got hit by a car walking across the street there are lots of things that you might notice like it’s colour, shape, size and the direction it was travelling, but really only it’s speed would matter if you hoped to survive. Not all things that are accurate (close to being the “true” value) are equally relevant, and this exam board sometimes requires you to understand and list the most relevant factors, properties or characteristics first.

<table>
<thead>
<tr>
<th>Activity</th>
<th>What you should do</th>
<th>Why it helps</th>
<th>When you should do it</th>
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<tbody>
<tr>
<td>FUNDAMENTAL 1. Translation</td>
<td>Translate ALL new words, especially the ones in bold, ideally next to the text. Use the glossary at the back to help you.</td>
<td>The most important words to translate are the non-scientific words you already know in Chinese.</td>
<td>As you are reading.</td>
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<tr>
<td>FUNDAMENTAL 2. Underlining</td>
<td>Underline, highlight circle, put a *star or symbol 😊 next to the biggest new ideas. But remember, if you highlight everything, you’ve actually highlighted nothing 😞.</td>
<td>Completing the in the Key Points task becomes quicker but most importantly, it is a form of ACTIVE READING.</td>
<td>As you are reading.</td>
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<tr>
<td>FUNDAMENTAL 3. Answers</td>
<td>Answer the Summary Questions about the material at the end of the double page spread.</td>
<td>Here you are shown what is most important about the ideas of this 2-page spread and forced to think about it in a new way.</td>
<td>After you have finished reading both pages</td>
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<tr>
<td>FUNDAMENTAL 4. Checking Answers</td>
<td>Check your answers with the answers provided at the end the textbook (pages 286 to 301)</td>
<td>Any major misunderstandings or confusions you have are likely to be discovered doing this.</td>
<td>After you’ve finished your answers</td>
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<tr>
<td>ESSENTIAL 5. Key Points</td>
<td>Main ideas, equations and diagrams for both pages. It’s the idea that you are trying to describe to your self, so try to make it as visual and colourful as possible! Make sure whatever you write is in your own words!!! Include any notes you have from lessons here!</td>
<td>At this point you are now starting to own the information you are processing. This task will force your brain to think about what is most important because space is limited and writing is work. After you have thought about it in a new way, you’ll need to remember your thoughts long enough to write them out, helping your long-term memory. This will also help to write out better que questions.</td>
<td>After you have finished the going through the questions and answers, but before you start the next two pages</td>
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<td><strong>ESSENTIAL</strong></td>
<td>Write out, in your own words, questions and bullet points that will force you to think about the essential ideas. Links to other parts of the topic and syllabus should also be included (e.g. half-equations are also covered in Topic 5 (Electrochemistry), so a note like: <strong>TS</strong> $2\text{Cl}^-(aq) \rightarrow \text{Cl}_2(g) + 2e^-$ [conc only!]) Might be a good idea if you’ve missed a mark on this before.</td>
<td>If you covered up the notes section of the page, answering these questions should allow you revise the whole page simply by answering a few questions and thinking about a few core ideas. If this is done carefully and thoughtfully not only will it make revision quicker later on, but also because it helps long term memories form, it’ll mean less revision is needed to get the highest grade.</td>
<td>After you’ve finished the next 2-page spread.</td>
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<td><strong>ESSENTIAL</strong></td>
<td>Write one or two sentences, in your own words that contain only the most important ideas.</td>
<td>Another way of thinking about it is: what’s the least useful or important 80% content here? Give a thoughtful person 2 tasks and the first thing they’ll do is create a third task which they’ll do first and prioritize which of the two is most important.</td>
<td>After you’ve finished the section</td>
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<td><strong>EXCEPTIONAL</strong></td>
<td>Write out, in a different colour, or in any other way to identify it, any new questions or details that you’ve discovered are important to getting full marks on questions assessing material covered in this 2 page spread. After you’ve worked on the past exam questions you should understand this section as well as the quality of the work you have put in deserves. You should also know in detail which marks are the hardest and this information needs to go into your Cue section so the work you’ve put in to discover this information isn’t abandoned or forgotten.</td>
<td>The tricky marks and the slippery explanations (especially that 2\text{nd} or 3\text{rd} mark) are most obvious now, but unless you make a decent effort to write them down, not only will you have lost the value of the work you have done because you’ll be less likely to remember them, you’ll also have no record to use later on. This is essentially saving your hard work for later when you’ll nee it most.</td>
<td>After you’ve finished the past exam questions</td>
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<td><strong>EXCEPTIONAL</strong></td>
<td>Any new tough mark or detail that you have overlooked.</td>
<td>This level of attention to detail will help you become a person who is far less likely to make a mistake, but if you do, is far more likely to learn from it. It’s your capacity to learn effectively and efficiently that will get you into a good university in the short term; in the long term it will allow you to do more interesting things with your work and your life.</td>
<td>Any time after you’ve finished the topic, but before the iGCSE exam</td>
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2.5 EXTENSION Examples of active reading

Feel free to tape additional pieces of paper onto the edges of your textbook to increase the space you have for making additional notes while you are reading. Another option is to digitise your textbook as has been done below.

Activities To Do
(complete as you are reading)

A1. Translating - 翻译
A2. Underlining
A5. Key Points

EXAMINER SAYS...

You need to remember the products from the thermal decomposition of nitrates. If you don't know these, you won't be able to write equations for thermal decomposition.

Thermal decomposition means the breakdown of a compound into two or more different products by heat.

The more reactive the metal, the more stable its nitrate, hydroxide or carbonate.

Metal hydroxides decompose to oxides and water.

Most nitrates decompose to either nitrites and oxygen or to oxides, nitrogen dioxide and oxygen.

We could observe how long does the compound need to be decomposed to deduce how stable the compound is.

A7. Summary Section - Do this a after you have answered the past exam questions end write, in your own words, only one or two sentences that sum up the important points on this page.

The more reactive the metal, the more stable its nitrate, carbonate or hydroxide is.
Nitrates of very unreactive metals, such as silver, decompose to form the metal when they are heated:

\[ 2AgNO_3 \xrightarrow{\text{heat}} 2Ag(s) + 2NO_2(g) + O_2(g) \]

**Demonstration**

The decomposition of Group II nitrates

This experiment is demonstrated using a Bunsen burner because nitrogen dioxide is poisonous. We start a stopwatch when we begin to heat the magnesium nitrate. The nitrate is heated until we see dark brown fumes of nitrogen dioxide in the tube. We recall the time taken to see these fumes. Then we repeat the experiment using other nitrates. In this experiment we must keep the amount of nitrate and the rate of heating the same.

The longer it takes for the nitrate to decompose, the more stable the nitrate is.

Magnesium nitrate decomposes at 402 °C but barium nitrate decomposes at 865 °C. So it appears that barium nitrate is more stable than magnesium nitrate. Barium is more reactive than magnesium. So the more reactive the metal, the more stable to thermal decomposition its compound is. This is well demonstrated if we look at the temperatures at which carbonates decompose when heated.

**Key Points**

1. Thermal decomposition is the breakdown of a compound into two or more different products by heat.
2. The more reactive the metal, the more stable its nitrate, hydroxide or carbonate.
3. Metal hydroxides decompose to oxides and water when heated.
4. Most nitrates decompose to other nitrates and oxygen or to oxides, nitrogen dioxide and oxygen when heated.

**Summary Questions**

1. Copy and complete using the words below:

   alkali, heated, nitrate, less, dioxide, oxygen

   Nitrates of the______ metals decompose when ____ to form the metal ____ and oxygen. Nitrates of ____ reactive metals form metal oxides: nitrogen ____ and ____ when heated.

2. Write equations for the thermal decomposition of:
   a) copper(II) hydroxide, Cu(OH)_2
   b) calcium nitrate, Ca(NO_3)_2
   c) Suggest why lithium nitrate decomposes in a similar way to a Group II nitrate rather than a Group I nitrate.

**A3. Answers to Summary Questions (8 Activity 4 Checking answers)**

1. alkali, heated, nitrate, less, dioxide, oxygen

   2. a) Cu(OH)_2 \rightarrow CuO + H_2O
      b) 2Ca(NO_3)_2 \rightarrow 2CaO + 4NO_2 + O_2

3. Because it's the least reactive, reactive alkali metal.

   Lithium has a much smaller ion than the other Group I metals so has a higher charge density. The charge density is more similar to those of Group II metals.

   Only alkali metal nitrates decomposed to form metal nitrates and oxygen. Other nitrates don’t.

   Most of the alkali metal hydroxides (except LiOH) don’t decompose.
2.6 ESSENTIAL Examples of Mind Maps

Mind Map 1 of Section 10.1 & 10.2

- Metals are made into alloys to improve their strength, hardness or resistance to corrosion.
- The properties of a metal are altered by making it into an alloy.
- Alloys
- We could arrange the metal reactivity series by comparing how easily they react with water and hydrochloric acid.
- When metals react with cold water, metal hydride and hydrogen are formed. When metals react with oxygen, metal oxide and hydrogen will form.
- Only elements above hydrogen can react with hydrochloric acid, water and steam.
- The metal reactivity series
- More about reactivity series.
- Metal hydroxides decompose to oxides and water. Alkaline metal hydroxides do not decompose.
- Carbon and reactive metals can be used as reductants. The more reactive metal is a better reductant.
- Only metals below carbon in the reactivity series can be reduced by carbon when heating.
- When a more reactive metal is heated with a metal oxide, which the metal is less reactive. The more reactive metal is the reductant.
- Alkaline metal nitrates decompose to metal nitrides and oxygen.
- Other metals nitrates decompose to oxides, nitrogen dioxide and oxygen.
- Aluminium forms reactive because its oxide layer is resistant to corrosion. Aluminium itself is very reactive.
**TOPIC 1**

**ATOM STRUCTURE AND THE PERIODIC TABLE**

- Elements: Chemical properties of atoms, mass number, atomic number, isotopes, isotonicity.
- Periodic Table: Chemical elements arranged in a table by increasing atomic number.
- Electronic Configuration: Atomic structure, electron configuration, outermost electrons.
- Chemical Bonding: Ionic, covalent, hydrogen bonds.
- Chemical Equations: Reactions, stoichiometry, balancing equations.

**NUCLEAR MODEL**

- Bohr Model: Fixed electron shells.
- Nuclear Equations:
  - Mass Number: $A = \sum$ mass of protons and neutrons.
  - Atomic Number: $Z = \sum$ number of protons.
  - Isotopes: Same number of protons, different number of neutrons.
  - Isotonicity: Stable isotopes.

**MORE REACTIVE**

- Reactivity: Increasing order: $F > Cl > Br > I$.
- Reactivity with Metals: $F > Cl > Br > I$.

**IONIC COMPOUNDS**

- Properties: Chemical, physical, electrical.
- Formation: Reactants form ions, products form compounds.

**CHLORINE DISTILLATION**

- Process: Simple distillation, chemical equations, boiling points.

**CRYSTALLIZATION**

- Properties: Physical, chemical, electrical.
- Solutions: Seawater, brine, brine solutions.

**CHEMICAL EQUATIONS**

- Types: Balanced, unbalanced, stoichiometric.
- Reactions: Redox, precipitation, acid-base, single-displacement, double-displacement.

**CHEMICAL REACTIONS**

- Types: Fission, fusion, nuclear fission, nuclear fusion.
- Products: Products of nuclear reactions, nuclear power.

**atomic structure and periodic table**

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**nuclear model**

- Bohr Model: Fixed electron shells.
- Electron Configuration:
  - $1s^2$ (1s), $2s^2 2p^2$ (2s, 2p), $3s^2 3p^2$ (3s, 3p), $4s^2 3d^{10}$ (4s, 3d).

**more reactive**

- Reactivity: Increasing order: $F > Cl > Br > I$.
- Reactivity with Metals: $F > Cl > Br > I$.

**ionic compounds**

- Properties: Chemical, physical, electrical.
- Formation: Reactants form ions, products form compounds.

**chlorine distillation**

- Process: Simple distillation, chemical equations, boiling points.

**crystallization**

- Properties: Physical, chemical, electrical.
- Solutions: Seawater, brine, brine solutions.

**chemical equations**

- Types: Balanced, unbalanced, stoichiometric.
- Reactions: Redox, precipitation, acid-base, single-displacement, double-displacement.

**chemical reactions**

- Types: Fission, fusion, nuclear fission, nuclear fusion.
- Products: Products of nuclear reactions, nuclear power.

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**more reactive**

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**ionic compounds**

- Properties: Chemical, physical, electrical.
- Formation: Reactants form ions, products form compounds.

**chlorine distillation**

- Process: Simple distillation, chemical equations, boiling points.

**crystallization**

- Properties: Physical, chemical, electrical.
- Solutions: Seawater, brine, brine solutions.

**chemical equations**

- Types: Balanced, unbalanced, stoichiometric.
- Reactions: Redox, precipitation, acid-base, single-displacement, double-displacement.

**chemical reactions**

- Types: Fission, fusion, nuclear fission, nuclear fusion.
- Products: Products of nuclear reactions, nuclear power.
### FUNDAMENTAL Glossary of Quizlet Library of Weblinks

If you are struggling with the vocabulary and English in this course here’s a whole library of resources including games, puzzles and tests that are based on the Quizlet website that will help you get up to speed with the keywords.

Note: Words from Topic 1 and 2 are combined and found in Topic 1. The same is also true for words from 12 and 13 which are both in Topic 13.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Quizlet word list hyperlink</th>
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| 5.    | English word to English definition: [https://quizlet.com/_4ltdnw](https://quizlet.com/_4ltdnw)  
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| 6.    | English word to English definition: [https://quizlet.com/_4ltdqq](https://quizlet.com/_4ltdqq)  
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| 7.    | English word to English definition: [https://quizlet.com/_4lteab](https://quizlet.com/_4lteab)  
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| 12.   | This topics word list is grouped with topic 13 |
| 13.   | English word to English definition: [https://quizlet.com/_4lterb](https://quizlet.com/_4lterb)  
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English word & translation to Chinese google translate [https://quizlet.com/_4lth0u](https://quizlet.com/_4lth0u) |

All my English to Chinese by topic word lists:  

All my English keyword to English meaning by topic word lists:  
3 The Cornel Note-Taking System

3.1 Introduction

The main task your brain does is forgetting things. It is constantly, quietly and relentlessly erasing everything you see, hear and feel during both your conscious and unconscious (e.g. whilst sleeping) sense of being, including the single moment it takes for you look at this next full stop.

But if you have ever fallen off a bike or had an accident your brain stops deleting everything and instead stores as much of the information as it is able. Time slows down and your memory becomes almost photographic. Some things are therefore more memorable than others. The trick with learning is to make your brain think that what you are trying to learn matters to your brain. It is designed to only remember the things that it is programmed to think are important. It’s programming comes from culture, but some is also hard-wired into the system itself, like our shared interest in learning a language when we are babies, or our ability to process visual images or our ability to control our body temperature. This hard wiring is created by our genes, which we inherit from our parents. Our genes were created and adapted to survive and persist tens of thousands of years ago in a totally different world to the one your brain finds itself in a classroom.

Current understanding of the human brain is extremely basic, no-one knows what the smallest part of an idea might be in terms of brain cells. But we do know that brain cells make connections and we think that those connections are where the mind, and memory, is created. We also know that the brain is more likely to make connections, and therefore memories, from events we are emotionally attached to, like an accident or a totally awesome movie. If we feel emotions about something, either good or bad, than our brain thinks that thing is something it needs to keep for later.

If you keep returning to the same idea over time, but you make your brain think about it differently, for instance by taking notes using your own words, or making a summary, or writing out key questions raised by that idea, forces it to make new connections in order to enable this different kind of thinking. Not only will the brain be better able to use this new idea in a new situation, like in an exam, but these connections make the memory more stable. If the brain really thinks something is important, like your name or where you live, it will store these essential bits of information into what is called the Long Term Memory.

The goal of learning is not only to make as many interesting and important connections within the brain as possible, but also to put as much information into the long term storage area as possible. The goal of education, especially in the better universities is not fill a student’s brain with specific facts and ideas, or to test how intelligent someone is, but to train a students brain with skills and techniques to learn faster, better and longer. The more you know, for instance about the Avengers and the MCU, the more interesting and exciting watching Avengers Endgame for the first time was as a movie. But it was still kinda disappointing, unfortunately.

Learning how to learn better than before is the most valuable and important thing you will take away from any lesson. Luckily, you are not the first person to ever be taught. There are thousands of years of history and tens of thousands of years of culture that you can use to your advantage. Some systems of learning work better than others.
In the 1940s a professor of law at Cornell University called Walter Paulk realised his students, who were supposed to be some of the best of their generation, weren’t that good and he wondered what they could do to learn better. He invented the Cornell Notetaking system, which is widely considered to be the best way to learn difficult things in any subject.

If you imagine using this system gives you a token that allows you to have to revise less later. If you follow this system properly, that token has tremendous value and will not only allow you to aim for the highest grade, but allow you to do so with much less stress, challenge and negativity that often surrounds big exams for disorganised students. You are effectively being kinder to your future self by putting the work in earlier when it matters more. If you skip this, and just wait until the end of year exam you’ll more likely be learning instead of revising, which takes much longer and produces much poorer results. Even if you end up with the exact same grade, you’ll have failed to progress as a student, and that lack of progress eventually, maybe not even at A Level, but at a world leading university, will cause all kinds of calamities and challenges. You may even be so disappointed in how little you learnt about learning that you decide to become a teacher. It happens.

![Figure 2](image.png)

Figure 2 One way of thinking about the mind. Most of it involves aspects of the self that are hard to understand and even harder to change, but with enough work it is possible for anyone to nurture and grow the habits of an outstanding student, but it takes time and especially commitment.
3.2 The forgetting curve

Overcoming the Curve

The quicker you return to a lesson to review it, the less time you will need to gently nudge it into your long term memory, so 5 minutes within 24 hours can be as effective as an hour or more a month later. Remember, your brain does not understand what you are trying to do, but if you try to work with it, and help it along, remind it that this stuff matters to you (and it), it will be more likely respond in the way that you want and learn what you need it to.

https://psychology.stackexchange.com/questions/8377/how-are-these-review-forgetting-curve-calculated
3.3 Fundamental Cornell Notetaking Basics

**Cornell Note-taking System**

![Diagram of the Cornell Note-taking System]

3.3.1 Essential Cornell Notetaking for More Able Students

**The Cornell Note-taking System**

1. **Record**: During the lecture, use the note-taking column to record the lecture using telegraphic sentences.

2. **Questions**: As soon as possible, formulate questions based on the notes in the right-hand column. Writing questions helps to clarify meanings, reveal relationships, establish continuity, and strengthen memory. Also, the writing of questions sets up a perfect stage for exam-studying later.

3. **Recite**: Cover the note-taking column with a sheet of paper. Then, looking at the questions or cue-words in the question and cue column only, say aloud, in your own words, the answers to the questions, facts, or ideas indicated by the cue-words.

4. **Reflect**: Reflect on the material by asking yourself questions, for example: “What’s the significance of these facts? What principle are they based on? How can I apply them? How do they fit in with what I already know? What’s beyond them?”

5. **Review**: Spend at least ten minutes every week reviewing all your previous notes. If you do, you’ll retain a great deal for current use, as well as, for the exam.

---

**Summary**

After class, use this space at the bottom of each page to summarize the notes on that page.
### 3.4 Extension Cornell Notetaking for Better Students

**Cornell Note Taking**

**Cue Column**

This section is to be completed after the lesson/lecture, and should include key words or phrases as well as vocabulary, people or case studies you may need to research, and potential exam questions.

I guess you could say this column is for the **WHAT'S**, **WHO'S**, **WHEN'S**, and **WHERE'S**.

**Note Taking Column**

This section of your page is dedicated to lesson time and in class note taking. You might want to include:

- Main points and lesson objectives
- Diagrams, graph sketches, drawings or charts
- Bullet points/numbered processes
- Concise sentences
- Shorthand symbols/paraphrases/abbreviations

Also, try to leave lines between points so you can go back in and add any brief notes you may have missed. This extra space will also give you a sense of clarity.

You don't have to use a ruled line version—try one with a blank note taking section to experiment with mindmaps, tables or whatever takes your fancy - make it personal to you.

You might say this column is for the **WHY'S** and **HOW'S** with some of these guys thrown in.

**Summary Section**

This section should be written last, after class. It should also only really contain a basic, condensed summary of your notes in the Cue column, and important details of your main notes. It is used to quickly find & digest info later.

---

If you really run out of space, add a post-it, but do try to summarise on just one page!
3.5 Exceptional Cornell Notetaking for the Best Students

The advice and ideas here are not needed for most students but include further ideas that can help develop your notetaking skills, which is at the heart of the most successful students (and intellectuals).

**The Five R’s:**

1. RECORD your notes in the right-hand column.
2. REDUCE your notes into the recall column on the left
3. RECITE out loud from the recall column.
4. REFLECT on the information that you are studying.
5. REVIEW your notes immediately and regularly

---

**Step 1: Record**

Write main ideas and supporting material in the right column
Use signals from the lecture
Titles & keywords = topics
main ideas
Use abbreviations to get the full idea.
Leave spaces between ideas so you can fill in more later. see how ideas relate to one another

**Step 2: Reduce**

Write the topics and vocabulary words, in the left column of your notes
Write questions to quiz yourself on the material.
– Write a question for each new topic, main idea, or significant detail.
– Write questions on the material which you think your teacher will test you.

**Step 3: Recite**

This will help transfer ideas to your long-term memory!
Study the information by answering your questions in the left column.
– Cover the Record Column.
Step 4: Reflect

After the lecture, write a summary at the bottom of your notes.

Step 5: Review

Improve your memory.

– If you spend 10 minutes after every class in a quick review of your notes, you will retain most of what you have studied you won’t have to cram during an “all-nighter” you will relate the facts and ideas to present lectures or readings.

3.6 Essential Note-Taking Tips and Examples

Develop a code system of note-marking to indicate questions, comments, important points …for example,

• Mark unfamiliar vocabulary & unclear ideas in unique ways, such as with a star or asterisk.
• Highlight vocabulary terms and important people.
• Circle ideas that are still unclear.
• Make sure you can understand what you have written and if needed, make corrections.
• Use drawings, arrows or other organizers to help you see concepts and relationships between them.
• Use abbreviations and symbols wherever possible in the notes portion (but try to keep your abbreviations simple to understand, if you forget later your system then your notes lose their meaning!)
• If you completely don’t understand an idea, leave a blank space and ask your teacher for help on it.

For a more detailed and involved exploration and explanation of notetaking download document attached to this QR code (30 pages):
How to Illustrate Your Notes

By Revise or Die

It’s all about Pic n’ Mix, y’know!

1. Choose your ‘bag’… (type of notes)
   - Mindmap?
   - Poster?
   - The Cornell method?
   - The outlining method?
   - The charting method?

2. Choose your ‘scoop’… (fonts/tools/colours)
   - There are so many kinds to choose from!
   - If you’re feeling really snazzy, choose a colour palette for your work! Here’s some suggested ones I use...
   - A)  
   - B)  
   - C)  
   - D)  
   - E)  

3. Choose your ‘sweets’… (twiddly bits)
   - Clouds
   - Bangs
   - Flags
   - Ribbons
   - Dashed lines
   - Arrows
   - LOTS OF ARROWS
   - anything specific to the subject—don’t be afraid to draw it!
how i write outlines/take notes

**ROMAN NUMERAL METHOD:**

- **Main Topic**
  - **Section Name (pg #)**
    1. Important facts, concepts, examples, etc.
    2. Expansion, details, more examples, etc.
  - and so on...

**EXAMPLE**

- **I. Energy and the Cell**
  - **A. Cell transform energy as they perform work (pg 80)**
    1. Energy is the capacity to cause change or to perform work. The 2 types of energy are kinetic and potential.
      - **a. Kinetic energy** is the energy of motion. Moving objects transfer motion to other matter. **Heat** is a type of kinetic energy associated with the random movement of atoms/electrons.
      - **b. Potential energy** is energy that is a result of its location or structure. Chemical energy is the potential energy available for release in a chemical reaction.

**MY USUAL OUTLINE METHOD:**

- **[Section #]** Section Name
  - Summary from textbook
  - **Main Idea**
    - info (important dates/events/people/concepts/etc.)
  - **Subheading**
    - info (Ex. examples)

**EXAMPLE**

- **[Section 1] The Road to World War I**
  - 1914, summer: Crisis in the Balkins led to conflict when a Serbian terrorist assassinated Archduke Francis Ferdinand...

- **Causes of the War**
  - **Main Idea** Nationalism, militarism, and a system of alliances contributed to the start of World War I.
    - System of nation-states that were formed led to competition
  - **Nationalism and Alliances**
    - Europe's greatest powers were divided into 2 alliances the **Triple Alliance (1882)** and the **Triple Entente (1907)**
      - Germany
      - Austria-Hungary
      - Italy
      - France
      - Great Britain
      - Russia
### 3.7 Cornel Notetaking Note Paper

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**Summary Section:** Do this a week later and write, in your own words, only one or two sentences that sums up the important points on this page.

For a whole variety of different formats and types of paper: [https://incompetech.com/graphpaper/cornelllined/](https://incompetech.com/graphpaper/cornelllined/)
### Questions & Translations

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<td>Fill this in AFTER lesson</td>
<td></td>
</tr>
</tbody>
</table>

**Summary Section**: *Do this a week later* and write, in your own words, only one or two sentences that sums up the important points on this page.
Summary Section - Do this a week later and write, in your own words, only one or two sentences that sums up the important points on this page.
<table>
<thead>
<tr>
<th>Questions &amp; Translations</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Fill this in AFTER lesson</em></td>
<td></td>
</tr>
</tbody>
</table>

**Summary Section:** Do this a week later and write, in your own words, only one or two sentences that sums up the important points on this page.
**Summary Section** - *Do this a week later* and write, in your own words, only one or two sentences that sums up the important points on this page.
### 3.8 Top Tips for Smashing! your Exams

<table>
<thead>
<tr>
<th>Idea</th>
<th>Why it matters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Adding to your answers at the end</strong></td>
<td><strong>For most students.</strong> The harder explain questions, or other multi-mark questions often will require details that may not be the first ones you include. After you have given the question roughly the right amount of time per mark, <strong>MOVE ON</strong> to the next part of the exam. Return later if you have made the time to do so, after you have checked through the exam and add whatever else you can think might be relevant AND correct. If you are not sure if it’s relevant, but you are sure that it is correct, then add it anyways, <strong>but only if you have the time!</strong></td>
</tr>
<tr>
<td><strong>Annotating your multiple-choice questions</strong></td>
<td><strong>For ALL students!</strong> Although the examiner will not see you question paper for multiple choice questions, you should still make notes on the question paper itself. This will help you break the question down, which will often require you to have one idea that follows another, if this is written down inside the question you are more likely to see this second step. Also important, at the end you can see your own thinking when you check through your exam at the end, which will make checking your work easier and more effective.</td>
</tr>
<tr>
<td><strong>Annotating your questions</strong></td>
<td><strong>For ALL students!</strong> You should be writing out what you know about the compounds and ideas as you are reading the question. Underline numbers, these are usually only ever given to you because they are necessary in a calculation. For questions involving unknowns, try to write what X is if that is possible. This way you break down a larger problem in to more manageable parts helping you see more clearly the answer.</td>
</tr>
<tr>
<td><strong>Checking your exam paper</strong></td>
<td><strong>For most students</strong> try to allow at least 10% of the exam time to check your exam paper at the end, for Paper 2 this is about 5 minutes, Paper 4 it is 8 minutes, for Paper 6 it is 6 minutes. As you move through the paper, you should have already marked the hardest questions with a star or other symbol, these should be checked the most carefully. <strong>For the most able students</strong> who are aiming for a good A* you ought to have about 20 to 30% of the time left at the end for checking which will allow you to thoroughly check all of the exam and locate every mark. For less able students you may need to ignore the later parts of a tough topic to ensure you are able to check through the easiest questions at the end to correct any easy mistakes you may have made.</td>
</tr>
<tr>
<td><strong>Chemical equations</strong></td>
<td>For most students. A good answer ought to try to include at least one balanced chemical equation, even if you feel you have just explained the same thing in words, because you may have missed something out or not explained properly the idea that you had in your mind which the chemical equation will provide evidence to the examiner that will allow you to get the mark. It is an example of REDUNDENCY or a FAIL-SAFE.</td>
</tr>
<tr>
<td><strong>Crossing out mistakes</strong></td>
<td>Never cross out work that you think is a mistake unless you have already provided another answer, so draw a box around what you intend to replace, then write your new answer, <strong>THEN</strong> write a neat cross through that box. Your crossed-out work should always be readable to the examiner. If it contradicts your new work, it will not be considered, but if it helps to clarify your new answer, than it ought to be considered by the examiner. For instance, in a recent exam students were expected to describe a difference and explain it; many students simply explained without saying if the value would be larger or smaller, one student suggested that it would be smaller in their crossed out work, but only different in their final answer, but they had shown they understood how it would be different and got the mark.</td>
</tr>
<tr>
<td><strong>Diagrams</strong></td>
<td><strong>For ALL students!</strong> A picture is worth a 1000 words. A good LABELLED diagram even if there is not there is no blank space for a diagram, can sometimes be acceptable and can help give a fuller answer to allow you to pick up the hardest marks or prevent silly mistakes where you have accidentally not included enough information.</td>
</tr>
<tr>
<td><strong>Drawing graphs</strong></td>
<td><strong>In pencil!!!</strong> If you make a mistake in the real exam in pen it your answer may not be clear enough for you to be awarded really easy marks, you cannot ask for another exam paper, so mistakes that are made in pen are permanent! <strong>For ALL students!</strong></td>
</tr>
<tr>
<td><strong>Eliminating the wrong answers in multiple choice questions</strong></td>
<td><strong>For ALL students!</strong> Usually two of the 4 answers are more easily seen as incorrect. Finding these two will give you a 50/50 chance of getting the right answer with less understanding, so even though you don’t fully understand the question, you have at least managed to increase your odds of guessing correctly. If you can’t easily and quickly find these 2 answers, mark the question, make a guess IN PENCIL, then move on, this question is obviously a difficult question therefore.</td>
</tr>
<tr>
<td><strong>Exam Questions</strong></td>
<td><strong>For ALL students!</strong> Almost none of the marks are awarded for answering actual questions (you will almost never see a question mark!!?). What are commonly referred to as exam questions, even by Mr Paddy, are in fact commands: calculate this, or explain that or state how etc. This is to reduce confusion so that you know exactly what is expected from the language of the command (which is why the command terms exist and why they are so important to properly understand!</td>
</tr>
<tr>
<td>Idea</td>
<td>Why it matters</td>
</tr>
<tr>
<td>------</td>
<td>----------------</td>
</tr>
<tr>
<td><strong>FAIL SAFE or REDUNDENCY</strong></td>
<td>For most students. If you really want to make sure you pick up every single mark you should be aiming to include additional information in a slightly different format, including labelled diagrams and balanced chemical equations with state symbols. This level of attention to detail means that if your first attempt at the hardest marks in the exam paper fails, it fails into a safe position, because you have a backup plan. This is an essential idea in engineering and research science.</td>
</tr>
<tr>
<td><strong>Give some properties/etc</strong></td>
<td><strong>For the most able students.</strong> Give about 40 to 100% more properties or conditions than there are marks: irrelevant answers, or incomplete answers will not go against you, so to ensure you include all of the answers that the examiner requires you need to be very cautious. Answers acceptable one year may not be acceptable in another exam session, they are not incorrect, just not enough to get a mark. <strong>This is essential for a candidate to hope for a good A</strong>*!!! <strong>For the least able students.</strong> Make sure that you are at least giving as many answers as there are marks, if you are not sure, give your best guess, never leave an answer blank!</td>
</tr>
<tr>
<td><strong>Give x# properties/conditions/etc</strong></td>
<td><strong>For ALL Students!</strong> Give exactly and only x number of properties, any more will either not be marked, so if one of your answers is irrelevant, and you are supposed to give 3 answers, but you give 4 and the 4th is correct, you could lose the mark. If one of the answers is wrong, then you will most likely lose the mark. They do not reward candidates who try to use ambiguity to increase their score, and in fact actively penalise it.</td>
</tr>
<tr>
<td><strong>Name</strong></td>
<td><strong>For most students.</strong> Give the name, in English, for the chemical compound, ion or element. Only the name is acceptable, and if you misspell it, especially if it is a negative ion, like chloride, you will not be awarded the mark.</td>
</tr>
<tr>
<td><strong>Plurals</strong></td>
<td><strong>For ALL students!</strong> If a question requires more than one answer, it will have ALWAYS indicated this with the use of plurals. If only one answer is needed than again, the statement will indicate this grammatically. <strong>PAY ATTENTION TO THIS!!!</strong></td>
</tr>
<tr>
<td><strong>Showing your working in calculations</strong></td>
<td><strong>For ALL students!</strong> The space given for your working for a calculation should not be considered as ‘rough paper’ or include incomplete numbers or ideas. The space for your response should be considered as a place for you to communicate with the examiner what you are doing, and especially thinking, in each step, even if it seems obvious to you what you are doing, each step should be clearly labelled and written in a way that can be easily followed. Sometimes the final answer is only worth one mark, and the other marks can only be achieved with carefully laid out working. Another important reason for good, systematic working, even for easy questions that involve more than one step is that they allow you at the end of the exam to check your thinking quickly, efficiently and effectively.</td>
</tr>
<tr>
<td><strong>Spelling</strong></td>
<td><strong>For ALL students!</strong> It is only really in the naming of a specific process or compound that spelling is vital. Otherwise anything that is spelt well enough for the word to be clear and the meaning to be understood is acceptable. Your written response is used by the exam board to measure you level of understanding, some students with certain disabilities may not be able to write, but they could still get an A* in this subject if they could shown, e.g. through speech, that they are able to understand the ideas. If you think of Stephen Hawking, a world famous scientist, who was also a professor at the University of Cambridge, he could not write, but he was still extremely well respected.</td>
</tr>
<tr>
<td><strong>State or identify</strong></td>
<td><strong>For ALL Students!</strong> In this case you can use either the chemical formula or the full English name of the compound, ion or element. If you give the formula and the name and one of them is incorrect, you will lose the mark, so you are better off only identifying the substance by the way you are most confident in. For instance, if you say that it is &quot;Bromine (Br)&quot; when it is in fact Br₂, you will likely lose the mark. Or &quot;Bromine (Br)&quot; when it is the bromide ion, you will also lose the mark.</td>
</tr>
<tr>
<td><strong>State symbols</strong></td>
<td>For most students. Always include these in your diagrams where you can, even if you are not able to include all of them for the whole equation (e.g. the electrolysis of aluminium). This is another example of a FAIL SAFE.</td>
</tr>
<tr>
<td><strong>The order you answer questions</strong></td>
<td><strong>For ALL students!</strong> This should be organised at the start of the exam. Take 2 minutes to skim through the exam paper and find the hardest questions and the easiest ones. The hardest questions should be answered last, these are the least efficient use of your time (in terms of marks achieved versus time spent). The easiest questions are the most efficient use of your time, unless you have run out of time and are forced to leave them unanswered, or poorly answered. <strong>DON’T ANSWER EXAM QUESTIONS IN THE ORDER THEY APPEAR ON THE EXAM PAPER!!!</strong></td>
</tr>
</tbody>
</table>

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Patrick Brannac  
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<table>
<thead>
<tr>
<th>Idea</th>
<th>Why it matters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time management in exams</strong></td>
<td>For ALL students! You should know how long you have for each mark (normally it is around 1 mark a minute). You should also have a watch that you are familiar with that is not a smart watch or a smart band. A simple, cheap classic Casio watch would be best, and you can use this same watch throughout your academic career making sure to replace the battery before every exam session. Some questions you should be able to make time up on, others will take considerably longer, for those harder questions, stop after about 1 minute a mark and return to them at the end to ensure the easiest marks have been answered fully and carefully.</td>
</tr>
<tr>
<td><strong>Understanding the distracter answer in a multiple-choice question</strong></td>
<td>For the most able students. After you have eliminated the 2 easily incorrect answers there will be two very similar answers that will differ in a fundamental way, hopefully, that will allow you to find the correct answer. Sometimes, however, neither will be easily identified as correct, so you will need to find the most incorrect answer and chose the other one. These questions tend to be the hardest marks in the exam.</td>
</tr>
<tr>
<td><strong>Units</strong></td>
<td>For ALL students! Always include units in your answer! Often, they will not be enough to allow you to get a mark, but if they are not there you will lose a mark.</td>
</tr>
<tr>
<td><strong>Writing in the mathematics formula booklets</strong></td>
<td>For ALL maths students. Nothing to do with chemistry, but I find it really unnecessary. DO NOT TO THIS! At best rough work which should have been included in your answer booklet, then neatly crossed out, will not be seen by an examiner, so you could very pointlessly drop marks. At worst the handwriting is yours in this booklet, so you could be accused of writing the answers in there before the exam and therefore cheating. It is CAIE policy (and all exam boards, actually) that everything a candidate does in the exam is sent to them, which is again related to exam security which they take extremely seriously. Most likely however, the booklets are just thrown away for no good reason which is a waste of paper.</td>
</tr>
<tr>
<td><strong>Wrong answer + Right Answer</strong></td>
<td>= No marks! If you are unsure go with your best guess, but don’t give two answers if only one answer is acceptable. For ALL Students!</td>
</tr>
</tbody>
</table>
IB Diploma

The Diploma Programme is a rigorous pre-university course of study designed for students in the 16 to 19 age range. It is a broad-based two-year course that aims to encourage students to be knowledgeable and inquiring, but also caring and compassionate. There is a strong emphasis on encouraging students to develop intercultural understanding, open-mindedness, and the attitudes necessary for them to respect and evaluate a range of points of view.

The Diploma Programme model

The course is presented as six academic areas enclosing a central core (see figure 1). It encourages the concurrent study of a broad range of academic areas. Students study two modern languages (or a modern language and a classical language), a humanities or social science subject, a science, mathematics and one of the creative arts. It is this comprehensive range of subjects that makes the Diploma Programme a demanding course of study designed to prepare students effectively for university entrance. In each of the academic areas students have flexibility in making their choices, which means they can choose subjects that particularly interest them and that they may wish to study further at university.
IB learner profile

As IB learners we strive to be:

**INQUIRERS**
We nurture our curiosity, developing skills for inquiry and research. We know how to learn independently and with others. We learn with enthusiasm and sustain our love of learning throughout life.

**KNOWLEDGEABLE**
We develop and use conceptual understanding, exploring knowledge across a range of disciplines. We engage with issues and ideas that have local and global significance.

**THINKERS**
We use critical and creative thinking skills to analyse and take responsible action on complex problems. We exercise initiative in making reasoned, ethical decisions.

**COMMUNICATORS**
We express ourselves confidently and creatively in more than one language and in many ways. We collaborate effectively, listening carefully to the perspectives of other individuals and groups.

**PRINCIPLED**
We act with integrity and honesty, with a strong sense of fairness and justice, and with respect for the dignity and rights of people everywhere. We take responsibility for our actions and their consequences.

**OPEN-MINDED**
We critically appreciate our own cultures and personal histories, as well as the values and traditions of others. We seek and evaluate a range of points of view, and we are willing to grow from the experience.

**CARING**
We show empathy, compassion and respect. We have a commitment to service, and we act to make a positive difference in the lives of others and in the world around us.

**RISK-TAKERS**
We approach uncertainty with forethought and determination; we work independently and cooperatively to explore new ideas and innovative strategies. We are resourceful and resilient in the face of challenges and change.

**BALANCED**
We understand the importance of balancing different aspects of our lives—intellectual, physical, and emotional—to achieve well-being for ourselves and others. We recognize our interdependence with other people and with the world in which we live.

**REFLECTIVE**
We thoughtfully consider the world and our own ideas and experience. We work to understand our strengths and weaknesses in order to support our learning and personal development.

The IB learner profile represents 10 attributes valued by IB World Schools. We believe these attributes, and others like them, can help individuals and groups become responsible members of local, national and global communities.
4.2 Standard Level (SL) and Higher Level (HL) Group 4 Courses

The PreIB Chemistry Course is designed to prepare you for the SL or HL Chemistry IB Diploma courses, however, regardless of what course you chose for group 4 (the Sciences, including Chemistry, Physics or Biology), they all have common ideas behind their organisation and are assessed using a similar format.

4.3 Group 4 aims

Through studying biology, chemistry or physics, students should become aware of how scientists work and communicate with each other. While the scientific method may take on a wide variety of forms, it is the emphasis on a practical approach through experimental work that characterizes these subjects.

The aims enable students, through the overarching theme of the Nature of science, to:

1. Appreciate scientific study and creativity within a global context through stimulating and challenging opportunities
2. Acquire a body of knowledge, methods and techniques that characterize science and technology
3. Apply and use a body of knowledge, methods and techniques that characterize science and technology
4. Develop an ability to analyse, evaluate and synthesize scientific information
5. Develop a critical awareness of the need for, and the value of, effective collaboration and communication during scientific activities
6. Develop experimental and investigative scientific skills including the use of current technologies
7. Develop and apply 21st century communication skills in the study of science
8. Become critically aware, as global citizens, of the ethical implications of using science and technology
9. Develop an appreciation of the possibilities and limitations of science and technology
10. Develop an understanding of the relationships between scientific disciplines and their influence on other areas of knowledge.

![Diagram of the scientific method]

**Figure 2**
Pathways to scientific discovery
Group 4 covers all of the sciences, but only the main sciences (Chemistry, Biology and Physics) are offered at most schools, including this one.

### 4.4 IB SL and HL Chemistry Syllabus outline

The last topic is the Organic topic, which will be covered in the second year, IB2, which is why it has been removed from the PreIB course.

<table>
<thead>
<tr>
<th>Syllabus component</th>
<th>Recommended teaching hours</th>
<th>SL</th>
<th>HL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Core</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Stoichiometric relationships</td>
<td>95</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Atomic structure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Periodicity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Chemical bonding and structure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Energetics/thermochemistry</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Chemical kinetics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Equilibrium</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Acids and bases</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Redox processes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Organic chemistry</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Measurement and data processing</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| **Additional higher level (AHL)**         |                           |     |     |
| 12. Atomic structure                      |                           | 2   |     |
| 13. The periodic table—the transition metals |                       | 4   |     |
| 14. Chemical bonding and structure        |                           | 7   |     |
| 15. Energetics/thermochemistry            |                           | 7   |     |
| 16. Chemical kinetics                     |                           | 6   |     |
| 17. Equilibrium                           |                           | 4   |     |
| 18. Acids and bases                       |                           | 10  |     |
| 19. Redox processes                       |                           | 6   |     |
| 20. Organic chemistry                     |                           | 12  |     |
| 21. Measurement and analysis              |                           | 2   |     |

<p>| <strong>Option</strong>                                |                           |     |     |
| A. Materials                              | 15                        | 25  |     |
| B. Biochemistry                           | 15                        | 25  |     |
| C. Energy                                 | 15                        | 25  |     |
| D. Medicinal chemistry                    | 15                        | 25  |     |</p>
<table>
<thead>
<tr>
<th>Syllabus component</th>
<th>SL</th>
<th>HL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Practical scheme of work</strong></td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>Practical activities</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>Individual investigation (internal assessment—IA)</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Group 4 project</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td><strong>Total teaching hours</strong></td>
<td>150</td>
<td>240</td>
</tr>
</tbody>
</table>

The recommended teaching time is 240 hours to complete HL courses and 150 hours to complete SL courses as stated in the document *General regulations: Diploma Programme* (2011) (page 4, Article 8.2).

**Distinction between SL and HL**

Group 4 students at standard level (SL) and higher level (HL) undertake a common core syllabus, a common internal assessment (IA) scheme and have some overlapping elements in the option studied. They are presented with a syllabus that encourages the development of certain skills, attributes and attitudes, as described in the “Assessment objectives” section of this guide.

While the skills and activities of group 4 science subjects are common to students at both SL and HL, students at HL are required to study some topics in greater depth, in the additional higher level (AHL) material and in the common options. The distinction between SL and HL is one of breadth and depth.

4.5 **IB Group 4 External Assessment Details SL Chemistry**

**Paper 1**

Duration: 3/4 hour
Weighting: 20%
Marks: 30
- 30 multiple-choice questions on core, about 15 of which are common with HL.
- The questions on paper 1 test assessment objectives 1, 2 and 3.
- The use of calculators is not permitted.
- Students will be provided with a periodic table.
- No marks are deducted for incorrect answers.

**Paper 2**

Duration: 1¼ hours
Weighting: 40%
Marks: 50
- Short-answer and extended-response questions on core material.
- The questions on paper 2 test assessment objectives 1, 2 and 3.
- The use of calculators is permitted. (See calculator section on the OCC.)
- A chemistry data booklet is to be provided by the school.
Paper 3
Duration: 1 hour
Weighting: 20%
Marks: 35
- This paper will have questions on core and SL option material.
- Section A: one data-based question and several short-answer questions on experimental work.
- Section B: short-answer and extended-response questions from one option.
- The questions on paper 3 test assessment objectives 1, 2 and 3.
- The use of calculators is permitted. (See calculator section on the OCC.)
- A chemistry data booklet is to be provided by the school.

Paper 1
Duration: 1 hour
Weighting: 20%
Marks: 40
- 40 multiple-choice questions on core and AHL, about 15 of which are common with SL.
- The questions on paper 1 test assessment objectives 1, 2 and 3.
- The use of calculators is not permitted.
- Students will be provided with a periodic table.
- No marks are deducted for incorrect answers.

Paper 2
Duration: 2½ hours
Weighting: 36%
Marks: 95
- Short-answer and extended-response questions on the core and AHL material.
- The questions on paper 2 test assessment objectives 1, 2 and 3.
- The use of calculators is permitted. (See calculator section on the OCC.)
- A chemistry data booklet is to be provided by the school.

Paper 3
Duration: 1¼ hours
Weighting: 24%
Marks: 45
- This paper will have questions on core, AHL and option material.
- Section A: one data-based question and several short-answer questions on experimental work.
- Section B: short-answer and extended-response questions from one option.
- The questions on paper 3 test assessment objectives 1, 2 and 3.
- The use of calculators is permitted. (See calculator section on the OCC.)
- A chemistry data booklet is to be provided by the school.
4.2 IB Group 4 Internal Assessment (IA)

If you add up all of the percentages for the External Assessment (which is the main exam at the end of 2 years) you will find that they only add up to 80%. The remainder, 20% for BOTH HL and SL, of your grade comes from an Internally Assessed component, which you complete during the 2 years in class and is graded by your teacher. It follows a very specific pattern of assessment that is easy once you are experienced in it, but can be very challenging if you haven’t been given enough practice.

Duration: 10 hours
Weighting: 20%

- Individual investigation
- This investigation covers assessment objectives 1, 2, 3 and 4.

Internal assessment criteria

The new assessment model uses five criteria to assess the final report of the individual investigation with the following raw marks and weightings assigned:

<table>
<thead>
<tr>
<th>Personal engagement</th>
<th>Exploration</th>
<th>Analysis</th>
<th>Evaluation</th>
<th>Communication</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 (8%)</td>
<td>6 (25%)</td>
<td>6 (25%)</td>
<td>6 (25%)</td>
<td>4 (17%)</td>
<td>24 (100%)</td>
</tr>
</tbody>
</table>

Each of the above criteria will be explored this year through practicals which will contribute towards your final PreIB grade.

4.3 Explaining the IB IA Assessment Criteria

Personal engagement

This criterion assesses the extent to which the student engages with the exploration and makes it their own. Personal engagement may be recognized in different attributes and skills. These could include addressing personal interests or showing evidence of independent thinking, creativity or initiative in the designing, implementation or presentation of the investigation.

<table>
<thead>
<tr>
<th>Mark</th>
<th>Descriptor</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>The student’s report does not reach a standard described by the descriptors below.</td>
</tr>
<tr>
<td>1</td>
<td>The evidence of personal engagement with the exploration is limited with little independent thinking, initiative or creativity. The justification given for choosing the research question and/or the topic under investigation does not demonstrate personal significance, interest or curiosity. There is little evidence of personal input and initiative in the designing, implementation or presentation of the investigation.</td>
</tr>
<tr>
<td>2</td>
<td>The evidence of personal engagement with the exploration is clear with significant independent thinking, initiative or creativity. The justification given for choosing the research question and/or the topic under investigation demonstrates personal significance, interest or curiosity. There is evidence of personal input and initiative in the designing, implementation or presentation of the investigation.</td>
</tr>
</tbody>
</table>
### Exploration

This criterion assesses the extent to which the student establishes the scientific context for the work, states a clear and focused research question and uses concepts and techniques appropriate to the Diploma Programme level. Where appropriate, this criterion also assesses awareness of safety, environmental, and ethical considerations.

<table>
<thead>
<tr>
<th>Mark</th>
<th>Descriptor</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>The student’s report does not reach a standard described by the descriptors below.</td>
</tr>
</tbody>
</table>
| 1–2  | The topic of the investigation is identified and a research question of some relevance is **stated but it is not focused**.  
The background information provided for the investigation is **superficial** or of limited relevance and does not aid the understanding of the context of the investigation.  
The methodology of the investigation is only appropriate to address the research question to a very limited extent since it takes into consideration few of the significant factors that may influence the relevance, reliability and sufficiency of the collected data.  
The report shows evidence of limited awareness of the significant safety, ethical or environmental issues that are **relevant to the methodology of the investigation**.* |
| 3–4  | The topic of the investigation is identified and a relevant but not fully focused research question is described.  
The background information provided for the investigation is mainly appropriate and relevant and aids the understanding of the context of the investigation.  
The methodology of the investigation is mainly appropriate to address the research question but has limitations since it takes into consideration only some of the significant factors that may influence the relevance, reliability and sufficiency of the collected data.  
The report shows evidence of some awareness of the significant safety, ethical or environmental issues that are **relevant to the methodology of the investigation**.* |
| 5–6  | The topic of the investigation is identified and a relevant and fully focused research question is clearly described.  
The background information provided for the investigation is entirely appropriate and relevant and enhances the understanding of the context of the investigation.  
The methodology of the investigation is highly appropriate to address the research question because it takes into consideration all, or nearly all, of the significant factors that may influence the relevance, reliability and sufficiency of the collected data.  
The report shows evidence of full awareness of the significant safety, ethical or environmental issues that are **relevant to the methodology of the investigation**.* |
Analysis
This criterion assesses the extent to which the student's report provides evidence that the student has selected, recorded, processed and **interpreted** the data in ways that are relevant to the research question and can support a conclusion.

<table>
<thead>
<tr>
<th>Mark</th>
<th>Descriptor</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>The student's report does not reach a standard described by the descriptors below.</td>
</tr>
</tbody>
</table>
| 1–2  | The report includes **insufficient relevant** raw data to support a valid conclusion to the research question.  
Some **basic** data processing is carried out but is either too **inaccurate or too insufficient to lead to a valid** conclusion.  
The report shows evidence of little consideration of the impact of measurement uncertainty on the analysis.  
The processed data is incorrectly or insufficiently interpreted so that the conclusion is invalid or very incomplete. |
| 3–4  | The report includes relevant but incomplete quantitative and qualitative raw data that could support a simple or partially valid conclusion to the research question.  
Appropriate and sufficient data processing is carried out that could lead to a broadly valid conclusion but there are significant inaccuracies and inconsistencies in the processing.  
The report shows evidence of some consideration of the impact of measurement uncertainty on the analysis.  
The processed data is interpreted so that a broadly valid but incomplete or limited conclusion to the research question can be deduced. |
| 5–6  | The report includes sufficient relevant quantitative and qualitative raw data that could support a detailed and valid conclusion to the research question.  
Appropriate and sufficient data processing is carried out with the **accuracy** required to enable a conclusion to the research question to be drawn that is fully **consistent** with the experimental data.  
The report shows evidence of full and appropriate consideration of the impact of measurement uncertainty on the analysis.  
The processed data is correctly interpreted so that a completely valid and detailed conclusion to the research question can be deduced. |
**Evaluation**

This criterion assesses the extent to which the student’s report provides evidence of evaluation of the investigation and the results with regard to the research question and the accepted scientific context.

<table>
<thead>
<tr>
<th>Mark</th>
<th>Descriptor</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>The student’s report does not reach a standard described by the descriptors below.</td>
</tr>
</tbody>
</table>
| 1–2  | A conclusion is **outlined** which is not relevant to the research question or is not supported by the data presented.  
The conclusion makes superficial comparison to the accepted scientific context.  
Strengths and weaknesses of the investigation, such as limitations of the data and sources of error, are **outlined** but are restricted to an account of the **practical** or **procedural issues** faced.  
The student has **outlined** very few realistic and relevant suggestions for the improvement and extension of the investigation. |
| 3–4  | A conclusion is **described** which is relevant to the research question and supported by the data presented.  
A conclusion is described which makes some relevant comparison to the accepted scientific context.  
Strengths and weaknesses of the investigation, such as limitations of the data and sources of error, are **described** and provide evidence of some awareness of the **methodological issues** involved in establishing the conclusion.  
The student has **described** some realistic and relevant suggestions for the improvement and extension of the investigation. |
| 5–6  | A detailed conclusion is **described and justified** which is entirely relevant to the research question and fully supported by the data presented.  
A conclusion is correctly **described and justified** through relevant comparison to the accepted scientific context.  
Strengths and weaknesses of the investigation, such as limitations of the data and sources of error, are **discussed** and provide evidence of a clear understanding of the **methodological issues** involved in establishing the conclusion.  
The student has **discussed** realistic and relevant suggestions for the improvement and extension of the investigation. |
**Communication**
This criterion assesses whether the investigation is presented and reported in a way that supports effective communication of the focus, process and outcomes.

<table>
<thead>
<tr>
<th>Mark</th>
<th>Descriptor</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>The student’s report does not reach a standard described by the descriptors below.</td>
</tr>
</tbody>
</table>
| 1–2  | **The presentation of the investigation is unclear, making it difficult to understand the focus, process and outcomes.**  
The report is not well structured and is unclear: the necessary information on focus, process and outcomes is missing or is presented in an incoherent or disorganized way.  
The understanding of the focus, process and outcomes of the investigation is obscured by the presence of inappropriate or irrelevant information.  
There are many errors in the use of subject specific terminology and conventions*. |
| 3–4  | **The presentation of the investigation is clear. Any errors do not hamper understanding of the focus, process and outcomes.**  
The report is well structured and clear: the necessary information on focus, process and outcomes is present and presented in a coherent way.  
The report is relevant and concise thereby facilitating a ready understanding of the focus, process and outcomes of the investigation.  
The use of subject specific terminology and conventions is appropriate and correct. Any errors do not hamper understanding. |
# Topic 1 Particulate Theory of Matter

## 5.1 End of Topic 1 Goals Checklist

For each topic you ought to try to do as many of the following things to get the most out of your time, the resources available to you and to help you grow as a student. Tick each goal off as you complete it. Growth is difficult and uncomfortable, but you should choose to do these things, and the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win!

<table>
<thead>
<tr>
<th>Aspect</th>
<th>What you should have done</th>
<th>Yes/No</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interacted with your teacher</td>
<td>Ask your teacher 1 question, about anything, once a week</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Try to answer one question asked by your teacher at least once a week</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Ask your teacher one question about something you do not understand in science once a week</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Ask your teacher one question about something to do with science every lesson</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td>Notes and follow up notes</td>
<td>Complete set of class note</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Attempted</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Completed</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Completed to an exemplary standard</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Attempted the Mind Map for this topic</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Completed the Mind Map for this topic</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td>Textbook</td>
<td>Read ahead before the topic has been started</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Highlighted key ideas and translate new words</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Completed the questions at the end of each 2 page spread in your exercise book</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Added to your class notes ideas and important information from the textbook that you learnt</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td>Past Exam Questions</td>
<td>Worked on at least 25% of the exam questions in this workbook</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Attempted more than 25% of the questions and those questions you have completed you have marked in a different colour pen</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Completed and marked all questions here</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Completed, marked and additional key ideas where you have located the most difficult marks added to your notebook</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Used the resources available online to answer additional questions not found in this workbook on the current topic.</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Ask your teacher about an exam question that they cannot answer</td>
<td></td>
<td>EXCEPTIONALLY SMASHING!!!</td>
</tr>
<tr>
<td>Assessed Activities</td>
<td>Complete the word list activity using the word list at the front of each topic as little as possible</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities, either in class or as homework</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 70% on average</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 80% on average</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 90% on average</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td>End of Topic Test</td>
<td>Revised sufficiently well to improve upon your score from the previous test (except if you are scoring over 90%, then just write Y for this goal)</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Scored 10% higher than your current average</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Scored 15% or more than your previous end of topic average</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Scored over 90%</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Scored over 95%</td>
<td></td>
<td>SMASHING!!!</td>
</tr>
<tr>
<td>Aspect</td>
<td>What you should have done</td>
<td>Yes/No</td>
<td>Level</td>
</tr>
<tr>
<td>------------</td>
<td>-------------------------------------------------------------------------------------------</td>
<td>--------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Reading</td>
<td>Spend more than 1 hour a week reading a book you enjoy (in any language) about anything.</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Spend more than 3 hours a week reading a book you enjoy (in any language) about anything.</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Spend more than 5 hours a week reading a book you enjoy (in any language) about anything.</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Spend at least one hour a week reading a book you enjoy in English about anything.</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Spend more than 3 hours a week reading a book you enjoy in English about anything.</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td>Reflection</td>
<td>You completed this goal setting table</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>You have looked at the goals you have achieved and the ones you have not and added them up and entered them into the table in the Review and Reflection section</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>You have given an answer for every question in the Review and Reflection section at the end of this topic</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>You have Given good and thoughtful answers for every question in the Review and Reflection section at the end of this topic</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
</tbody>
</table>

5.2 Topic 1 Syllabus

1 The particulate nature of matter

1.1 The particulate nature of matter

Core

- State the distinguishing properties of solids, liquids and gases
- Describe the structure of solids, liquids and gases in terms of particle separation, arrangement and types of motion
- Describe changes of state in terms of melting, boiling, evaporation, freezing, condensation and sublimation
- Describe qualitatively the pressure and temperature of a gas in terms of the motion of its particles
- Show an understanding of the random motion of particles in a suspension (sometimes known as Brownian motion) as evidence for the kinetic particle (atoms, molecules or ions) model of matter
- Describe and explain diffusion

Supplement

- Explain changes of state in terms of the kinetic theory
- Describe and explain Brownian motion in terms of random molecular bombardment
- State evidence for Brownian motion
- Describe and explain dependence of rate of diffusion on molecular mass
## 5.1 ESSENTIAL Glossary for Keywords for this topic

Many words used in science have a meaning that is slightly different to their common everyday English meaning, for instance a salt is the product of an acid and base reacting together in chemistry, but normally thought of as table salt (NaCl) in common use.

The keywords have been auto translated into Chinese, so the translations will not be perfect but they should hopefully make sense. If there is a better translation you can simply write it out yourself on a Post-it note and stick it over the printed one.

<table>
<thead>
<tr>
<th>Topic</th>
<th>English</th>
<th>Chinese</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>boiling a condition under which gas bubbles are able to form within a liquid – gas molecules escape from the body of a liquid, not just from its surface</td>
<td>沸腾在液体中能够形成气泡的条件下—气体分子从液体体内逸出，而不仅仅是从其表面逸出</td>
</tr>
<tr>
<td>1</td>
<td>boiling point the temperature at which a liquid boils, when the pressure of the gas created above the liquid equals atmospheric pressure</td>
<td>沸点，当在液体上方产生的气体压力等于大气压时·液体沸腾的温度</td>
</tr>
<tr>
<td>1</td>
<td>condensation the change of a vapour or a gas into a liquid; during this process heat is given out to the surroundings</td>
<td>将蒸气或气体的变化冷凝成液体；在此过程中，热量散发到周围环境中</td>
</tr>
<tr>
<td>1</td>
<td>diffusion the process by which different fluids mix as a result of the random motions of their particles</td>
<td>扩散由于粒子的随机运动而导致不同流体混合的过程</td>
</tr>
<tr>
<td>1</td>
<td>evaporation a process occurring at the surface of a liquid, involving the change of state from a liquid into a vapour at a temperature below the boiling point</td>
<td>蒸发一种在液体表面发生的过程，包括在低于沸点的温度下从液体状态转变为蒸气状态</td>
</tr>
<tr>
<td>1</td>
<td>fluid a gas or a liquid, they are able to flow</td>
<td>流体是气体或液体，它们能够流动</td>
</tr>
<tr>
<td>1</td>
<td>melting point the temperature at which a solid turns into a liquid – it has the same value as the freezing point; a pure substance has a sharp melting point</td>
<td>熔点固体变成液体的温度•它与凝固点的值相同；纯物质具有尖锐的熔点</td>
</tr>
<tr>
<td>1</td>
<td>physical change a change in the physical state of a substance or the physical nature of a situation that does not involve a change in the chemical substance(s) present</td>
<td>物理变化不涉及所存在化学物质变化的物质的物理状态变化或情况的物理性质变化</td>
</tr>
<tr>
<td>1</td>
<td>states of matter solid, liquid and gas are the three states of matter in which any substance can exist, depending on the conditions of temperature and pressure</td>
<td>固体，液体和气体的物质状态是可以存在任何物质的三种物质状态，具体取决于温度和压力的条件</td>
</tr>
<tr>
<td>1</td>
<td>sublimation the direct change of state from solid to gas or gas to solid: the liquid phase is bypassed</td>
<td>升华状态从固体到气体或从气体到固体的直接变化；绕过液相</td>
</tr>
</tbody>
</table>
5.1 ESSENTIAL EXAM QUESTIONS Paper 4 Topic 1 50marks

Q# 1/ IGCSE Chemistry/2015/s/Paper 31/ Q6

(c) Gases diffuse, which means that they move to occupy the total available volume.

(i) Explain, using kinetic particle theory, why gases diffuse.

(ii) When the colourless gases hydrogen bromide and ethylamine come into contact, a white solid is formed.

\[
\text{CH}_2\text{CH}_2\text{NH}_2(g) + \text{HBr}(g) \rightarrow \text{CH}_3\text{CH}_2\text{NH}_2\text{Br}(s) \quad \text{white solid}
\]

The following apparatus can be used to compare the rates of diffusion of the two gases ethylamine and hydrogen bromide.

Predict at which position, A, B or C, the white solid will form. Explain your choice.

Q# 2/ IGCSE Chemistry/2014/s/Paper 31/Q3 (c)

(iii) Suggest another method, other than diffusion, by which helium could be separated from the mixture of gases in natural gas.

Q# 3/ IGCSE Chemistry/2014/s/Paper 31/

3 (a) Different gases diffuse at different speeds.

(i) What is meant by the term diffusion?

(ii) What property of a gas molecule affects the speed at which it diffuses?
(b) Helium is a gas used to fill balloons. It is present in the air in very small quantities. Diffusion can be used to separate it from the air.

Air at 1000 °C is on one side of a porous barrier. The air which passes through the barrier has a larger amount of helium in it.

(i) Why does the air on the other side of the barrier contain more helium? .................................................................................................................................................... [1]

(ii) Why is it an advantage to have the air at a high temperature? .................................................................................................................................................................................. [1]

Q# 4/ IGCSE Chemistry/2012/w/Paper 31/

7 Both strontium and sulfur have chlorides of the type XCl₂. The table below compares some of their properties.

<table>
<thead>
<tr>
<th></th>
<th>strontium chloride</th>
<th>sulfur chloride</th>
</tr>
</thead>
<tbody>
<tr>
<td>appearance</td>
<td>white crystals</td>
<td>red liquid</td>
</tr>
<tr>
<td>formula</td>
<td>SrCl₂</td>
<td>SCl₂</td>
</tr>
<tr>
<td>melting point/°C</td>
<td>874</td>
<td>-120</td>
</tr>
<tr>
<td>boiling point/°C</td>
<td>1250</td>
<td>59</td>
</tr>
<tr>
<td>conductivity of liquid</td>
<td>good</td>
<td>poor</td>
</tr>
<tr>
<td>solubility in water</td>
<td>dissolves to form a neutral solution</td>
<td>reacts to form a solution of pH 1</td>
</tr>
</tbody>
</table>

(a) (i) Use the data in the table to explain why sulfur chloride is a liquid at room temperature, 25 °C. .................................................................................................................................................... [2]

Q# 5/ IGCSE Chemistry/2010/s/Paper 31/

2 Ozone is a form of oxygen. Ozone is present in the upper atmosphere and it prevents dangerous solar radiation from reaching the Earth's surface. Some of the chemicals that diffuse into the upper atmosphere decompose ozone. Chemicals that have this effect are methane (CH₄), chloromethane (CH₂Cl) and an oxide of nitrogen (NO₂).

(i) Which of these three chemicals diffuses the most slowly? Give a reason for your choice. .............................................................................................................................................................................. [2]
2. The table shows the melting points, boiling points and electrical properties of the six substances A to F.

<table>
<thead>
<tr>
<th>substance</th>
<th>melting point / °C</th>
<th>boiling point / °C</th>
<th>electrical conductor at room temperature</th>
<th>electrical conductor of substance dissolved in water</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>961</td>
<td>2193</td>
<td>good</td>
<td>does not dissolve</td>
</tr>
<tr>
<td>B</td>
<td>113</td>
<td>444</td>
<td>does not conduct</td>
<td>does not dissolve</td>
</tr>
<tr>
<td>C</td>
<td>0</td>
<td>100</td>
<td>very poor</td>
<td>very poor</td>
</tr>
<tr>
<td>D</td>
<td>803</td>
<td>1465</td>
<td>does not conduct</td>
<td>good</td>
</tr>
<tr>
<td>E</td>
<td>−5 to -10</td>
<td>102 to 105</td>
<td>good</td>
<td>good</td>
</tr>
<tr>
<td>F</td>
<td>−85</td>
<td>−60</td>
<td>does not conduct</td>
<td>does not dissolve</td>
</tr>
</tbody>
</table>

(i) Which three substances are solids at room temperature? [1]

(iii) Which one is a gas at room temperature? [1]

(iv) Which two substances are liquids at room temperature? [1]
2 Ethanoic acid is a colourless liquid at room temperature. It has the typical acid properties and forms compounds called ethanoates.

(a) A pure sample of ethanoic acid is slowly heated from 0°C to 150°C and its temperature is measured every minute. The results are represented on the graph below.

(i) Name the change that occurs in the region D to E.

.......................................................................................................................................................... [1]

(ii) What would be the difference in the region B to C if an impure sample had been used?

.......................................................................................................................................................... [1]

(iii) Sketch on the graph how the line would continue if the acid was heated to a higher temperature. [1]
(iv) Complete the following table that compares the separation and movement of the molecules in regions C to D with those in E to F.

<table>
<thead>
<tr>
<th></th>
<th>C to D</th>
<th>E to F</th>
</tr>
</thead>
<tbody>
<tr>
<td>separation (distance</td>
<td>...............................................</td>
<td>...............................................</td>
</tr>
<tr>
<td>between particles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>movement of particles</td>
<td>random and slow</td>
<td></td>
</tr>
<tr>
<td>Can particles move</td>
<td>...............................................</td>
<td>...............................................</td>
</tr>
<tr>
<td>apart to fill any</td>
<td></td>
<td></td>
</tr>
<tr>
<td>volume?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q# 8/ iGCSE Chemistry/2005/s/Paper 3/ Q/GCSE Chemistry/201

(d) Traces of chlorine can be separated from bromine vapour by diffusion. Which gas would diffuse the faster and why?

.............................................................................................................................................. [2]

Q# 9/ iGCSE Chemistry/2003/w/Paper 3/

4 Esters occur naturally in plants and animals. They are manufactured from petroleum. Ethyl ethanoate and butyl ethanoate are industrially important as solvents.

(a) (i) Explain the term solvent.

..............................................................................................................................................[1]

Q# 10/ iGCSE Chemistry/2003/s/Paper 3/ Q4

(b) When nitrogen dioxide is cooled, it forms a yellow liquid and then pale yellow crystals. These crystals are heated and the temperature is measured every minute. The following graph can be drawn.
(i) Describe the arrangement and movement of the molecules in the region A–B.

(ii) Name the change that occurs in the region B–C

Q# 11/ iGCSE Chemistry/2002/s/Paper 3/
5  (a) The Kinetic Theory explains the properties of solids, liquids and gases in terms of the movement of particles.

Liquids and gases both take up the shape of the container but a gas always fills the container. Explain this, using the ideas of the Kinetic Theory.

liquid

gas

does not fill container but has shape of bottom of container

fills container
(b) The following apparatus can be used to measure the rate of diffusion of a gas.

metal foil, gas escapes through small hole in foil

costant pressure applied
gas syringe
gas

(i) What measurements would need to be taken to calculate the rate of diffusion of a gas? [2]

(ii) Which gas, carbon dioxide or sulphur dioxide, would diffuse faster? Explain your choice. [3]

5.1.1 ESSENTIAL EXAM QUESTIONS Paper 4 Topic 1 50marks Mark Scheme

Q# 1/ IGCSE Chemistry/2015/s/Paper 31/Q3c

<table>
<thead>
<tr>
<th>6(c)(i)</th>
<th>Any two from: (partides move in) random motion; (partides) collide; (partides) move from a region of high concentration to low concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A alternative phrases for collide A down a concentration gradient</td>
</tr>
<tr>
<td>6(c)(i)</td>
<td>C: M2 it has a lower (relative) molecular mass (than HBr); M3 ethylamine diffuses faster (than HBr);</td>
</tr>
<tr>
<td></td>
<td>A ethylamine is less dense A ethylamine is a lighter molecule but 1 ethylamine is lighter 1 ethylamine is a smaller molecule A ethylamine molecules or particles move faster</td>
</tr>
<tr>
<td></td>
<td>A ECF for M2 and M3 if A is given e.g. HBr diffuses faster for M3 because it is a lighter molecule for M2 A ECF for M2 if B is given e.g. they diffuse at same rate for M3 because molecules weigh the same for M2</td>
</tr>
</tbody>
</table>

Q# 2/ IGCSE Chemistry/2014/s/Paper 31/Q3c

(iii) fractional distillation (1)

Q# 3/ IGCSE Chemistry/2014/s/Paper 31/31

3 (a) (i) (particles) spread to fill total available volume / move from high concentration to low concentration / moves down a concentration gradient (1)

(ii) mass or \(M\) (1)

(b) (i) helium atoms / molecules are lighter than molecules in air or \(N_2\) and \(O_2\), or helium is less dense than air or \(N_2\) and \(O_2\). or helium diffuses (through the porous barrier) faster than air or \(N_2\) and \(O_2\). (1)

(ii) faster rate of diffusion / molecules move faster (at high temperatures). (1)
Q# 6/ IGCSE Chemistry/2006/w/Paper 3/

2 More than required number of answers – [0]
   (i) A, B, D
   (ii) D
   (iii) F
   (iv) C and E
   (v) A
   (vi) E

(a)(i) boiling

   (ii) lower temperature or
        over temperature range or no plateau

   (iii) direct continuation of E to F

   (iv) close or touching far apart
        fast and random
        cannot move apart can move apart

Q# 7/ IGCSE Chemistry/2005/s/Paper 3/ QI

Q# 8/ IGCSE Chemistry/2002/s/Paper 3/Q5 (a)

Particles are free to move in both liquids and gases, so they can change their shape;
In a gas, there are no bonds between particles, so they are free to assume the volume of the container
In a liquid the particles are connected together by bonds, so can only change their shape, not their volume
Total 4 marks
5 (b) (i)
Time taken
For volume to decrease 2 marks

(ii) Carbon dioxide
Because it has a Mr of 44, SO₂ has an Mr of 64
Molecules with smaller mass diffuse more quickly
3 marks

5.1 Essential End of Topic 1 Review and Reflection
Looking at the goals you could have achieved and the goals you actually achieved try to reflect on your progress.

Try to be as honest and as detailed as possible. Sometimes you may think you have thought about an idea well, but when you talk with someone else, or write it out, it helps you better understand and allows you think more completely and more clearly.

Did you achieve more goals this topic than last topic?

Fill in this table

<table>
<thead>
<tr>
<th>Level</th>
<th>Number of goals achieved at each level</th>
<th>Success rate, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>FUNDAMENTAL</td>
<td></td>
<td>/5</td>
</tr>
<tr>
<td>ESSENTIAL</td>
<td></td>
<td>/10</td>
</tr>
<tr>
<td>EXTENSION</td>
<td></td>
<td>/13</td>
</tr>
<tr>
<td>EXCEPTIONAL</td>
<td></td>
<td>/10</td>
</tr>
</tbody>
</table>

Do you feel you tired harder? If yes, what helped you to do so? If not, why not?

What could you do differently next time, in addition to what you are already doing to improve, not only your score in the end of topic tests and other assessed activities, but also in how you learn. How could you become a more effective student to get more learning out of the time you are investing in your studies?

What did you enjoy most about this topic?

What did you find most difficult?

What did you find easiest?

On a scale of 1 being hardest and 5 being most difficult, circle how challenging you found this topic

1  2  3  4  5

What could be done to make this topic easier to understand?

Do you have any questions about this topic?
### 6.1 End of Topic 2 Goals Checklist

For each topic you ought to try to do as many of the following things to get the most out of your time, the resources available to you and to help you grow as a student. Tick each goal off as you complete it. Growth is difficult and uncomfortable, but you should choose to do these things, and the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win!

<table>
<thead>
<tr>
<th>Aspect</th>
<th>What you should have done</th>
<th>Yes/No</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interacted with your teacher</td>
<td>Ask your teacher 1 question, about anything, once a week</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Try to answer one question asked by your teacher at least once a week</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Ask your teacher one question about something you do not understand in science once a week</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Ask your teacher one question about something to do with science every lesson</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td>Notes and follow up notes</td>
<td>Complete set of class note</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Attempted</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Completed</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Completed to an exemplary standard</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Attempted the Mind Map for this topic</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Completed the Mind Map for this topic</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td>Textbook</td>
<td>Read ahead before the topic has been started</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Highlighted key ideas and translate new words</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Completed the questions at the end of each 2 page spread in your exercise book</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Added to your class notes ideas and important information from the textbook that you learnt</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td>Past Exam Questions</td>
<td>Worked on at least 25% of the exam questions in this workbook</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Attempted more than 25% of the questions and those questions you have completed in a different colour pen</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Completed and marked all questions here</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Completed, marked and additional key ideas where you have located the most difficult marks added to your notebook</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Used the resources available online to answer additional questions not found in this workbook on the current topic.</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Ask your teacher about an exam question that they cannot answer</td>
<td></td>
<td>EXCEPTIONALLY SMASHING!!!</td>
</tr>
<tr>
<td>Assessed Activities</td>
<td>Complete the word list activity using the word list at the front of each topic as little as possible</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities, either in class or as homework</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 70% on average</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 80% on average</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 90% on average</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td>End of Topic Test</td>
<td>Revised sufficiently well to improve upon your score from the previous test (except if you are scoring over 90%, then just write Y for this goal)</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Scored 10% higher than your current average</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Scored 15% or more than your previous end of topic average</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Scored over 90%</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Scored over 95%</td>
<td></td>
<td>SMASHING!!!</td>
</tr>
<tr>
<td>Aspect</td>
<td>What you should have done</td>
<td>Yes/No</td>
<td>Level</td>
</tr>
<tr>
<td>--------</td>
<td>--------------------------</td>
<td>--------</td>
<td>-------------</td>
</tr>
<tr>
<td>Reading</td>
<td>Spend more than 1 hour a week reading a book <strong>you enjoy</strong> (in any language) about anything.</td>
<td>ESSENTIAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spend more than 3 hours a week reading a book <strong>you enjoy</strong> (in any language) about anything.</td>
<td>EXTENSION</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spend more than 5 hours a week reading a book <strong>you enjoy</strong> (in any language) about anything.</td>
<td>EXCEPTIONAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spend at least one hour a week reading a book <strong>you enjoy</strong> in English about anything.</td>
<td>EXTENSION</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spend more than 3 hours a week reading a book <strong>you enjoy</strong> in English about anything.</td>
<td>EXCEPTIONAL</td>
<td></td>
</tr>
<tr>
<td>Reflection</td>
<td>You completed this goal setting table</td>
<td>FUNDAMENTAL</td>
<td></td>
</tr>
</tbody>
</table>
### ESSENTIAL Glossary for Keywords for this topic

Many words used in science have a meaning that is slightly different to their common everyday English meaning, for instance a salt is the product of an acid and base reacting together in chemistry, but normally thought of as table salt (NaCl) in common use.

The keywords have been auto translated into Chinese, so the translations will not be perfect but they should hopefully make sense. If there is a better translation you can simply write it out yourself on a Post-it note and stick it over the printed one.

<table>
<thead>
<tr>
<th>English</th>
<th>Chinese</th>
</tr>
</thead>
<tbody>
<tr>
<td>chromatogram</td>
<td>纸质色谱分析结果的色谱图；显示了样品斑点移至的位置</td>
</tr>
<tr>
<td>chromatography</td>
<td>色谱法一种用于分离溶解物质混合物的技术；该技术最初用于分离有色染料</td>
</tr>
<tr>
<td>crystallisation</td>
<td>结晶从饱和溶液中形成晶体的过程</td>
</tr>
<tr>
<td>decanting</td>
<td>通过仔细倾倒，倾析从沉降的固体或不混溶的较重液体中除去液体的过程</td>
</tr>
<tr>
<td>distillation</td>
<td>蒸馏过程：将液体煮沸，然后将产生的蒸气冷凝回液体中：用于纯化液体并将液体与溶液分离</td>
</tr>
<tr>
<td>downward delivery</td>
<td>向下输送一种向下收集气体的方法；该方法将比空气更浓的气体向下传送到一个煤气罐中</td>
</tr>
<tr>
<td>filtrate</td>
<td>过滤在过滤过程中通过滤纸的液体</td>
</tr>
<tr>
<td>filtration</td>
<td>使用不允许固体通过的细滤纸过滤从液体中分离出的固体</td>
</tr>
<tr>
<td>fractional distillation</td>
<td>分馏通过分馏塔进行蒸馏的方法；用于分离沸点不同的液体</td>
</tr>
<tr>
<td>insoluble</td>
<td>不溶性术语；描述了不溶于溶剂的物质</td>
</tr>
<tr>
<td>locating agent</td>
<td>定位剂一种化合物；它与色谱分离的无色无色斑点反应；生成有色产物；可以看到</td>
</tr>
<tr>
<td>mixture</td>
<td>混合两种或多种可以通过物理方式分离的物质的系统</td>
</tr>
<tr>
<td>pure substance</td>
<td>纯物质是一种化学元素或化合物–在一定温度下会熔化并沸腾</td>
</tr>
<tr>
<td>residue</td>
<td>过滤后残留在滤纸中的固体残留物</td>
</tr>
<tr>
<td>( R_f ) value</td>
<td>色谱中的( R_f )值；溶质行进距离与溶剂前沿行进距离之比</td>
</tr>
<tr>
<td>risk assessment</td>
<td>风险评估：对特定实验中使用的方法和化学物质的评估；以了解可能涉及的安全问题</td>
</tr>
<tr>
<td>saturated solution</td>
<td>饱和溶液在特定温度下包含尽可能多的溶解溶质的溶液</td>
</tr>
</tbody>
</table>
### English

<table>
<thead>
<tr>
<th>Solubility</th>
<th>A measure of how much of a solute dissolves in a solvent at a particular temperature</th>
<th>溶解度，用于衡量在特定温度下有多少溶质溶解在溶剂中</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soluble</td>
<td>Term that describes a solute that dissolves in a particular solvent</td>
<td>可溶术语，描述了溶解在特定溶剂中的溶质</td>
</tr>
<tr>
<td>Solute</td>
<td>The solid substance that has dissolved in a liquid (the solvent) to form a solution</td>
<td>溶解溶解在液体（溶剂）中的固体物质以形成溶液</td>
</tr>
<tr>
<td>Solution</td>
<td>Formed when a substance (solute) dissolves into another substance (solvent)</td>
<td>当一种物质（溶质）溶于另一种物质（溶剂）时形成的溶液</td>
</tr>
<tr>
<td>Solvent Front</td>
<td>The moving boundary of the liquid solvent that moves up the paper during chromatography</td>
<td>溶剂在色谱分析过程中沿纸向上移动的液体溶剂的移动边界的前面</td>
</tr>
<tr>
<td>Solvent</td>
<td>The liquid that dissolves the solid solute to form a solution; water is the most common solvent but liquids in organic chemistry that can act as solvents are called organic solvents</td>
<td>溶解溶解固体溶质形成溶液的液体；水是最常见的溶剂，但有机化学中可以用作溶剂的液体称为有机溶剂</td>
</tr>
<tr>
<td>Upward Delivery</td>
<td>A method of collecting a gas that is lighter than air by passing it upwards into an inverted gas jar</td>
<td>向上输送一种向上收集气体的方法，该方法是将比空气轻的气体向上传递到倒置的煤气罐中</td>
</tr>
</tbody>
</table>

### 6.4 EXTENSION Keywords

Using your textbook find out what each of these words means and write it in English, then give an example and translate.

<table>
<thead>
<tr>
<th>Topic #</th>
<th>English</th>
<th>Example</th>
<th>Chinese Translation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Hazard</td>
<td>Any situation or practical that includes risks that need to be carefully managed to perform that experiment safely for you and your classmates</td>
<td>水平放置于长条形玻璃器皿中，该方法是将比空气轻的气体向上传递到倒置的煤气罐中</td>
</tr>
<tr>
<td>2</td>
<td>Corrosive</td>
<td></td>
<td>燃烧</td>
</tr>
<tr>
<td>2</td>
<td>Irritant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Harmful</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Flammable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Poisonous</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Explosive</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Extension activity: State and explain which of these hazards is most dangerous in the space below

---

### EXTENSION Activity 1 WS Safety in the Lab

Find the danger and create a rule to stop it

<table>
<thead>
<tr>
<th>Where the problem is</th>
<th>What could happen as a result?</th>
<th>Write a rule to prevent this danger from causing harm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Student could transfer harmful chemicals on the bench to his food with his hands</td>
<td>Never eat or drink in a lab!</td>
</tr>
</tbody>
</table>

A
B
C
D
E
F
G
H
I
J
K
L
M
6.6 ESSENTIAL Activity 2 Hazard Symbols

Hazard symbols are used across the world as a way to keep everyone safer. They use pictures instead of words so they can be understood by everyone, but **before you can be safe in a lab you MUST learn these.**

Link the hazard symbols to the correct label and description.

<table>
<thead>
<tr>
<th>Old hazard symbol</th>
<th>New hazard symbol</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Corrosive" /></td>
<td><img src="image" alt="Corrosive" /></td>
<td>Corrosive</td>
<td>This may dissolve or burn materials, including skin</td>
</tr>
<tr>
<td><img src="image" alt="Health hazard" /></td>
<td><img src="image" alt="Health hazard" /></td>
<td>Health hazard (Harmful)</td>
<td>This includes irritants, harmful substances, and some low-hazard substances</td>
</tr>
<tr>
<td><img src="image" alt="Explosive" /></td>
<td><img src="image" alt="Explosive" /></td>
<td>Explosive</td>
<td>This contains dangerous organisms such as bacteria</td>
</tr>
<tr>
<td><img src="image" alt="Flammable" /></td>
<td><img src="image" alt="Flammable" /></td>
<td>Flammable</td>
<td>This can be poisonous and possibly deadly</td>
</tr>
<tr>
<td><img src="image" alt="Toxic" /></td>
<td><img src="image" alt="Toxic" /></td>
<td>Toxic</td>
<td>This may explode</td>
</tr>
<tr>
<td><img src="image" alt="Caution" /></td>
<td><img src="image" alt="Caution" /></td>
<td>Caution (Irritant)</td>
<td>This can catch fire easily</td>
</tr>
</tbody>
</table>

6.7 ESSENTIAL Activity 3 Laboratory apparatus

Apparatus is a scientific name for equipment. Use the list below to label this equipment.
<table>
<thead>
<tr>
<th>(Round bottom) flask</th>
<th>Stirring rod</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burette</td>
<td>Teat pipette</td>
</tr>
<tr>
<td>Clamp stand</td>
<td>Test tube brush</td>
</tr>
<tr>
<td>Conical flask</td>
<td>Test tube holder</td>
</tr>
<tr>
<td>Evaporating basin</td>
<td>Test tube rack</td>
</tr>
<tr>
<td>Funnel</td>
<td>Thermometer</td>
</tr>
<tr>
<td>Glass beaker</td>
<td>Tongs</td>
</tr>
<tr>
<td>Heat proof gauze</td>
<td>Tripod and Bunsen burner</td>
</tr>
<tr>
<td>Measuring cylinder</td>
<td>Volumetric flask</td>
</tr>
<tr>
<td>Mortar</td>
<td>Volumetric pipette</td>
</tr>
<tr>
<td>Pistil</td>
<td>Wash bottle (filled with distilled water)</td>
</tr>
<tr>
<td>Spatula</td>
<td></td>
</tr>
</tbody>
</table>
6.8 ESSENTIAL EXAM QUESTIONS Paper 2 Topic 2 11marks

Q# 1/ iGCSE Chemistry/2018/w/Paper 21/

2 The diagrams show four pieces of laboratory equipment.

![balance](image1.png)  ![pipette](image2.png)  ![stop-clock](image3.png)  ![thermometer](image4.png)

Which equipment is essential to find out if dissolving a salt in water is an exothermic process?

<table>
<thead>
<tr>
<th></th>
<th>balance</th>
<th>pipette</th>
<th>stop-clock</th>
<th>thermometer</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>B</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>C</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>D</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
</tr>
</tbody>
</table>

Q# 2/ iGCSE Chemistry/2018/s/Paper 23/

2 Paper chromatography is done in the same way with three different mixtures of dyes. Each mixture contains at least one of the dyes W, X, Y and Z.

The \( R_f \) values of the dyes in the three mixtures are shown.

<table>
<thead>
<tr>
<th>dye</th>
<th>( R_f ) values from mixture 1</th>
<th>( R_f ) values from mixture 2</th>
<th>( R_f ) values from mixture 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td>X</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Y</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>Z</td>
<td>0.00</td>
<td>0.91</td>
<td>0.91</td>
</tr>
</tbody>
</table>

Which conclusion is correct?

A Dye W is nearest the solvent front and is present only in mixture 1 and mixture 3.
B Dye X has travelled furthest up the chromatography paper.
C Dye Y is the only dye present in all three mixtures.
D Dye Z is nearest the solvent front and is found in only two of the mixtures.
3. Solid R reacted with dilute sulfuric acid.

The initial temperature of the dilute sulfuric acid and the final temperature of the solution are shown.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

Initial temperature of the dilute sulfuric acid (°C) | Final temperature of the solution (°C)

What was the change in temperature in °C?

A. -6  
B. -4  
C. 4  
D. 6

Q# 3/ IGCSE Chemistry/2018/s/Paper 22/

2. A chromatography experiment was done to separate a mixture of four substances.

The Rₚ values measured for these substances were 0.3, 0.5, 0.8 and 0.8.

Which diagram shows the chromatogram obtained?

3. Which piece of apparatus cannot be used to collect and measure the volume of gas produced in an experiment?

A. burette  
B. gas syringe  
C. measuring cylinder  
D. pipette
1 A student investigated the diffusion of ammonia gas, NH₃, and hydrogen chloride gas, HCl.

Two sets of apparatus were set up as shown at room temperature and pressure.

![Apparatus](image)

The damp red litmus paper in apparatus 1 changed colour after 30 seconds.

How long does it take for the damp blue litmus paper to change colour in apparatus 2?

A 64 seconds  
B 30 seconds  
C 21 seconds  
D The blue litmus paper would not change colour.

2 Chromatography is a technique used to separate coloured dyes.

Which dye has an Rf value of 0.7?

![Chromatogram](image)

3 Which piece of apparatus is used to measure exactly 26.3 cm³ of a liquid?

![Apparatus](image)
Q# 5/ iGCSE Chemistry/2018/m/Paper 22/

2 Which method should be used to separate a mixture of two liquids?
   A crystallisation
   B electrolysis
   C filtration
   D fractional distillation

3 Lead(II) iodide is insoluble in water.
   Lead(II) iodide is made by adding aqueous lead(II) nitrate to aqueous potassium iodide.
   Which pieces of apparatus are needed to obtain solid lead(II) iodide from 20 cm³ of aqueous lead(II) nitrate?
   A 1, 2 and 4   B 1, 3 and 5   C 1, 4 and 5   D 2, 4 and 5

4 The chromatogram of substance S is shown.
   Some distances, W, X, Y and Z, are labelled on the diagram.
   How is the $R_f$ value of substance S calculated?
   A $\frac{X}{Y}$  B $\frac{W}{Z}$  C $\frac{Y}{X}$  D $\frac{Y}{W}$
6.8.1 ESSENTIAL EXAM QUESTIONS Paper 2 T2 11marks Mark Scheme

<table>
<thead>
<tr>
<th>Q# 1/ iGCSE Chemistry/2018/w/Paper 21/</th>
<th>Q# 4/ iGCSE Chemistry/2018/s/Paper 21/</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>A</td>
</tr>
<tr>
<td>3</td>
<td>A</td>
</tr>
</tbody>
</table>

6.9 ESSENTIAL EXAM QUESTIONS Paper 6 Labelling Equipment and Understanding Experiments

iGCSE EQ 18w to 16m Labelling Equipment and Understanding Experiments 66marks

Q# 2/ iGCSE Chemistry/2018/w/Paper 62/Q1

1 A sample of copper was prepared from lumps of copper(II) carbonate. The first step was to make a solution of copper(II) nitrate as shown. Carbon dioxide was produced.

![Diagram showing the preparation of copper(II) nitrate from copper(II) carbonate.]

(a) Complete the boxes to name the apparatus. [2]

1 Magnesium ribbon was burned in air.

![Diagram showing the burning of magnesium ribbon in air.]

(a) Complete the box to name the apparatus. [1]

(f) State one safety precaution that should be taken when magnesium is burned in air.
1 A student obtains pure, dry samples of sand and sodium chloride from a mixture of sand and sodium chloride. The student uses the apparatus shown. The method consists of six steps, A, B, C, D, E and F, which are shown in the wrong order.

(a) Order the steps in the method.

A → ........ → ........ → ........ → ........ → ........ [2]

(b) Complete the box to name the apparatus in D. [1]

(c) Why is the sand rinsed with water in B?

................................................................................................................. [1]

(d) Name the process in F. [1]

................................................................................................................. [1]

(e) How could the purity of the sodium chloride obtained be checked? [1]
Q# 4/ iGCSE Chemistry/2018/s/Paper 63/Q1
1 Zinc sulfate crystals are hydrated. They contain water of crystallisation. A student did an experiment to find the mass of water in hydrated zinc sulfate crystals. The hydrated zinc sulfate crystals were weighed and then heated with a Bunsen burner to remove the water as shown.

(a) (i) Name the apparatus used to weigh the crystals in A.
......................................................................................................................... [1]

(ii) Complete the box to name the apparatus.
......................................................................................................................... [1]

Q# 5/ iGCSE Chemistry/2018/s/Paper 62/Q1
1 The rate of reaction between an excess of dilute nitric acid and powdered calcium carbonate was investigated. The carbon dioxide produced was collected. The apparatus used is shown.

(a) Complete the box to name the apparatus. [1]
Q# 6/ iGCSE Chemistry/2018/s/Paper 61/Q1
1 The volume of dilute nitric acid that reacts with 25.0 cm³ of aqueous potassium hydroxide can be found by titration using the apparatus shown.

(a) Complete the box to name the apparatus. [1]

Q# 7/ iGCSE Chemistry/2018/m/Paper 62/Q1
1 A student used paper chromatography to separate a mixture of coloured dyes. The diagram shows the apparatus used.

(a) (i) Draw a line on the diagram to show the level of the solvent. [1]

(ii) Suggest a suitable solvent that could be used. [1]

(b) What could be used to put the mixture of coloured dyes onto the paper? [1]
(c) The clips hold the paper in position.

Why is this important for the chromatography experiment?

The diagram shows the chromatogram obtained from four dyes, A, B, C and D.

(d) Give one conclusion that can be drawn about dye B.

(e) Suggest why dye C remained on the baseline.

(f) $R_t$ values are used to identify compounds.

\[ R_t = \frac{\text{distance travelled by the compound}}{\text{distance travelled by the solvent}} \]

Calculate the $R_t$ value of dye A.

\[ R_t = \ldots \]  

[Total: 8]
Q# 8/ iGCSE Chemistry/2017/w/Paper 63/Q1

1 Cerussite is a lead ore which contains lead(II) carbonate. A student obtained a solution of lead(II) nitrate from cerussite using the apparatus shown.

(a) Complete the boxes to name the apparatus. [2]

(b) Why was the cerussite crushed in step 1? [1]

(d) What is the general name given to an insoluble solid left on a filter paper after filtration? [1]

Q# 9/ iGCSE Chemistry/2017/w/Paper 61/Q1

1 A student reacted dilute hydrochloric acid with zinc oxide to prepare zinc chloride solution. The diagram shows part of the procedure.

(a) Complete the box to name the apparatus. [1]
(b) Which of the reactants was in excess?

......................................................................................................................... [1]

(c) (i) Name the separation process this apparatus is used for.

......................................................................................................................... [1]

(ii) Suggest why this apparatus would not work.

......................................................................................................................... [1]

Q# 10/ iGCSE Chemistry/2017/s/Paper 63/Q1

A mixture of alcohols can be separated by fractional distillation. The apparatus shown was used to separate ethanol from the mixture.

(a) (i) Complete the box to identify the apparatus. [1]

(ii) Indicate with an arrow where heat is applied. [1]

(b) What is the purpose of the water?

......................................................................................................................... [2]

(c) Why is the thermometer bulb placed as shown and not in the mixture of alcohols?

......................................................................................................................... [1]

(d) Use the letter E to indicate on the diagram where ethanol would collect. [1]

(e) (ii) Give a physical test to identify pure ethanol.

......................................................................................................................... [1]
Q# 11/ iGCSE Chemistry/2017/s/Paper 62/Q1

1 A student investigated the rate of reaction between an excess of dilute hydrochloric acid and magnesium ribbon. The apparatus is shown.

Two experiments were carried out. The temperature was the same in each case.

(a) Complete the boxes to identify the apparatus. [2]

Q# 12/ iGCSE Chemistry/2017/s/Paper 61/Q1

1 A student prepared strontium nitrate crystals.

The diagram shows some of the stages in this preparation.

(a) (i) Complete the box to identify the apparatus. [1]

(ii) What is used to add the strontium carbonate to the acid in stage 1? [1]
Q# 13/ iGCSE Chemistry/2016/w/Paper 62/Q1

1) This question is about the separation of mixtures. The diagram shows four sets of apparatus that can be used to separate mixtures.

(a) Complete the boxes to name the apparatus.

(b) The table shows four different mixtures.

Complete the table to show which set of apparatus should be used to obtain the substance listed. The first one has been completed for you. Each set of apparatus can be used once, more than once or not at all.

<table>
<thead>
<tr>
<th>mixture</th>
<th>to obtain</th>
<th>use apparatus</th>
</tr>
</thead>
<tbody>
<tr>
<td>petroleum and water</td>
<td>petroleum</td>
<td>B</td>
</tr>
<tr>
<td>sodium chloride dissolved in water</td>
<td>sodium chloride crystals</td>
<td>.........................</td>
</tr>
<tr>
<td>sodium chloride dissolved in water</td>
<td>water</td>
<td>.........................</td>
</tr>
<tr>
<td>insoluble silver chloride and water</td>
<td>silver chloride</td>
<td>.........................</td>
</tr>
</tbody>
</table>

(c) Put a ring around the separation method that should be used to separate a mixture of coloured dyes.

centrifugation chromatography condensation evaporation

[2]

[3]
Q# 14/ iGCSE Chemistry/2016/s/Paper 63/Q1

1 Air is a mixture of gases. The diagram shows the apparatus used to find the percentage of oxygen in air. 50 cm³ of air were passed backwards and forwards over excess heated copper until there was no further change. The apparatus was left to cool and the volume of gas remaining was 40 cm³.

(a) Complete the box to name the apparatus. [1]

(b) Use an arrow to indicate where heat is applied. [1]

Q# 15/ iGCSE Chemistry/2016/s/Paper 62/Q1

1 The diagram shows the apparatus used to reduce copper(II) oxide with hydrogen.

(a) Complete the boxes to name the apparatus. [2]

(d) Suggest a reason why the U-tube is surrounded by ice. [1]
(e) The colourless liquid is water

(iii) How could you show that this liquid is pure?

Q# 16/ iGCSE Chemistry/2016/s/Paper 61/Q1

1 The diagram shows the apparatus used to separate a mixture of water, boiling point 100 °C, and ethanol, boiling point 78 °C.

(a) Complete the boxes to name the apparatus.

(b) Label the arrows on the condenser.

(c) Identify one mistake in the apparatus.

(d) Which liquid would collect first? Explain your answer.

(e) Why would it be better to use an electrical heater instead of a Bunsen burner to heat the water and ethanol mixture?
Q# 17/ iGCSE Chemistry/2016/m/Paper 62/Q1

1. The diagrams show the apparatus used to obtain crystals of calcium chloride from a mixture of solid calcium chloride and solid calcium carbonate. Calcium chloride is soluble in water and calcium carbonate is insoluble in water.

(a) Complete the boxes to name the apparatus. [2]

(b) (i) Write down the order in which the apparatus should be used in this experiment. [1]

(ii) Name the separation process in C. [1]

(c) (i) What has been added to the mixture in B? [1]

(ii) What is the general name given to the liquid in the dish in C? [1]

(d) How would you know when to stop heating the dish in A? [1]

6.9.1 Mark Scheme iG Chem 2 EQ 18w to 16m Labelling Equipment

Q# 1/ iGCSE Chemistry/2018/w/Paper 63/Q1

<table>
<thead>
<tr>
<th>1(a)</th>
<th>mortar</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Teat/dropping) pipette/dropper</td>
<td>1</td>
</tr>
</tbody>
</table>

Q# 2/ iGCSE Chemistry/2018/w/Paper 62/Q1

| 1(a) | Tong(s) | 1 |
### Q# 3/ iGCSE Chemistry/2018/w/Paper 61/Q1

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(a)</td>
<td><strong>M1</strong>(A), C, F</td>
<td>1</td>
</tr>
<tr>
<td>1(b)</td>
<td>Evaporating / crystallising basin / dish</td>
<td>1</td>
</tr>
<tr>
<td>1(c)</td>
<td>To wash-out / dissolve / remove sodium chloride / salt</td>
<td>1</td>
</tr>
<tr>
<td>1(d)</td>
<td>Filtration</td>
<td>1</td>
</tr>
<tr>
<td>1(e)</td>
<td>Melting point</td>
<td>1</td>
</tr>
</tbody>
</table>

### Q# 4/ iGCSE Chemistry/2018/s/Paper 63/Q1

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(a)(i)</td>
<td>balance</td>
<td>1</td>
</tr>
<tr>
<td>1(a)(ii)</td>
<td>crucible</td>
<td>1</td>
</tr>
<tr>
<td>1(b)</td>
<td>open</td>
<td>1</td>
</tr>
<tr>
<td>1(c)</td>
<td>weigh the solid</td>
<td>1</td>
</tr>
<tr>
<td>1(d)</td>
<td>heat to constant mass</td>
<td>1</td>
</tr>
<tr>
<td>1(e)</td>
<td>anhydrous copper sulfate / cobalt chloride paper</td>
<td>1</td>
</tr>
<tr>
<td>1(f)</td>
<td>turns blue / turns pink</td>
<td>1</td>
</tr>
</tbody>
</table>

### Q# 5/ iGCSE Chemistry/2018/s/Paper 62/Q1

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(a)</td>
<td>(gas) syringe</td>
<td>1</td>
</tr>
</tbody>
</table>

### Q# 6/ iGCSE Chemistry/2018/s/Paper 61/Q1

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(a)</td>
<td>burette</td>
<td>1</td>
</tr>
</tbody>
</table>

### Q# 7/ iGCSE Chemistry/2018/m/Paper 62/Q1

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(a)(i)</td>
<td>line drawn on diagram between base line and bottom of paper and below dot</td>
<td>1</td>
</tr>
<tr>
<td>1(a)(ii)</td>
<td>water</td>
<td>1</td>
</tr>
<tr>
<td>1(b)</td>
<td>dropper / teat pipette</td>
<td>1</td>
</tr>
<tr>
<td>1(c)</td>
<td>so mixture is above / not in contact / does not run / dissolve in solvent</td>
<td>1</td>
</tr>
<tr>
<td>1(d)</td>
<td>is three substances / contains D</td>
<td>1</td>
</tr>
<tr>
<td>1(e)</td>
<td>insoluble</td>
<td>1</td>
</tr>
<tr>
<td>1(f)</td>
<td>2.0 to 3.2 / 5</td>
<td>1</td>
</tr>
<tr>
<td>1(g)</td>
<td>0.58 – 0.64</td>
<td>1</td>
</tr>
</tbody>
</table>

### Q# 8/ iGCSE Chemistry/2017/w/Paper 63/

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(a)</td>
<td>pestle</td>
<td>1</td>
</tr>
<tr>
<td>1(b)</td>
<td>(teat) pipette</td>
<td>1</td>
</tr>
<tr>
<td>1(c)</td>
<td>to increase surface area / make it dissolve faster</td>
<td>1</td>
</tr>
<tr>
<td>1(d)</td>
<td>nitric (acid)</td>
<td>1</td>
</tr>
</tbody>
</table>

### Q# 9/ iGCSE Chemistry/2017/w/Paper 61/

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(a)</td>
<td>evaporating basin / dish</td>
<td>1</td>
</tr>
<tr>
<td>1(b)</td>
<td>zinc oxide</td>
<td>1</td>
</tr>
<tr>
<td>1(c)(i)</td>
<td>filtration</td>
<td>1</td>
</tr>
<tr>
<td>1(c)(ii)</td>
<td>no filter paper</td>
<td>1</td>
</tr>
</tbody>
</table>
Q# 10/ iGCSE Chemistry/2017/s/Paper 63/

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(a)</td>
<td><strong>(delivery) tube</strong></td>
<td>1</td>
</tr>
<tr>
<td>1(a)(iii)</td>
<td>arrow beneath the tube containing the mixture of alcohols</td>
<td>1</td>
</tr>
<tr>
<td>1(b)</td>
<td>to cool</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>the gas into a liquid</td>
<td>1</td>
</tr>
<tr>
<td>1(c)</td>
<td>to measure the temperature of the vapour/temperature of liquid would not be constant</td>
<td>1</td>
</tr>
<tr>
<td>1(d)</td>
<td>E shown on the test-tube in water bath</td>
<td>1</td>
</tr>
<tr>
<td>1(a)(i)</td>
<td><strong>(delivery) tube</strong></td>
<td>1</td>
</tr>
<tr>
<td>1(a)(iii)</td>
<td>arrow beneath the tube containing the mixture of alcohols</td>
<td>1</td>
</tr>
<tr>
<td>1(b)</td>
<td>to cool</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>the gas into a liquid</td>
<td>1</td>
</tr>
<tr>
<td>1(c)</td>
<td>to measure the temperature of the vapour/temperature of liquid would not be constant</td>
<td>1</td>
</tr>
<tr>
<td>1(d)</td>
<td>E shown on the test-tube in water bath</td>
<td>1</td>
</tr>
<tr>
<td>1(e)(ii)</td>
<td>melted splint ignites the liquid/test for water, e.g., add anhydrous copper(II) sulphate gives a negative result</td>
<td>1</td>
</tr>
</tbody>
</table>

Q# 11/ iGCSE Chemistry/2017/s/Paper 62/

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(a)</td>
<td>measuring cylinder</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>conical flask</td>
<td>1</td>
</tr>
</tbody>
</table>

Q# 12/ iGCSE Chemistry/2017/s/Paper 61/

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(a)(i)</td>
<td>stirrer/glass rod</td>
<td>1</td>
</tr>
<tr>
<td>1(a)(ii)</td>
<td>Spatula</td>
<td>1</td>
</tr>
</tbody>
</table>

Q# 13/ iGCSE Chemistry/2016/w/Paper 62/

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(c)</td>
<td><strong>(liebig) condenser</strong></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>tripod</td>
<td>1</td>
</tr>
<tr>
<td>1(b)</td>
<td>sodium chloride crystals: C</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>water: D</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>silver chloride: A</td>
<td>1</td>
</tr>
<tr>
<td>1(c)</td>
<td>chromatography</td>
<td>1</td>
</tr>
</tbody>
</table>

Q# 14/ iGCSE Chemistry/2016/s/Paper 63/

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(a)</td>
<td><strong>(gas) syringe</strong></td>
<td>1</td>
</tr>
<tr>
<td>1(b)</td>
<td>arrow under copper</td>
<td>1</td>
</tr>
</tbody>
</table>

Q# 15/ iGCSE Chemistry/2016/s/Paper 62/

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(a)</td>
<td><strong>stand;</strong></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td><strong>beaker;</strong></td>
<td>1</td>
</tr>
<tr>
<td>1(d)</td>
<td>to condense (the water vapour);</td>
<td>1</td>
</tr>
<tr>
<td>1(e)(ii)</td>
<td><strong>boiling/melting point determination;</strong></td>
<td>1</td>
</tr>
</tbody>
</table>

Q# 16/ iGCSE Chemistry/2016/s/Paper 61/

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(a)</td>
<td>fractionating column;</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td><strong>tripod;</strong></td>
<td>1</td>
</tr>
<tr>
<td>1(b)</td>
<td>water labelled twice</td>
<td>1</td>
</tr>
<tr>
<td>1(c)</td>
<td>heat under (the collecting) beaker;</td>
<td>1</td>
</tr>
<tr>
<td>1(d)</td>
<td>M1 ethanol; M2 lowest/ lower boiling point;</td>
<td>2</td>
</tr>
<tr>
<td>1(e)(i)</td>
<td>ethanol is flammable;</td>
<td>1</td>
</tr>
</tbody>
</table>
6.10 ESSENTIAL EXAM QUESTIONS Paper 6 Topic 2 Experimental Techniques 79 marks

Q# 17/ iGCSE Chemistry/2016/m/Paper 62/

1. (a) tripod; stirring rod/stirrer;
   (b) B C A;
   (c) filtration;
   (d) water;
   (e) filtrate;
   (f) solid/crystals appearing on edge/glass rod test;

Q# 1/ iGCSE Chem/2015/w/Paper 62/

2 A mixture of three compounds, P, Q and R, was separated using a piece of paper.

(a) Name this method of separation.

.................................................................................................................................................. [1]

(b) What could have been used to apply the mixture onto the paper?

.................................................................................................................................................. [1]

(c) Suggest a possible solvent that could be used for this separation.

.................................................................................................................................................. [1]

(d) Suggest why compound Q remained on the baseline.

.................................................................................................................................................. [1]
(e) \( R_i \) values are used to identify compounds.

\[
R_i = \frac{\text{distance travelled by compound}}{\text{distance travelled by the solvent}}
\]

Use the diagram to work out the \( R_i \) value of compound R.

Q# 2/ IGCSE Chem/2015march/Paper 6/

1 A teacher separated a mixture of two liquids using the apparatus shown. The liquids were:

- ethanoic acid, boiling point 118°C,
- chloroethanoic acid, boiling point 190°C.

(a) Complete the boxes to label the pieces of apparatus used.  

(b) (i) Which liquid would be collected first? Explain why.

(ii) How would the teacher know when all of this liquid had been collected?
(c) Suggest why small glass beads are used in the fractionating column instead of large glass beads.

Q# 3/ iGCSE Chem/2015march/Paper 6/
4 A student investigated the solubility of salt D in water at various temperatures.

Four experiments were carried out.

(a) Experiment 1

4 g of salt D was added to a boiling tube. A burette was filled with distilled water and 10.0 cm$^3$ of water added to the boiling tube. The mixture of salt D and water was heated carefully until all of the solid had dissolved. The boiling tube was removed from the heat and the solution allowed to cool. The solution was stirred gently with a thermometer.

The temperature at which crystals first appeared was noted.

The boiling tube and its contents were kept for the remaining three experiments.

(b) Experiment 2

From the burette another 2.0 cm$^3$ of water was added to the boiling tube and contents from Experiment 1.

The mixture was heated to dissolve the crystals and allowed to cool as in Experiment 1. The temperature at which crystals first appeared was noted.

Record, in the table, the total volume of water in the boiling tube.

(c) Experiment 3

From the burette another 2.0 cm$^3$ of water was added to the boiling tube and contents from Experiment 2. The experiment was repeated exactly as before.

Record, in the table, the total volume of water in the boiling tube.

(d) Experiment 4

From the burette another 4.0 cm$^3$ of water was added to the boiling tube and contents from Experiment 3. The experiment was repeated exactly as before.

Record in the table the total volume of water in the boiling tube.

Use the thermometer diagrams in the table to record the temperatures at which crystals first appeared in the four experiments.

<table>
<thead>
<tr>
<th>Experiment number</th>
<th>total volume of water/cm$^3$</th>
<th>thermometer diagram</th>
<th>temperature at which crystals first appeared/°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10.0</td>
<td><img src="95,90,85" alt="thermometer diagram" /></td>
<td></td>
</tr>
</tbody>
</table>
(e) Plot the results on the grid below and draw a smooth line graph.

temperature at which crystals first appeared/°C

total volume of water/cm³
(f) *From your graph*, find the temperature at which crystals of \( D \) would first appear if the total volume of water in the solution was 20.0 cm\(^2\).
Show clearly on the grid how you worked out your answer.

.................................................................................................................................................. [3]

(g) How would the student know when salt \( D \) was completely dissolved in the water?

.................................................................................................................................................. [1]

(h) The solubility of salt \( D \) at 100°C is 57g in 100 cm\(^3\) of water.
Suggest, with a reason, the effect of using 8g of salt \( D \) instead of 4g in these experiments.

.................................................................................................................................................. [2]

(i) Salt \( C \) is less soluble in water than salt \( D \).

Sketch on the grid the graph you would expect for salt \( C \). Label this graph. [2]

(j) Describe and explain one improvement that could be made to the experimental method to obtain more reliable results in this investigation.

improvement .................................................................................................................................. [2]

explanation ................................................................................................................................... [2]

.................................................................................................................................................. [2]

Q# 4/ iGCSE Chem/2014/w/Paper 6/

3 A student investigated the colours present in a fruit drink. The fruit drink was tested to check that no artificial colours had been added. The apparatus below was used.

![Apparatus diagram]

(a) (i) Name the method used.

.................................................................................................................................................. [1]
(ii) Why is there a glass cover on the beaker?  

........................................................................................................... [1]  

(b) When should the paper be removed from the beaker?  

........................................................................................................... [1]  

(c) The diagram shows the results of the experiment:

(i) How many different coloured compounds were present in the fruit drink?  

........................................................................................................... [1]  

(ii) Are there any of the artificial colours present in the fruit drink? Explain your answer.  

...........................................................................................................  

........................................................................................................... [2]
A student separated a mixture of two alcohols, ethanol (boiling point 78°C) and butanol (boiling point 118°C). The apparatus used is shown below.

(a) Complete the boxes to identify the pieces of apparatus labelled. [2]

(b) Label the arrows. [1]

(c) State the name of this separation process. [2]

(d) (i) Which liquid is first to collect in the beaker? [1]

(ii) How would the student know when all of this liquid had collected? [1]
(e) Identify and explain a possible hazard in this experiment.

Q# 6/ iGCSE Chem/2013s/Paper 6/

2 A student found a recipe for making elderberry wine by fermentation.

1 kg elderberries
0.5 kg sugar
10 g yeast granules
3 dm³ water

The student decided to make some elderberry wine using the apparatus below.

The student carried out the following method.

Step 1 The elderberries were crushed.

Step 2 The crushed elderberries and sugar were added to the water and the mixture was boiled for ten minutes. The crushed elderberries were then separated from the mixture.

Step 3 Yeast was added to the liquid when it had cooled to room temperature.

(a) Suggest the purpose of the airlock in the apparatus.

(b) What apparatus could be used in Step 1?

(d) Why was the yeast in Step 3 not added until the liquid was at room temperature?
(e) (i) State one observation during the fermentation.

.................................................................................................................. [1]

(ii) Suggest how the rate of the fermentation reaction could be measured.

.................................................................................................................. [2]

(f) Name the method that could be used to separate ethanol from the fermented mixture.

.................................................................................................................. [1]

Q# 7/ IGCSE Chem/2012s/Paper 6/

3 Coffee beans contain caffeine and other compounds. Caffeine is soluble in water and in trichloromethane, an organic solvent. A student obtained crystals of caffeine by the following method.

Stage 1 Some coffee beans were crushed into small pieces.

Stage 2 Hot water was added to the crushed beans to dissolve the soluble substances.

Stage 3 The crushed beans were separated from the liquid solution.

Stage 4 The liquid was allowed to cool and shaken with trichloromethane to extract the caffeine from the water.

Stage 5 The caffeine was crystallised from the trichloromethane solution.

Stage 6 The caffeine crystals were checked for purity.

(a) What apparatus should be used to crush the beans in Stage 1?

.................................................................................................................. [2]

(b) How could the dissolving process in Stage 2 be speeded up?

.................................................................................................................. [1]

(c) Draw a diagram of the apparatus used in Stage 3.
(d) How should Stage 5 be carried out?

.................................................................................................................................................. [2]

(e) What method could be used to check the purity of the crystals in Stage 6?

.................................................................................................................................................. [1]

Q# 8/ iGCSE Chem/2011s/Paper 6/

1 A student heated hydrated zinc sulfate crystals, ZnSO₄·7H₂O, using the apparatus below to obtain a sample of water.

(a) Complete the box to identify the piece of apparatus labelled. [1]

(b) Use labelled arrows to indicate:

(i) where the heat is applied,

(ii) where the sample of water would collect. [2]

(c) State the purpose of the ice cubes. [1]

(d) Describe a physical test for pure water.

test .................................................................................................................................................

result ................................................................................................................................................ [2]
6 You are provided with a pot of paint as shown below.

The paint is a mixture of a liquid and a solid. The liquid can be dissolved in water. The solids are insoluble in water but soluble in organic solvents.

(a) How can a sample of the solid be separated from the rest of the paint?

...........................................................................................................................................................................
...........................................................................................................................................................................
...........................................................................................................................................................................
........................................................................................................................................................................... [2]

(c) The label on the paint tin states

"Touch-dry in three hours"

(i) How could you check this value?

...........................................................................................................................................................................
...........................................................................................................................................................................
........................................................................................................................................................................... [2]

(ii) Suggest how you could speed up this drying process.

........................................................................................................................................................................... [1]
Q# 10/ iGCSE Chem/2003/w/Paper 6/

2 A student extracted and investigated the orange colour in some sweets. The student followed these instructions:

1 Collect sweets, a watch glass, a beaker, eye protection and 100 cm$^3$ of ethanol.
2 Crush the sweets.
3 Place the crushed sweets in the beaker containing 100 cm$^3$ of ethanol.
4 Boil the mixture with the watch glass covering the beaker.
5 Decant the liquid and concentrate it by evaporation until the colour is dark orange.
6 Investigate which colours are present in the orange solution.

(a) Why should the sweets be crushed? 

.................................................................................................................................................................................................[2]

(b) Why should the experiment be carried out in a well-ventilated laboratory? 

.................................................................................................................................................................................................................................................................................................................................[1]

(c) State one safety precaution that the student should have taken, other than carrying out the experiment in a well-ventilated laboratory and using eye protection. 

.................................................................................................................................................................................................................................................................................................................................................................................................[1]

(d) State the purpose of the watch glass. 

.................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................[1]

(e) Explain the term decant. 

.................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................[1]

6.10.1 ESSENTIAL EXAM QUESTIONS Paper 6 Topic 2 Experimental Techniques 79 marks Mark Scheme

Q# 1/ iGCSE Chem/2015/w/Paper 62/

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>2(a)</td>
<td>chromatography;</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2(b)</td>
<td>(teat) pipette/capillary tube;</td>
<td>1</td>
<td>A: dropper/ glass rod</td>
</tr>
<tr>
<td>2(c)</td>
<td>water/organic solvent;</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2(d)</td>
<td>compound Q is insoluble;</td>
<td>1</td>
<td>R: it reacts with the solvent</td>
</tr>
<tr>
<td>2(e)</td>
<td>between (4.7 and 5.1) divided by (9.2 or 6.3); answer: between 0.74 and 0.82;</td>
<td>1</td>
<td>correct answer with no working scores 2</td>
</tr>
</tbody>
</table>
Q# 2/ iGCSE Chem/2015march/Paper 6/
1  (a) thermometer (1)
    condenser (1) [2]

    (b) (i) ethanoic acid (1)
        lower boiling point / evaporates first (1) [2]

        (ii) temperature reading will rise / gap in liquid coming over / no more collected at 118°C (1) [1]

    (c) larger surface area (1) [1]
Q# 3/ iGCSE Chem/2015march/Paper 6/
4  (d) **Table of results**

    total volume of water boxes completed correctly (1),
    10, 12, 14, 18
    temperature boxes completed (2)
    all 4 correct (2)
    3 correct (1)
    2 or fewer correct (0)

    91, 73, 65, 54 [3]

    (e) appropriate scale for y axis (1)
    note: must use at least 4 large squares vertically to plot points

    all points correctly plotted (3),
    all 4 correct (3)
    3 correct (2)
    2 correct (1)
    1 or fewer correct (0)
    note: origin should not be included

    smooth line graph (1) [5]

    (f) value from graph for 20 cm³ water, 50–53 (1) ± half a small square
    shown clearly by extrapolation (1)

    unit, °C (1) [3]
(g) clear/colourless liquid forms/no solid/crystals/salt visible (1) [1]

(h) salt would not all dissolve (1)
   use of figures (1)
   e.g. only 5.7 g would dissolve in 10 cm³ water at 100 °C [2]

(i) sketch graph always above line (1)
   label (1) [2]

(j) any one improvement from: (1)
   do not remove thermometer from solution
   use IT method/second person to note formation of crystals
   repeat
   do separate experiments
   use smaller volumes of water
   evaporation
   linked explanation (1)
   loss of solid on thermometer
   observing formation of first crystals may vary
   average
   more results to plot on graph
   method of avoiding evaporation e.g. separate experiments, lid [2]

Q# 4/ iGCSE Chem/2014/w/Paper 6/
3 (a) (i) chromatography (1) [1]
   (ii) to prevent loss/ evaporation of solvent (1) [1]

(b) when the solvent is near the top of the paper/ before the solvent reaches the top of the paper (1) [1]

(c) (i) 4 (1) [1]
   (ii) yes, one artificial dye (1)
   at same height/ matches (1) [2]

Q# 5/ iGCSE Chem/2014s/Paper 6/
1 (a) thermometer (1)
   condenser (1)
   allow condensing tube, condensating tube, etc. [2]

(b) arrows labelled – water in) and water (out) (1) [1]

(c) fractional (1)
   distillation (1) [2]
(d) (i) ethanol (1)

(ii) temperature would rise (above 78°C) (1)

(e) alcohols are (in)flammable / catch fire / burn (1)
       ignore: explode

       Bunsen burner / flame / heat (1)

Q# 6/ IGCSE Chem/2013s/Paper 6/
2 (a) to prevent air / oxygen / bacteria entering jar (1) (1)

(b) pestle and / or mortar (1)

(c) diagram of funnel and filter paper (1) labelled (1) (2)

(d) yeast would not work at high temperatures / kills yeast / denatures enzymes / owtie (1)
       allow: kills enzyme (1)

(e) (i) bubbles / froth (1)
       not: gas / CO₂ given off / turns cloudy (1)

(ii) (collect gas) and measure volume / count bubbles (1)

       over certain time interval (1)
       allow: one mark for timing until bubbles / reaction stopped (2)

(f) fractional distillation (1) (1)

Q# 7/ IGCSE Chem/2012s/Paper 6/
3 (a) pestle (1) mortar (1) (2)

(b) stir/mix/shake (1) allow: heat/boil (1)

(c) diagram showing funnel (1)

       indication of filter paper (1) note: labels not necessary (2)

(d) heat/evaporation (1)

       to crystallising point or description (1)

       in fume cupboard (1) max 2 (2)

(e) melting point/description of (1) allow: chromatography ignore: bp (1)
Q# 8/ iGCSE Chem/2011s/Paper 6/

1  (a) beaker (1)
    
    (b) (i) (arrow) labelled heat in correct position under shaded crystals (1)
        (ii) arrow labelled water in test-tube at or below the level of the ice (1)
    
    (c) to cool/condense the water or steam/owttte (1)
    
    (d) physical test ignore chemical tests
        boiling point/freezing point (1)
        100/0°C (1)

Q# 9/ iGCSE Chem/2006/w/Paper 6/

6  (a) paint sample + water(1) filter(1) solid residue(1) max 2
    (c) (i) apply paint, start timer(1) method of checking dry, note time(1)
        no painting = 0
        (ii) correct method(1) e.g. hair drier/wind/fan/increase temperature.
            NOT catalyst.

Q# 10/ iGCSE Chem/2003/w/Paper 6/

2  (a) Larger surface area (1)
    Quicker to extract colour/more colour extracted (1) not easier/faster 2
    
    (b) Reference to ethanol (1)
    
    (c) Reference to flammability of ethanol (1)
    
    (d) To prevent loss cf solvent (1) not splash/evaporation
    
    (e) Pour off liquid (1)
Ethanedioic acid dihydrate, $\text{H}_2\text{C}_2\text{O}_4\cdot2\text{H}_2\text{O}$, is a white crystalline solid. This acid is water-soluble and is found in rhubarb leaves.

Plan an investigation to obtain crystals of ethanedioic acid dihydrate from some rhubarb leaves. You are provided with common laboratory apparatus, water and sand.
Q# 2/ iGCSE Chem/2013s/Paper 6/

5 Identical pieces of steel were placed in two different boiling liquids for 12 hours. The graphs show how the mass of each piece of steel changed.

(a) Give one similarity in the change in mass of the steel in both liquids.

........................................................................................................................................... [1]

(b) Describe two ways in which the mass loss shown in graph A is different from that shown in graph B.

1. ..............................................................................................................................................

.............................................................................................................................................. [3]

2. .............................................................................................................................................. [3]

(c) State two different safety precautions that would need to be taken when carrying out this investigation.

1. ..............................................................................................................................................

2. .............................................................................................................................................. [2]
Q# 3/ iGCSE Chem/2011/w/Paper 6/

6  Seawater contains sodium chloride and other salts. 
Plan an experiment to find the mass of salts in 1 dm³ of seawater. 
You will be provided with a small bottle of seawater. 
You should include details of the method and any apparatus used. 
(1 dm³ = 1000 cm³) 

Q# 4/ iGCSE Chem/2010/w/Paper 6/

7  E numbers identify chemicals which are added to foods. 
   (c) E110 is Sunset yellow. 
   Outline a method you could use to show the presence of E110 in a food colouring. 
   A space has been left if you want to draw a diagram to help you answer the question.
Q# 5/ iGCSE Chem/2009/w/Paper 6/

7 Leaves from trees contain a mixture of coloured pigments which are not soluble in water. A student was given these two instructions to investigate the pigments in the leaves.

1. Crush some leaves to extract the coloured pigments.
2. Use the liquid extract to find the number of coloured pigments in the leaves.

(a) What would the student need in order to effectively carry out instruction 1?

(b) Describe an experiment to carry out instruction 2.
A space has been left below if you want to draw a diagram to help answer the question.

...
6. You are provided with a pot of paint as shown below.

The paint is a mixture of a liquid and a solid. The liquid can be dissolved in water. The solids are insoluble in water but soluble in organic solvents.

(b) How would you determine the number of coloured substances contained in the solid you separated in (a)?

...........................................................................................................................................
...........................................................................................................................................
...........................................................................................................................................
...........................................................................................................................................
...........................................................................................................................................
........................................................................................................................................... [4]

7. The green pigment chlorophyll can be obtained from grass.

Step 1 The grass is crushed with sand.
Step 2 The grass is ground with ethanol until the solution is saturated.
Step 3 The solution is separated from the rest of the mixture.
Step 4 The colours in the solution are separated.
(d) Describe how Step 4 is carried out.

7 Forged Banknote

A fake banknote can be investigated by dissolving the ink off the paper.

You are provided with four different inks from four different criminals. Describe an experiment to show which one of these inks is the same as the ink from the banknote.

You can use a labelled diagram to help you answer the question.
2. A student extracted and investigated the orange colour in some sweets. The student followed these instructions:

1. Collect sweets, a watch glass, a beaker, eye protection and 100 cm$^3$ of ethanol.
2. Crush the sweets.
3. Place the crushed sweets in the beaker containing 100 cm$^3$ of ethanol.
4. Boil the mixture with the watch glass covering the beaker.
5. Decant the liquid and concentrate it by evaporation until the colour is dark orange.
6. Investigate which colours are present in the orange solution.

(f) Describe how the student could carry out instruction 6. You may draw a diagram in the space below to help you answer the question.
6.11.1 EXTENSION EXAM QUESTIONS Paper 6 Topic 2 Long Answer Questions 53 marks Mark Scheme

Q# 1/ iGCSE Chem/2015march/Paper 6/

6 any seven from:

 extraction

cut leaves up/small pieces/grind/crush (1)

use of pestle/mortar (1)

add water (1)

sand (1)

boil/heat/stir/mix/shake (1)

separation

decant/filter (1)

obtaining crystals

evaporate/heat solution (1)

to crystallising point/until crystals start to form (1)

leave to cool (1)

Q# 2/ iGCSE Chem/2013s/Paper 6/

5 (a) both lose mass (1)

not: change mass

(b) mass loss increases constantly in graph A (1)

becomes constant in graph B (after about 7–9 hours) (1)

mass loss or change is greater in acid/less in alkali (1)

(c) goggles/lab coat/tongs/fume cupboard/well ventilated area any two

ignore: reference to hair

Q# 3/ iGCSE Chem/2011/w/Paper 6/

6 measured volume of seawater (1)

using measuring cylinder (1)

into evaporating dish/beaker (1)

pre-weighted (1)

evaporate/heat (1)

to dryness/constant mass (1)

re-weigh (1)

indication of calculation method (1)

would not work = max 0

max [6]
Q# 4/ iGCSE Chem/2010/w/Paper 6/ Q7

(c) marks can be obtained from diagram
chromatography (1) description of applying E110 to paper (1)
use of solvent (1) results / number of spots (1) [4]

Q# 5/ iGCSE Chem/2009/w/Paper 6/

7 (a) pestle/mortar/solvent/sand (any three)
ignore water and/or heat [3]

(b) NB marks can be obtained from a diagram
chromatography or chromatogram (1)
paper (1) apply spot/extract to paper (1)
description or name of solvent used (1)
and separation e.g. spots on paper (1) (max 4) [4]

If water used as solvent (max 3)
If paper dipped into extract (max 3)
If method would not work (max 2)

Q# 6/ iGCSE Chem/2006/w/Paper 6/ Q6

(b) solid + organic solvent(1) add to paper(1)
chromatography(1) use of solvent(1) description of spots(1)
max 4 NB use of water = max 1 for chromatography [4]

Q# 7/ iGCSE Chem/2005/w/Paper 6/

3 (a) pestle (1) and mortar (1) [2]
(b) chlorophyll more soluble in ethanol or similar [1]
(c) filtration [1]
(d) chromatography (1), paper (1), add pigments (1), use of solvent (1) [4]

Q# 8/ iGCSE Chem/2004/w/Paper 6/

7 chromatography (1) apply inks/spots to paper (1)
organic solvent/water (1) rises up paper (1)
check heights/positions of spots (1) compare to find ink from banknote (1) (6)

N.B. all marks can be obtained from a diagram

Q# 9/ iGCSE Chem/2003/w/Paper 6/ Q5

(f) Chromatography (1)
Apply orange concentrate (1) to paper (1)
Use of solvent (1)
Description of elution (1)
Result of experiment (1)

Max 5 – all marks could be obtained from a suitable diagram 5
**6.12  FUNDAMENTAL Assessed Activity 1 Keyword Test**

Only complete this Assessed Activity if you are struggling in this subject and finding the course and the language really difficult.

<table>
<thead>
<tr>
<th>English</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>distillation</td>
<td></td>
</tr>
<tr>
<td>downward delivery</td>
<td></td>
</tr>
<tr>
<td>risk assessment</td>
<td></td>
</tr>
<tr>
<td>( R_f ) value</td>
<td></td>
</tr>
<tr>
<td>chromatogram</td>
<td></td>
</tr>
<tr>
<td>locating agent</td>
<td></td>
</tr>
<tr>
<td>soluble</td>
<td></td>
</tr>
<tr>
<td>saturated solution</td>
<td></td>
</tr>
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<td>solvent front</td>
<td></td>
</tr>
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<td>solubility</td>
<td></td>
</tr>
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<td>chromatography</td>
<td></td>
</tr>
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<tr>
<td>mixture</td>
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</tr>
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<td>pure substance</td>
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<td>crystallisation</td>
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<td>fractional distillation</td>
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<td>--------------</td>
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<tr>
<td>decanting</td>
<td></td>
</tr>
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<td>upward delivery</td>
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<td>filtration</td>
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<td>solvent</td>
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</tr>
<tr>
<td>residue</td>
<td></td>
</tr>
<tr>
<td>insoluble</td>
<td></td>
</tr>
<tr>
<td>solution</td>
<td></td>
</tr>
</tbody>
</table>

6.13 ESSENTIAL Assessed Activity 2 – Which separation technique?

Q#1/

1 The following techniques are used to separate mixtures.

   A simple distillation   B fractional distillation   C evaporation
   D chromatography        E filtration               F diffusion

From this list, choose the most suitable technique to separate the following.

(a) methane from a mixture of the gases, methane and ethane ..................  [1]
(b) water from aqueous magnesium sulfate ..................  [1]
(c) glycine from a mixture of the amino acids, glycine and lysine ..................  [1]
(d) iron filings from a mixture of iron filings and water ..................  [1]
(e) zinc sulfate crystals from aqueous zinc sulfate ..................  [1]
(f) hexane from a mixture of the liquids, hexane and octane ..................  [1]

[Total: 6]
EXTENSION activity – How fast can you finish?

Q# 2/
Butane and propane are both gases, silver chloride is a salt that is insoluble in water, glucose and maltose are both sugars.

1. A list of techniques used to separate mixtures is given below.

   filtration
   diffusion
   fractional distillation
   simple distillation
   crystallisation
   chromatography

From this list, choose the most suitable technique to separate the following mixtures. A technique may be used once, more than once or not at all.

(a) butane from a mixture of propane and butane ................................................................. [1]
(b) oxygen from liquid air ........................................................................................................ [1]
(c) water from aqueous magnesium sulfate ........................................................................... [1]
(d) potassium chloride from aqueous potassium chloride .................................................... [1]
(e) silver chloride from a mixture of silver chloride and water ............................................. [1]
(f) glucose from a mixture of glucose and maltose ................................................................. [1]

Q# 3/
Helium and argon are gases at room temperature.
Barium sulphate does not dissolve in water.

1. A list of techniques used to separate mixtures is given below.

   fractional distillation  simple distillation  crystallisation  filtration  diffusion

From the list choose the most suitable technique to separate the following.

water from aqueous copper(II) sulphate ..............................................................................

helium from a mixture of helium and argon ...........................................................................

copper(II) sulphate from aqueous copper(II) sulphate .........................................................

ethanol from aqueous ethanol ...............................................................................................

barium sulphate from a mixture of water and barium sulphate ........................................... [5]
6.14 ESSENTIAL Assessed Activity 3 Labelling equipment

Q# 2/
1. The volume of hydrochloric acid that reacts with 25.0 cm$^3$ of aqueous sodium hydroxide can be found using the apparatus below.

(a) Complete the boxes to identify the pieces of apparatus labelled. [2]

Q# 3/
1. A student separated a mixture of two alcohols, ethanol (boiling point 78°C) and butanol (boiling point 118°C). The apparatus used is shown below.

(a) Complete the boxes to identify the pieces of apparatus labelled. [2]
(b) Label the arrows.

(e) Identify and explain a possible hazard in this experiment.

Q# 4/

1. A student reacted dilute nitric acid with lead(II) oxide to prepare lead(II) nitrate. The diagram shows the stages in the method used.

1. 50 cm³ of dilute nitric acid was measured into a beaker.

2. Lead(II) oxide was added until all the nitric acid had reacted.

3. The mixture was separated.

4. The solution was allowed to cool.

The solution of lead(II) nitrate was then obtained.

(a) Complete the boxes to identify the pieces of apparatus.

(c) The lead(II) oxide was weighed before and after the additions.

Use the balance diagrams to work out the mass of lead(II) oxide added to the dilute nitric acid.

Extension work Labelling equipment

Q# 6/
1 A student investigated the products formed when ethanol was burned using the apparatus shown.

(a) Complete the box to identify the piece of apparatus. [1]

(b) Why is a suction pump used? [1]

Q# 7/

1 A student reacted excess iron powder with sulfuric acid to prepare a solution of iron(II) sulfate. The diagram shows the procedure followed in three stages.

2

iron powder was added until all the sulfuric acid had reacted

1

50 cm$^3$ of dilute sulfuric acid was measured and added to a beaker

heat

the mixture was allowed to cool

(a) Complete the boxes to identify the pieces of apparatus labelled. [2]
Q# 8/

1. A student heated hydrated zinc sulfate crystals, ZnSO₄·7H₂O, using the apparatus below to obtain a sample of water.

(a) Complete the box to identify the piece of apparatus labelled. [1]
(b) Use labelled arrows to indicate:
   (i) where the heat is applied,
   (ii) where the sample of water would collect. [2]
(c) State the purpose of the ice cubes. [1]

Q# 9/

1. A student investigated the reaction of air with copper. 100 cm³ of air was passed continuously over heated copper using the apparatus below. When the volume remained constant, the apparatus was left to cool and the volume of gas was measured.

(a) (i) Complete the box to show the apparatus labelled. [1]
   (ii) Indicate on the diagram, with an arrow, where heat is applied. [1]

Q# 10/ iGCSE Chem/2010s/Paper 6/
1. The diagram shows the apparatus used to prepare a gas. The gas is more dense than air.

(a) Complete the boxes to name the apparatus. [3]

6.15 Extension Mind Map for Topic 2 Experimental Techniques and Separation
6.16 Essential End of Topic 2 Review and Reflection

Looking at the goals you could have achieved and the goals you actually achieved try to reflect on your progress.

Try to be as honest and as detailed as possible. Sometimes you may think you have thought about an idea well, but when you talk with someone else, or write it out, it helps you better understand and allows you think more completely and more clearly.

Did you achieve more goals this topic than last topic?

Fill in this table

<table>
<thead>
<tr>
<th>Level</th>
<th>Number of goals achieved at each level</th>
<th>Success rate, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>FUNDAMENTAL</td>
<td>/5</td>
<td></td>
</tr>
<tr>
<td>ESSENTIAL</td>
<td>/10</td>
<td></td>
</tr>
<tr>
<td>EXTENSION</td>
<td>/13</td>
<td></td>
</tr>
<tr>
<td>EXCEPTIONAL</td>
<td>/10</td>
<td></td>
</tr>
</tbody>
</table>

Do you feel you tried harder? If yes, what helped you to do so? If not, why not?

What could you do differently next time, in addition to what you are already doing to improve, not only your score in the end of topic tests and other assessed activities, but also in how you learn. How could you become a more effective student to get more learning out of the time you are investing in your studies?

What did you enjoy most about this topic?

What did you find most difficult?

What did you find easiest?

On a scale of 1 being hardest and 5 being most difficult, circle how challenging you found this topic

1 2 3 4 5

What could be done to make this topic easier to understand?

Do you have any questions about this topic?
Learning about science by reading newspapers, journals, and popular science magazines. Not all of these magazines can be accessed everywhere, but it is important that you understand and read as widely as you can, especially about the subject you are interested in pursuing at A levels and beyond. You may need to buy a subscription, but the school library also has an excellent selection of current magazines and newspapers.

To give you a sample of the kinds of articles and things you could be reading I’ve downloaded selected articles that relate to this topic, which is about experiments. If you find the language challenging, which is likely, instead of reading for meaning you could instead try reading for vocabulary, print out an article and translate any words you may find. One way to learn another language if you are already very confident in that language is to explain the meaning of new words in English, rather than simply translate them. All are available from here:

https://www.smashingsciencecn.org/igcse-chem-additional-resources

- The Atlantic (an article which helped to introduce the idea that medicine and chemistry might be a new direction in healthcare, back in 1909)
- The Economist, possibly the most read newspaper by CEO’s and corporate executives, as well as politicians and academics, published an article which challenged the idea that science is getting better
- The Smithsonian looked at 10 of the most interesting experiments
- The New York Times also looked at 10 important experiments
- Some of the most popular online (and sometimes offline) sources for news aimed at an educated general audience include:
  - https://www.wired.com/
  - https://www.newscientist.com/
  - https://www.sciencemag.org/
  - National Institute of Health: https://kids.niehs.nih.gov/
  - Smithsonian website: https://ssec.si.edu/ and https://www.si.edu/kids
  - And especially Wikipedia, which also has a Simple English version: https://simple.wikipedia.org/wiki/Main_Page

Academic Journals

This is where new science and discoveries is reported to the scientific community, and then the world. They follow a very specific set of rules, and try to explain exactly what they did in their experiments and what they think their results mean. Normally, even after finishing a degree it is difficult to understand what is going on in these articles (usually you just read the abstract, which tells you roughly what they found out, and sometimes the conclusions, which tells you in more detail why their study matters) The two most famous journals are: “Nature” and “Science”.

You are unlikely to understand anything about these, but two famous experiments are included if you go to the iGCSE Additional Resources webpage.
7 Topic 3 Atoms, Elements and Compounds

7.1 End of Topic 3 Goals Checklist
For each topic you ought to try to do as many of the following things to get the most out of your time, the resources available to you and to help you grow as a student. Tick each goal off as you complete it. Growth is difficult and uncomfortable, but you should choose to do these things, and the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win!

<table>
<thead>
<tr>
<th>Aspect</th>
<th>What you should have done</th>
<th>Yes/No</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interacted with your teacher</td>
<td>Ask your teacher 1 question, about anything, once a week</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Try to answer one question asked by your teacher at least once a week</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Ask your teacher one question about something you do not understand in science once a week</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Ask your teacher one question about something to do with science every lesson</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td>Notes and follow up notes</td>
<td>Complete set of class note</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Attempted</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Completed</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Completed to an exemplary standard</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Attempted the Mind Map for this topic</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Completed the Mind Map for this topic</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td>Textbook</td>
<td>Read ahead before the topic has been started</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Highlighted key ideas and translate new words</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Completed the questions at the end of each 2 page spread in your exercise book</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Added to your class notes ideas and important information from the textbook that you learnt</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td>Past Exam Questions</td>
<td>Worked on at least 25% of the exam questions in this workbook</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Attempted more than 25% of the questions and those questions you have completed you have marked in a different colour pen</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Completed and marked all questions here</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Completed, marked and additional key ideas where you have located the most difficult marks added to your notebook</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Used the resources available online to answer additional questions not found in this workbook on the current topic.</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Ask your teacher about an exam question that they cannot answer</td>
<td></td>
<td>EXCEPTIONALLY SMASHING!!</td>
</tr>
<tr>
<td>Assessed Activities</td>
<td>Complete the word list activity using the word list at the front of each topic as little as possible</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities, either in class or as homework</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 70% on average</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 80% on average</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 90% on average</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td>End of Topic Test</td>
<td>Revised sufficiently well to improve upon your score from the previous test (except if you are scoring over 90%, then just write Y for this goal)</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Scored 10% higher than your current average</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Scored 15% or more than your previous end of topic average</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Scored over 90%</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Scored over 95%</td>
<td></td>
<td>SMASHING!!!</td>
</tr>
<tr>
<td>Aspect</td>
<td>What you should have done</td>
<td>Yes/No</td>
<td>Level</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------------------------------------------------------------------------------------</td>
<td>--------</td>
<td>---------------</td>
</tr>
<tr>
<td>Reading</td>
<td>Spend more than 1 hour a week reading a book you enjoy (in any language) about anything.</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Spend more than 3 hours a week reading a book you enjoy (in any language) about anything.</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Spend more than 5 hours a week reading a book you enjoy (in any language) about anything.</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Spend at least one hour a week reading a book you enjoy in English about anything.</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Spend more than 3 hours a week reading a book you enjoy in English about anything.</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td>Reflection</td>
<td>You completed this goal setting table</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>You have looked at the goals you have achieved and the ones you have not and added them</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>up and entered them into the table in the Review and Reflection section</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>You have given an answer for every question in the Review and Reflection section at the</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>end of this topic</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>You have Given good and thoughtful answers for every question in the Review and Reflection</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>section at the end of this topic</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 7.2 Topic 3 Syllabus

3.1 Atomic structure and the Periodic Table

<table>
<thead>
<tr>
<th>Core</th>
<th>Supplement</th>
</tr>
</thead>
<tbody>
<tr>
<td>• State the relative charges and approximate relative masses of protons, neutrons and electrons</td>
<td>• Understand that isotopes have the same properties because they have the same number of electrons in their outer shell</td>
</tr>
<tr>
<td>• Define proton number (atomic number) as the number of protons in the nucleus of an atom</td>
<td></td>
</tr>
<tr>
<td>• Define nucleon number (mass number) as the total number of protons and neutrons in the nucleus of an atom</td>
<td></td>
</tr>
<tr>
<td>• Use proton number and the simple structure of atoms to explain the basis of the Periodic Table (see section 9), with special reference to the elements of proton number 1 to 20</td>
<td></td>
</tr>
<tr>
<td>• Define isotopes as atoms of the same element which have the same proton number but a different nucleon number</td>
<td></td>
</tr>
<tr>
<td>• State the two types of isotopes as being radioactive and non-radioactive</td>
<td></td>
</tr>
</tbody>
</table>
### 3.1 Atomic structure and the Periodic Table continued

**Core**
- State one medical and one industrial use of radioactive isotopes
- Describe the build-up of electrons in 'shells' and understand the significance of the noble gas electronic structures and of the outer shell electrons. (The ideas of the distribution of electrons in s and p orbitals and in d block elements are **not** required.)

*Note: a copy of the Periodic Table, as shown in the Appendix, will be available in Papers 1, 2, 3 and 4.*

### 3.2 Structure and bonding

#### 3.2.1 Bonding: the structure of matter

**Core**
- Describe the differences between elements, mixtures and compounds, and between metals and non-metals
- Describe an alloy, such as brass, as a mixture of a metal with other elements

#### 3.2.2 Ions and ionic bonds

**Core**
- Describe the formation of ions by electron loss or gain
- Describe the formation of ionic bonds between elements from Groups I and VII

**Supplement**
- Describe the formation of ionic bonds between metallic and non-metallic elements
- Describe the lattice structure of ionic compounds as a regular arrangement of alternating positive and negative ions

#### 3.2.3 Molecules and covalent bonds

**Core**
- Describe the formation of single covalent bonds in H₂, Cl₂, H₂O, CH₄, NH₃ and HCl as the sharing of pairs of electrons leading to the noble gas configuration
- Describe the differences in volatility, solubility and electrical conductivity between ionic and covalent compounds

**Supplement**
- Describe the electron arrangement in more complex covalent molecules such as N₂, C₂H₆, CH₃OH and CO₂
- Explain the differences in melting point and boiling point of ionic and covalent compounds in terms of attractive forces
3.2.4 Macromolecules

Core
- Describe the giant covalent structures of graphite and diamond
- Relate their structures to their uses, e.g. graphite as a lubricant and a conductor, and diamond in cutting tools

Supplement
- Describe the macromolecular structure of silicon(IV) oxide (silicon dioxide)
- Describe the similarity in properties between diamond and silicon(IV) oxide, related to their structures

3.2.5 Metallic bonding

Supplement
- Describe metallic bonding as a lattice of positive ions in a ‘sea of electrons’ and use this to describe the electrical conductivity and malleability of metals
7.3 ESSENTIAL Glossary for Keywords for this topic

Many words used in science have a meaning that is slightly different to their common everyday English meaning, for instance a salt is the product of an acid and base reacting together in chemistry, but normally thought of as table salt (NaCl) in common use.

The keywords have been auto translated into Chinese, so the translations will not be perfect but they should hopefully make sense. If there is a better translation you can simply write it out yourself on a Post-it note and stick it over the printed one.

<table>
<thead>
<tr>
<th>Topic #</th>
<th>English</th>
<th>Chinese</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>atom the smallest particle of an element that can take part in a chemical reaction</td>
<td>原子可以参与化学反应的元素的最小颗粒</td>
</tr>
<tr>
<td>3</td>
<td>atomic number (Z) the number of protons in the nucleus of an atom; it is also the number of electrons present in an atom and the position of the element in the Periodic Table</td>
<td>原子序数（Z）原子核中的质子数；它也是原子中存在的电子数和元素在周期表中的位置</td>
</tr>
<tr>
<td>3</td>
<td>chemical bonding the strong forces that hold atoms (or ions) together in the various structures that chemical substances can form – metallic bonding, covalent bonding and ionic (electrovalent bonding)</td>
<td>化学键将化学物质可形成的各种结构中的原子（或离子）保持在一起的强大力-金属键·共价键和离子（电价键）</td>
</tr>
<tr>
<td>3</td>
<td>compound a substance formed by the chemical combination of two or more elements in fixed proportions</td>
<td>由两种或多种元素按固定比例化学结合形成的物质</td>
</tr>
<tr>
<td>3</td>
<td>covalent bond a chemical bond formed by the sharing of one or more pairs of electrons between two atoms</td>
<td>共价键由两个原子之间共享一对或多对电子形成的化学键</td>
</tr>
<tr>
<td>3</td>
<td>density expresses the relationship between the mass of a substance and the volume it occupies: density = mass / volume</td>
<td>密度表示物质的质量与它所占据的体积之间的关系：密度=质量/体积</td>
</tr>
<tr>
<td>3</td>
<td>diatomic molecule a molecule containing two atoms, for example hydrogen, H2</td>
<td>双原子分子一种包含两个原子的分子，例如氢·H2</td>
</tr>
<tr>
<td>3</td>
<td>electrical conductor a substance that conducts electricity but is not chemically changed in the process</td>
<td>电导体导电但在过程中不会发生化学变化的物质</td>
</tr>
<tr>
<td>3</td>
<td>electron (arrangement) configuration a shorthand method of describing how electrons are organised by energy levels of an atom.</td>
<td>电子（排列）构型是描述电子如何通过原子能级组织的简写方法。</td>
</tr>
<tr>
<td>3</td>
<td>electron a subatomic particle with negligible mass and a charge of −1; electrons are present in all atoms, located in energy levels outside the nucleus</td>
<td>电子是质量可忽略且电荷为-1的亚原子粒子；电子存在于所有原子中·位于原子核之外的能级</td>
</tr>
<tr>
<td>3</td>
<td>electrostatic force of attraction a strong pulling force between particles with opposite charges – such forces are involved in</td>
<td>静电吸引力在带相反电荷的粒子之间产生强大的拉力·这种力与</td>
</tr>
<tr>
<td>3</td>
<td>element a substance which cannot be further divided into simpler substances by chemical methods; all the atoms of an element contain the same number of protons</td>
<td>指不能通过化学方法进一步分为简单物质的物质；元素的所有原子都包含相同数量的质子</td>
</tr>
<tr>
<td>3</td>
<td>energy levels (of electrons) the allowed energies of electrons in atoms – electrons fill these levels (or shells) starting with the one closest to the nucleus</td>
<td>（电子的）能级原子中电子的允许能量·电子从最靠近原子核的那一层开始填充这些能级（或壳）</td>
</tr>
<tr>
<td>3</td>
<td>giant ionic structure</td>
<td>a lattice held together by the electrostatic forces of attraction between positive and negative ions</td>
</tr>
<tr>
<td>3</td>
<td>giant metallic lattice</td>
<td>a regular arrangement of positive metal ions held together by the mobile ‘sea’ of electrons moving between the ions</td>
</tr>
<tr>
<td>3</td>
<td>giant molecular structure</td>
<td>substance where large numbers of atoms are joined by covalent bonds forming a strong lattice structure</td>
</tr>
<tr>
<td>3</td>
<td>insulator</td>
<td>substance that does not conduct electricity</td>
</tr>
<tr>
<td>3</td>
<td>intermolecular forces</td>
<td>the weak attractive forces which act between molecules</td>
</tr>
<tr>
<td>3</td>
<td>ionic (electrovalent) bond</td>
<td>a strong electrostatic force of attraction between oppositely charged ions</td>
</tr>
<tr>
<td>3</td>
<td>ions</td>
<td>charged particles made from an atom, or groups of atoms (polyatomic ions), by the loss or gain of electrons</td>
</tr>
<tr>
<td>3</td>
<td>isotopes</td>
<td>atoms of the same element which have different numbers of neutrons in their nuclei: they differ in their mass (nucleon) numbers; some isotopes are radioactive because their nuclei are unstable (radio-isotopes)</td>
</tr>
<tr>
<td>3</td>
<td>lattice</td>
<td>a regular three-dimensional arrangement of atoms, molecules or ions in a crystalline solid</td>
</tr>
<tr>
<td>3</td>
<td>malleable</td>
<td>a word used to describe the property that metals can be bent and beaten into sheets</td>
</tr>
<tr>
<td>3</td>
<td>mass number (A)</td>
<td>the total number of protons and neutrons present in the nucleus of an atom</td>
</tr>
<tr>
<td>3</td>
<td>matter</td>
<td>anything which occupies space and has mass</td>
</tr>
<tr>
<td>3</td>
<td>metallic bond</td>
<td>an electrostatic force of attraction between the mobile ‘sea’ of electrons and the regular array of positive metal ions within a solid metal</td>
</tr>
<tr>
<td>3</td>
<td>molecule</td>
<td>a group of atoms held together by covalent bonds</td>
</tr>
<tr>
<td>3</td>
<td>neutron</td>
<td>an uncharged subatomic particle present in the nuclei of atoms – a neutron has a mass of 1 relative to a proton</td>
</tr>
<tr>
<td>3</td>
<td>non-metals</td>
<td>a class of chemical elements that are typically poor conductors of heat and electricity</td>
</tr>
<tr>
<td>3</td>
<td>nucleon number (A)</td>
<td>the total number of protons and neutrons present in the nucleus of an atom</td>
</tr>
<tr>
<td>3</td>
<td><strong>nucleus (of an atom)</strong> the central region of an atom that is made up of the protons and neutrons of the atom; the electrons orbit around the nucleus in different ‘shells’ or ‘energy levels’</td>
<td>原子核（原子的）原子的中心区域，由原子的质子和中子组成；电子围绕原子核以不同的“壳”或“能级”运行</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>3</td>
<td><strong>proton</strong> a subatomic particle with a relative mass of 1 and a charge +1 found in the nucleus of all atoms</td>
<td>质子是在所有原子的原子核中都具有相对质量1且电荷+1的亚原子粒子</td>
</tr>
<tr>
<td>3</td>
<td><strong>proton number</strong> another name for atomic number</td>
<td>质子数原子数的别称</td>
</tr>
<tr>
<td>3</td>
<td><strong>radioactivity</strong> the spontaneous decay of unstable radio-isotopes</td>
<td>放射性不稳定同位素的自发衰减</td>
</tr>
<tr>
<td>3</td>
<td><strong>salts</strong> ionic compounds made by the neutralisation of an acid with a base (or alkali); for example, copper(II) sulfate and potassium nitrate</td>
<td>通过酸与碱（或碱）中和而制得的盐离子化合物；例如，硫酸铜（II）和硝酸钾</td>
</tr>
<tr>
<td>3</td>
<td><strong>simple molecular substances</strong> are made up of individual molecules held together by covalent bonds: there are only weak forces between the molecules</td>
<td>简单的分子物质由通过共价键结合在一起的单个分子组成：分子之间只有弱力</td>
</tr>
<tr>
<td>3</td>
<td><strong>subatomic particles</strong> very small particles – protons, neutrons and electrons – from which all atoms are built</td>
<td>亚原子粒子非常小的粒子-质子，中子和电子-构成所有原子</td>
</tr>
<tr>
<td>3</td>
<td><strong>valency</strong> the combining power of an atom or group of atoms: in ionic compounds the valency of each ion is equal to its charge; in a covalent molecule the valency of an atom is the number of bonds that atom makes</td>
<td>化合价一个原子或一组原子的结合能：在离子化合物中，每个离子的化合价等于其电荷；在共价分子中，原子的化合价是原子形成的键的数量</td>
</tr>
</tbody>
</table>
7.4 ESSENTIAL EXAM QUESTIONS Paper 4 Topic 3 327marks

Subtopic Chem 3.1 Q# 1/ iGCSE Chemistry/2012/w/Paper 31/ Q2

(b) A radioactive isotope of iodine, $^{131}_{53}$I, is used to treat cancer.

(i) Define the term *isotope*.

(ii) How many protons, electrons and neutrons are there in one atom of $^{131}_{53}$I?

number of protons ...........
number of electrons ...........
number of neutrons ........... [2]

(iii) When this isotope, $^{131}_{53}$I, emits radiation, a different element with a proton number of 54 is formed. What is the name of this element?

Subtopic Chem 3.1 Q# 2/ iGCSE Chemistry/2012/s/Paper 31/

4 Vanadium is a transition element. It has more than one oxidation state. The element and its compounds are often used as catalysts.

(a) Complete the electron distribution of vanadium by inserting one number.

$$2 + 8 + \ldots \ldots + 2$$ [1]

Subtopic Chem 3.1 Q# 3/ iGCSE Chemistry/2010/w/Paper 31/

1 The table gives the composition of three particles.

<table>
<thead>
<tr>
<th>particle</th>
<th>number of protons</th>
<th>number of electrons</th>
<th>number of neutrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>15</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>B</td>
<td>15</td>
<td>18</td>
<td>16</td>
</tr>
<tr>
<td>C</td>
<td>15</td>
<td>15</td>
<td>17</td>
</tr>
</tbody>
</table>

(a) What is the evidence in the table for each of the following?

(i) Particle A is an atom.

........................................................................................................................................... [1]
(ii) They are all particles of the same element.

............................................................................................................................ [1]

(iii) Particle B is a negative ion.

............................................................................................................................ [2]

(iv) Particles A and C are isotopes.

............................................................................................................................ [2]

(b) (i) What is the electronic structure of particle A?

............................................................................................................................ [1]

(ii) What is the valency of the element?

............................................................................................................................ [1]

(iii) Is the element a metal or a non-metal? Give a reason for your choice.

............................................................................................................................ [1]

Subtopic Chem 3.1 Q# 4/ iGCSE Chemistry/2008/s/Paper 31/

2 (a) Complete the table which gives the names, symbols, relative masses and relative charges of the three subatomic particles.

<table>
<thead>
<tr>
<th>name</th>
<th>symbol</th>
<th>relative mass</th>
<th>relative charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>electron</td>
<td>e⁻</td>
<td></td>
<td></td>
</tr>
<tr>
<td>proton</td>
<td></td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>n</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

............................................................................................................................ [3]

(b) Use the information in the table to explain the following.

(i) Atoms contain charged particles but they are electrically neutral because they have no overall charge.

............................................................................................................................ [2]
(ii) Atoms can form positive ions.

.................................................................................................................................................. [2]

(iii) Atoms of the same element can have different masses.

.................................................................................................................................................. [2]

(iv) Scientists are certain that there are no undiscovered elements missing from the Periodic Table from hydrogen to lawrencium.

.................................................................................................................................................. [1]

Subtopic Chem 3.1 Q# 5/ iGCSE Chemistry/2007/w/Paper 3/

2 The table below gives the number of protons, neutrons and electrons in atoms or ions.

<table>
<thead>
<tr>
<th>particle</th>
<th>number of protons</th>
<th>number of electrons</th>
<th>number of neutrons</th>
<th>symbol or formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>9</td>
<td>10</td>
<td>10</td>
<td>$^{19}_{9}F^-$</td>
</tr>
<tr>
<td>B</td>
<td>11</td>
<td>11</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>18</td>
<td>18</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>15</td>
<td>18</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>13</td>
<td>10</td>
<td>14</td>
<td></td>
</tr>
</tbody>
</table>

(a) Complete the table. The first line is given as an example. [6]

(b) Which atom in the table is an isotope of the atom which has the composition 11p, 11e and 14n? Give a reason for your choice.

.................................................................................................................................................. [2]

Subtopic Chem 3.1 Q# 6/ iGCSE Chemistry/2006/s/Paper 3/ Q6

(ii) Use the Periodic Table to work out the number of protons and the number of neutrons in one atom of iron.

number of protons = .................... number of neutrons = .................... [1]

Subtopic Chem 3.1 Q# 7/ iGCSE Chemistry/2006/s/Paper 3/ Q6

(b) Some radioactive isotopes are used as nuclear fuels.

(ii) Give another use of radioactive isotopes. [1]
5 Strontium and zinc are both metals with a valency of 2. Strontium is more reactive than zinc. Its chemistry is similar to that of calcium.

(a) (i) Complete the following table that shows the number of protons, electrons and neutrons in each particle.

<table>
<thead>
<tr>
<th>particle</th>
<th>protons</th>
<th>electrons</th>
<th>neutrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{88}\text{Sr}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$^{90}\text{Sr}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$^{68}\text{Zn}^{2+}$</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(ii) Explain why $^{88}\text{Sr}$ and $^{90}\text{Sr}$ are isotopes.

(iii) Complete the electron distribution of an atom of strontium.

$2 + 8 + 18 + \ldots + \ldots$

Subtopic Chem 3.1 Q# 9/ iGCSE Chemistry/2002/w/Paper 3/ Q2 (a)

(ii) Complete the electron distribution of manganese by inserting one number.

$2 + 8 + \ldots + 2$

Subtopic Chem 3.21-2 Q# 10/ iGCSE Chemistry/2012/w/Paper 31/ Q5

(c) The structural formula of carbonyl chloride is given below.

\[
\begin{array}{c}
\text{Cl} \\
\text{C} \equiv \text{O} \\
\text{Cl}
\end{array}
\]

Draw a diagram showing the arrangement of the outer (valency) electrons in one molecule of this covalent compound.

Use o to represent an electron from a carbon atom.
Use x to represent an electron from a chlorine atom.
Use • to represent an electron from an oxygen atom.
7 Both strontium and sulfur have chlorides of the type \( \text{XCl}_2 \). The table below compares some of their properties.

<table>
<thead>
<tr>
<th></th>
<th>strontium chloride</th>
<th>sulfur chloride</th>
</tr>
</thead>
<tbody>
<tr>
<td>appearance</td>
<td>white crystals</td>
<td>red liquid</td>
</tr>
<tr>
<td>formula</td>
<td>( \text{SrCl}_2 )</td>
<td>( \text{SCl}_2 )</td>
</tr>
<tr>
<td>melting point/°C</td>
<td>874</td>
<td>(-120)</td>
</tr>
<tr>
<td>boiling point/°C</td>
<td>1250</td>
<td>59</td>
</tr>
<tr>
<td>conductivity of liquid</td>
<td>good</td>
<td>poor</td>
</tr>
<tr>
<td>solubility in water</td>
<td>dissolves to form a neutral solution</td>
<td>reacts to form a solution of pH 1</td>
</tr>
</tbody>
</table>

(iii) Strontium is a metal and sulfur is a non-metal. Explain why both have chlorides of the type \( \text{XCl}_2 \).

The electron distribution of a strontium atom is \( 2 + 8 + 18 + 8 + 2 \).

__________________________________________________________________________

__________________________________________________________________________ [2]

Subtopic Chem 3.21-2 Q# 12/ IGCSE Chemistry/2012/s/Paper 31/Q3

(b) Lithium reacts with nitrogen to form the ionic compound, lithium nitride.

(i) State the formula of the lithium ion. ...................... [1]

(ii) Deduce the formula of the nitride ion. .................... [1]

(iii) In all solid ionic compounds, the ions are held together in a lattice. Explain the term lattice.

__________________________________________________________________________

__________________________________________________________________________ [1]

(iv) What is the ratio of lithium ions to nitride ions in the lattice of lithium nitride? Give a reason for your answer.

......... lithium ions : ....... nitride ions

__________________________________________________________________________

__________________________________________________________________________ [2]
Subtopic Chem 3.21-2 Q# 13/ IGCSE Chemistry/2011/w/Paper 31/

1. This question is concerned with the following oxides.

   - sulfur dioxide
   - carbon monoxide
   - lithium oxide
   - aluminium oxide
   - nitrogen dioxide
   - strontium oxide

   (this list is referred to in the next question)

   (c) Lithium oxide is an ionic compound.

      (i) Identify another ionic oxide in the list on page 3.

      ................................................................. [1]

      (ii) Draw a diagram which shows the formula of lithium oxide, the charges on the ions and the arrangement of the valency electrons around the negative ion.

            Use o to represent an electron from an atom of oxygen.

            Use x to represent an electron from an atom of lithium.

Subtopic Chem 3.21-2 Q# 14/ IGCSE Chemistry/2011/s/Paper 31/ Q2

(b) The electron distribution of a selenium atom is $2 + 8 + 18 + 6$.

   (i) Selenium forms an ionic compound with potassium. Draw a diagram which shows the formula of this ionic compound, the charges on the ions and the arrangement of the valency electrons around the negative ion.

            Use o to represent an electron from an atom of potassium.

            Use x to represent an electron from an atom of selenium.
3 The following is a list of the electron distributions of atoms of unknown elements.

<table>
<thead>
<tr>
<th>element</th>
<th>electron distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2,5</td>
</tr>
<tr>
<td>B</td>
<td>2,8,4</td>
</tr>
<tr>
<td>C</td>
<td>2,8,8,2</td>
</tr>
<tr>
<td>D</td>
<td>2,8,18,8</td>
</tr>
<tr>
<td>E</td>
<td>2,8,18,8,1</td>
</tr>
<tr>
<td>F</td>
<td>2,8,18,18,7</td>
</tr>
</tbody>
</table>

(b) Elements C and F can form an ionic compound.

(i) Draw a diagram that shows the formula of this compound, the charges on the ions and the arrangement of the valency electrons around the negative ion. Use o to represent an electron from an atom of C. Use x to represent an electron from an atom of F.

(ii) Predict two properties of this compound.

..........................................................................................................................................................................................
..........................................................................................................................................................................................
..........................................................................................................................................................................................
..........................................................................................................................................................................................
..........................................................................................................................................................................................
..........................................................................................................................................................................................
..........................................................................................................................................................................................
..........................................................................................................................................................................................
..........................................................................................................................................................................................
..........................................................................................................................................................................................
..........................................................................................................................................................................................

[3] [2]
2 There are three types of giant structure – ionic, metallic and macromolecular.

(a) Sodium nitride is an ionic compound. Draw a diagram that shows the formula of the compound, the charges on the ions and the arrangement of the valency electrons around the negative ion.

Use $x$ to represent an electron from a sodium atom.
Use $o$ to represent an electron from a nitrogen atom.

3 Magnesium reacts with bromine to form magnesium bromide.

(a) Magnesium bromide is an ionic compound. Draw a diagram that shows the formula of the compound, the charges on the ions and the arrangement of outer electrons around the negative ion.
The electron distribution of a bromine atom is $2, 8, 18, 7$.

Use $x$ to represent an electron from a magnesium atom.
Use $o$ to represent an electron from a bromine atom.

(b) In the lattice of magnesium bromide, the ratio of magnesium ions to bromide ions is 1:2.

(i) Explain the term lattice.

(ii) Explain why the ratio of ions is 1:2.
4 Use your copy of the periodic table to help you answer these questions.

(a) Predict the formula of each of the following compounds.

(i) barium oxide .......................................................... [1]

(ii) boron oxide .......................................................... [1]

(b) Give the formula of the following ions.

(i) sulphide .......................................................... [1]

(ii) gallium .......................................................... [1]

2 Complete the following table.

<table>
<thead>
<tr>
<th>type of structure</th>
<th>particles present</th>
<th>electrical conductivity of solid</th>
<th>electrical conductivity of liquid</th>
<th>example</th>
</tr>
</thead>
<tbody>
<tr>
<td>ionic</td>
<td>positive and negative ions</td>
<td>poor</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2 The table shows the melting points, boiling points and electrical properties of the six substances A to F.

<table>
<thead>
<tr>
<th>substance</th>
<th>melting point / °C</th>
<th>boiling point / °C</th>
<th>electrical conductor at room temperature</th>
<th>electrical conductor of substance dissolved in water</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>961</td>
<td>2193</td>
<td>good</td>
<td>does not dissolve</td>
</tr>
<tr>
<td>B</td>
<td>113</td>
<td>444</td>
<td>does not conduct</td>
<td>does not dissolve</td>
</tr>
<tr>
<td>C</td>
<td>0</td>
<td>100</td>
<td>very poor</td>
<td>very poor</td>
</tr>
<tr>
<td>D</td>
<td>803</td>
<td>1465</td>
<td>does not conduct</td>
<td>good</td>
</tr>
<tr>
<td>E</td>
<td>-5 to -10</td>
<td>102 to 105</td>
<td>good</td>
<td>good</td>
</tr>
<tr>
<td>F</td>
<td>-85</td>
<td>-60</td>
<td>does not conduct</td>
<td>does not dissolve</td>
</tr>
</tbody>
</table>
(ii) Which **one** is an ionic compound?

[1]

Subtopic Chem 3.21-2 Q# 21/ IGCSE Chemistry/2005/w/Paper 3/

1 (a) The structure of a typical ionic compound is a regular arrangement of positive and negative ions.

(i) What is the name of this regular arrangement of particles?

[1]

(ii) Give **two** physical properties of ionic compounds.

[2]

(b) Ions are formed by electron loss or gain. The electron distribution of a magnesium atom is $2 + 8 + 2$ and of a nitrogen atom is $2 + 5$.

(i) Give the formula of the magnesium ion.

[1]

(ii) Give the formula of the nitride ion.

[1]

(iii) What is the formula of the ionic compound, magnesium nitride?

[1]

(iv) In this compound there is an ionic bond. Why are the two ions attracted to each other?

[1]
(e) Describe, by means of a simple diagram, the lattice structure of an ionic compound, such as caesium chloride.


5 The first three elements in Period 6 of the Periodic Table of the Elements are caesium, barium and lanthanum.

(d) Barium chloride is an ionic compound. Draw a diagram that shows the formula of the compound, the charges on the ions and gives the arrangement of the valency electrons around the negative ion.
   The electron distribution of a barium atom is 2.8.18.18.8.2
   
   Use x to represent an electron from a barium atom.
   Use o to represent an electron from a chlorine atom.

Subtopic Chem 3.21-2 Q# 24/ IGCSE Chemistry/2002/w/Paper 3/ Q3

(e) Draw a diagram that shows the arrangement of the valency electrons in the ionic compound sodium phosphide.

Use o to represent an electron from sodium.
Use x to represent an electron from phosphorus.
Subtopic Chem 3.21-2  Q# 25/ IGCSE Chemistry/2001/w/Paper 3/ Q5  

(c) Sulphur reacts violently with magnesium to form the ionic compound magnesium sulphide. Draw a diagram that shows the arrangement of the valency electrons in this compound.

Use O to represent an electron from a magnesium atom.
Use X to represent an electron from a sulphur atom.  

Subtopic Chem 3.23-4  Q# 26/ IGCSE Chemistry/2012/w/Paper 31/  

7 Both strontium and sulfur have chlorides of the type XCl₂. The table below compares some of their properties.

<table>
<thead>
<tr>
<th></th>
<th>strontium chloride</th>
<th>sulfur chloride</th>
</tr>
</thead>
<tbody>
<tr>
<td>appearance</td>
<td>white crystals</td>
<td>red liquid</td>
</tr>
<tr>
<td>formula</td>
<td>SrCl₂</td>
<td>SCl₂</td>
</tr>
<tr>
<td>melting point/°C</td>
<td>874</td>
<td>−120</td>
</tr>
<tr>
<td>boiling point/°C</td>
<td>1250</td>
<td>59</td>
</tr>
<tr>
<td>conductivity of liquid</td>
<td>good</td>
<td>poor</td>
</tr>
<tr>
<td>solubility in water</td>
<td>dissolves to form a neutral solution</td>
<td>reacts to form a solution of pH 1</td>
</tr>
</tbody>
</table>

(iv) Explain the difference in the electrical conductivity of liquid strontium chloride and liquid sulfur chloride.

........................................................................................................................................ [3]

Subtopic Chem 3.23-4  Q# 27/ IGCSE Chemistry/2012/w/Paper 31/  

4 Silicon(IV) oxide, SiO₂, and zirconium(IV) oxide, ZrO₂, are both macromolecules. They have similar physical properties but silicon(IV) oxide is acidic and zirconium(IV) oxide is amphoteric.

(a) Define the term macromolecule.

........................................................................................................................................ [1]
(b) (i) Predict three physical properties of these two oxides.

........................................................................................................................................................................................................................................ [3]

........................................................................................................................................................................................................................................ [3]

(ii) Name an element which has the same physical properties as these two oxides.

........................................................................................................................................................................................................................................ [1]

Subtopic Chem 3.23-4 Q# 28/ iGCSE Chemistry/2011/s/Paper 31/ Q2

(b) The electron distribution of a selenium atom is 2 + 8 + 18 + 6.

(ii) Draw a diagram showing the arrangement of the valency electrons in one molecule of the covalent compound selenium chloride.
Use x to represent an electron from an atom of selenium.
Use o to represent an electron from an atom of chlorine.

........................................................................................................................................................................................................................................ [3]

(iii) Predict two differences in the physical properties of these two compounds.

........................................................................................................................................................................................................................................ [2]

Subtopic Chem 3.23-4 Q# 29/ iGCSE Chemistry/2010/w/Paper 31/ Q6

(c) (i) Give the formulae of lithium fluoride and nitrogen fluoride.

lithium fluoride ........................................................................................................................................................................................................................................ [2]

nitrogen fluoride ........................................................................................................................................................................................................................................ [2]
(ii) Predict two differences in their properties.

................................................................................................................................................ [2]

(iii) Explain why these two fluorides have different properties.

................................................................................................................................................ [2]

Subtopic Chem 3.23-4 Q# 30/ IGCSE Chemistry/2010/w/Paper 31/

4 Ammonia is an important industrial chemical.

(a) (i) Give the electron structure of an atom of nitrogen.

................................................................................................................................................ [1]

(ii) Use this electronic structure, rather than the valency of nitrogen, to explain why the formula of ammonia is NH₃ not NH₄.

................................................................................................................................................ [2]

Subtopic Chem 3.23-4 Q# 31/ IGCSE Chemistry/2010/w/Paper 31/

6 The table below shows the elements in the second period of the Periodic Table and some of their oxidation states in their most common compounds.

<table>
<thead>
<tr>
<th>element</th>
<th>Li</th>
<th>Be</th>
<th>B</th>
<th>C</th>
<th>N</th>
<th>O</th>
<th>F</th>
<th>Ne</th>
</tr>
</thead>
<tbody>
<tr>
<td>number of outer electrons</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>oxidation state</td>
<td>+1</td>
<td>+2</td>
<td>+3</td>
<td>+4</td>
<td>-3</td>
<td>-2</td>
<td>-1</td>
<td>0</td>
</tr>
</tbody>
</table>

(a) (iii) Select two elements in the table which exist as diatomic molecules of the type X₂.

................................................................................................................................................ [1]
Subtopic Chem 3.23-4 Q# 32/ IGCSE Chemistry/2010/s/Paper 31/ Q5

(b) Two of the oxides of these elements are carbon dioxide, \( \text{CO}_2 \), and silicon(IV) oxide, \( \text{SiO}_2 \).

(i) Draw a diagram showing the arrangement of the valency electrons in one molecule of the covalent compound carbon dioxide.
Use \( x \) to represent an electron from a carbon atom.
Use \( o \) to represent an electron from an oxygen atom.

Subtopic Chem 3.23-4 Q# 33/ IGCSE Chemistry/2009/w/Paper 3/ Q4

(c) It is now known that the smell of the seaside is due to the chemical dimethyl sulfide, \( (\text{CH}_3)_2\text{S} \).

(i) Draw a diagram that shows the arrangement of the valency electrons in one molecule of this covalent compound.
Use \( x \) to represent an electron from a carbon atom.
Use \( o \) to represent an electron from a hydrogen atom.
Use \( \bullet \) to represent an electron from a sulfur atom.

Subtopic Chem 3.23-4 Q# 34/ IGCSE Chemistry/2009/w/Paper 3/

5 The first three elements in Group IV are carbon, silicon and germanium. The elements and their compounds have similar properties.

(a) The compound, silicon carbide, has a macromolecular structure similar to that of diamond.
(ii) Complete the following description of the structure of silicon carbide.

Each carbon atom is bonded to four ...................... atoms.

Each silicon atom is bonded to ...................... carbon atoms.  \[2\]

(b) Germanium(IV) oxide, GeO₂, has the same macromolecular structure as silicon(IV) oxide. Draw the structural formula of germanium(IV) oxide.

(ii) Potassium and calcium are very reactive metals at the top of the series. Because their ions have different charges, K⁺ and Ca²⁺, their compounds behave differently when heated.

(i) Explain why the ions have different charges.

........................................................................................................................................................................  \[2\]

Subtopic Chem 3.23-4 Q# 35/ IGCSE Chemistry/2008/w/Paper 31/ Q6

(b) Potassium and calcium are very reactive metals at the top of the series. Because their ions have different charges, K⁺ and Ca²⁺, their compounds behave differently when heated.

(i) Explain why the ions have different charges.

........................................................................................................................................................................  \[2\]

Subtopic Chem 3.23-4 Q# 36/ IGCSE Chemistry/2008/w/Paper 31/

2 There are three types of giant structure – ionic, metallic and macromolecular.
(c) Silicon(IV) oxide has a macromolecular structure.

(i) Describe the structure of silicon(IV) oxide (a diagram is not acceptable).

........................................................................................................................................................................  \[3\]

(ii) Diamond has a similar structure and consequently similar properties. Give two physical properties common to both diamond and silicon(IV) oxide.

........................................................................................................................................................................  \[2\]
(d) The structural formula of carbonyl chloride is given below.

\[
\begin{array}{c}
\text{O} \\
\text{C} \\
\text{Cl}
\end{array}
\]

Draw a diagram that shows the arrangement of the valency electrons in one molecule of this covalent compound.
Use \( x \) for an electron from a chlorine atom.
Use \( o \) for an electron from a carbon atom.
Use \( \bullet \) for an electron from an oxygen atom.

4 Use your copy of the periodic table to help you answer these questions.

(c) Draw a diagram showing the arrangement of the valency electrons in one molecule of the covalent compound nitrogen trichloride.

Use \( x \) to represent an electron from a nitrogen atom.
Use \( o \) to represent an electron from a chlorine atom.

2 Complete the following table.

<table>
<thead>
<tr>
<th>type of structure</th>
<th>particles present</th>
<th>electrical conductivity of solid</th>
<th>electrical conductivity of liquid</th>
<th>example</th>
</tr>
</thead>
<tbody>
<tr>
<td>macro molecular</td>
<td>atoms of two different elements in a giant covalent structure</td>
<td>poor</td>
<td>poor</td>
<td>..........</td>
</tr>
</tbody>
</table>
(d) Give a diagram showing the arrangement of the valency electrons in one molecule of the covalent compound urea. Its structural formula is given below.

Use o to represent an electron from a carbon atom. Use x to represent an electron from a hydrogen atom. Use • to represent an electron from a nitrogen atom.

[3]

(iii) Draw a diagram to show the arrangement of the valency electrons in one molecule of the covalent compound hydrogen sulphide.
Use o to represent an electron from a sulphur atom.
Use x to represent an electron from a hydrogen atom.

[2]
5. Strontium and sulphur chlorides both have a formula of the type $XCl_2$ but they have different properties.

<table>
<thead>
<tr>
<th>property</th>
<th>strontium chloride</th>
<th>sulphur chloride</th>
</tr>
</thead>
<tbody>
<tr>
<td>appearance</td>
<td>white crystalline solid</td>
<td>red liquid</td>
</tr>
<tr>
<td>melting point / °C</td>
<td>873</td>
<td>-80</td>
</tr>
<tr>
<td>particles present</td>
<td>ions</td>
<td>molecules</td>
</tr>
<tr>
<td>electrical conductivity of solid</td>
<td>poor</td>
<td>poor</td>
</tr>
<tr>
<td>electrical conductivity of liquid</td>
<td>good</td>
<td>poor</td>
</tr>
</tbody>
</table>

(a) The formulae of the chlorides are similar because both elements have a valency of 2. Explain why Group II and Group VI elements both have a valency of 2.

(b) Draw a diagram showing the arrangement of the valency electrons in one covalent molecule of sulphur chloride.
Use $x$ to represent an electron from a sulphur atom.
Use $o$ to represent an electron from a chlorine atom.

(c) Explain the difference in electrical conductivity between the following.

(i) solid and liquid strontium chloride

(ii) liquid strontium chloride and liquid sulphur chloride
(b) Silicon has the same type of macromolecular structure as diamond.

(i) Explain why one atom of either element can form four covalent bonds.

(ii) Predict two physical properties of silicon.

(iii) Name a different element that has a similar structure and properties to silicon.

(c) Describe the structure of silicon(IV) oxide. You may use a diagram.

(b) Draw a diagram to show the arrangement of the valency electrons in one molecule of nitrogen.
(e) Another compound that contains nitrogen and hydrogen is hydrazine, $\text{N}_2\text{H}_4$.

(i) Draw the structural formula of hydrazine. Hydrogen can form only one bond per atom but nitrogen can form three.

(ii) Draw a diagram that shows the arrangement of the valency electrons in one molecule of hydrazine. Hydrazine is a covalent compound. Use $x$ to represent an electron from a nitrogen atom. Use $o$ to represent an electron from a hydrogen atom.
2  Calcium and other minerals are essential for healthy teeth and bones. Tablets can be taken to provide these minerals.

Healthy Bones

Each tablet contains

- calcium
- magnesium
- zinc
- copper
- boron

(a) Boron is a non-metal with a macromolecular structure.

(i) What is the valency of boron?

(ii) Predict two physical properties of boron.

(iii) Name another element and a compound that have macromolecular structures.

   element ....................

   compound ....................

(iv) Sketch the structure of one of the above macromolecular substances.
4   Bromine is one of the halogens in Group VII.

(c)   Bromine reacts with phosphorus to form phosphorus tribromide. Draw a diagram showing the arrangement of the valency electrons in one molecule of this covalent compound. The electron distribution of bromine is:

\[ 2 + 8 + 18 + 7. \]

Use \( x \) to represent an electron from phosphorus. Use \( o \) to represent an electron from bromine. [3]

Subtopic Chem 3.23-4 Q# 48/ IGCSE Chemistry/2001/w/Paper 3/ Q5

(b)   The diagram shows a possible arrangement of the valency electrons in a molecule of sulphur dioxide.

O represents an electron from an oxygen atom
X represents an electron from a sulphur atom

(i) What type of covalent bond is labelled bond 1?

................................................................. [1]

(ii) What is unusual about the covalent bond labelled bond 2?

................................................................. [1]
5 The first three elements in Group IV are carbon, silicon and germanium. The elements and their compounds have similar properties.

(a) The compound, silicon carbide, has a macromolecular structure similar to that of diamond.

(i) A major use of silicon carbide is to reinforce aluminium alloys which are used in the construction of spacecraft. Suggest three of its physical properties.

(ii) Silicon carbide is used in the manufacture of silicon carbide bricks in the lining of furnaces. Suggest two other applications of silicon carbide bricks.

(c) Both iron and steel have typical metallic structures - a lattice of positive ions and a sea of electrons.

(i) Suggest an explanation for why they have high melting points.

(ii) Explain why, when a force is applied to a piece of steel, it does not break but just changes its shape.

2 About 4000 years ago the Bronze Age started in Britain. Bronze is an alloy of copper and tin.

(a) (i) Suggest a reason why a bronze axe was better than a copper axe.

(ii) Brass is another copper alloy. Name the other metal in brass.
(b) The diagram below shows the arrangement of particles in a pure metal.

![Diagram of pure metal particles]

(i) What is the name given to a regular arrangement of particles in a crystalline solid?

........................................................................................................................................ [1]

(ii) Draw a diagram which shows the arrangement of particles in an alloy.

........................................................................................................................................ [2]

(iii) Explain the term *malleable*.

........................................................................................................................................ [1]

(iv) Why are metals malleable?

........................................................................................................................................ [2]

Subtopic Chem 3.25 Q# 52/ iGCSE Chemistry/2010/s/Paper 31/ Q5 (a)

(iii) Explain why graphite is a soft material.

........................................................................................................................................ [2]

(iv) Give one use of graphite.

........................................................................................................................................ [1]

(b) Two of the oxides of these elements are carbon dioxide, CO₂, and silicon(IV) oxide, SiO₂.
(ii) A section of the macromolecular structure of silicon(IV) oxide is given below.

\[
\text{Si} \quad \text{O} \quad \text{O} \\
\text{O} \\
\]

Use this diagram to explain why the formula is SiO\textsubscript{2} not SiO\textsubscript{4}.

................................................................................................................................................................................................................................................................................................................................................................................................................................................... [2]

(iii) Predict two differences in the physical properties of these two oxides.

................................................................................................................................................................................................................................................................................................................................................................................................................................................... [2]

Subtopic Chem 3.25 Q# 53/ IGCSE Chemistry/2010/s/Paper 31/

5 Carbon and silicon are elements in Group IV. Both elements have macromolecular structures.

(a) Diamond and graphite are two forms of the element carbon.

(i) Explain why diamond is a very hard substance.

................................................................................................................................................................................................................................................................................................................................................................................................................................................... [2]

(ii) Give one use of diamond.

................................................................................................................................................................................................................................................................................................................................................................................................................................................... [1]
There are three types of giant structure – ionic, metallic and macromolecular.

(b) (i) Describe metallic bonding.

(ii) Use the above ideas to explain why metals are good conductors of electricity, 

metals are malleable.

Complete the following table.

<table>
<thead>
<tr>
<th>type of structure</th>
<th>particles present</th>
<th>electrical conductivity of solid</th>
<th>electrical conductivity of liquid</th>
<th>example</th>
</tr>
</thead>
<tbody>
<tr>
<td>metallic</td>
<td>and</td>
<td>good</td>
<td></td>
<td>copper</td>
</tr>
</tbody>
</table>

Two of the elements in chalcopyrite are the metal, copper, and the non-metal, sulphur. These have different properties. Copper is an excellent conductor of electricity and is malleable. Sulphur is a poor conductor and is not malleable, it is brittle. Explain, in terms of their structures, why this is so.

difference in electrical conductivity

difference in malleability
2 The table shows the melting points, boiling points and electrical properties of the six substances A to F.

<table>
<thead>
<tr>
<th>substance</th>
<th>melting point / °C</th>
<th>boiling point / °C</th>
<th>electrical conductor at room temperature</th>
<th>electrical conductor of substance dissolved in water</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>961</td>
<td>2193</td>
<td>good</td>
<td>does not dissolve</td>
</tr>
<tr>
<td>B</td>
<td>113</td>
<td>444</td>
<td>does not conduct</td>
<td>does not dissolve</td>
</tr>
<tr>
<td>C</td>
<td>0</td>
<td>100</td>
<td>very poor</td>
<td>very poor</td>
</tr>
<tr>
<td>D</td>
<td>803</td>
<td>1465</td>
<td>does not conduct</td>
<td>good</td>
</tr>
<tr>
<td>E</td>
<td>-5 to -10</td>
<td>102 to 105</td>
<td>good</td>
<td>good</td>
</tr>
<tr>
<td>F</td>
<td>-85</td>
<td>-60</td>
<td>does not conduct</td>
<td>does not dissolve</td>
</tr>
</tbody>
</table>

(v) Which substance is a metal? [1]

Subtopic Chem 3.25 Q# 58/ iGCSE Chemistry/2006/s/Paper 3/

4 The first three elements in Group IV are carbon, silicon, germanium.

(a) The element germanium has a diamond-type structure. Describe the structure of germanium. A diagram is acceptable. [2]

(b) Unlike diamond, graphite is soft and is a good conductor of electricity.

(i) Explain why graphite has these properties. [3]
(ii) Give a use of graphite that depends on one of these properties.

property

use

[1]

(c) Carbon dioxide and silicon(IV) oxide have similar formulae but different types of structure.

(i) Give the formulae of these oxides.

[1]

(ii) How are their structures different?

[2]

(d) All these elements form compounds with hydrogen called hydrides. The saturated hydrides of carbon are the alkanes. Predict the formula of the hydride of germanium which contains two germanium atoms.

[1]

Subtopic Chem 3.25 Q# 59/ iGCSE Chemistry/2004/s/Paper 3/

5 (a) Copper has the structure of a typical metal. It has a lattice of positive ions and a "sea" of mobile electrons. The lattice can accommodate ions of a different metal.

Give a different use of copper that depends on each of the following.

(i) the ability of the ions in the lattice to move past each other

[1]

(ii) the presence of mobile electrons

[1]

(iii) the ability to accommodate ions of a different metal in the lattice

[1]

Subtopic Chem 3.25 Q# 60/ iGCSE Chemistry/2003/w/Paper 3/ Q2 (b)

(ii) Describe the structure of a typical metal, such as zinc, and explain why it is malleable.

[3]
Q# 1/ iGCSE Chemistry/2012/w/Paper 31/ Q22

(b) (i) same Z / same number of protons; 
accept: atoms of the same element
   different number of neutrons / different nucleon number / different mass number; [1]

   (ii) 53 protons and 53 electrons; [1]
   78 neutrons; [1]

   (iii) xenon; [1]

Q# 2/ iGCSE Chemistry/2012/s/Paper 31/

4   (a) 2 + 8 + 11 + 2 [1]

Q# 3/ iGCSE Chemistry/2010/w/Paper 31/

1   (a) (i) same number of protons and electrons [1]

   (ii) all have the same number of protons / same proton number / same atomic number [1]

   (iii) more electrons than protons
   number of protons and electrons not equal ONLY [1]

   (iv) same number of protons (and electrons) / same proton number / same atomic number
   different number of neutrons / different mass number / nucleon number [1]

(b) (i) 2 + 8 + 5 [1]

   (ii) 3 / 5 [1]

   (iii) non-metal because it accepts electrons
   / needs 3e to complete outer energy level
   / because it is in Group V or 5e in outer shell
   note need both non-metal and reason for [1]

[Total: 9]

Q# 4/ iGCSE Chemistry/2008/s/Paper 31/

2   (a)

<table>
<thead>
<tr>
<th></th>
<th>e⁻ or e</th>
<th>1/1840 or 1/2000 or 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>electron</td>
<td></td>
<td>1/1837 or negligible</td>
</tr>
<tr>
<td>proton</td>
<td>p or p⁻ or H⁺</td>
<td>1</td>
</tr>
<tr>
<td>neutron</td>
<td>n</td>
<td>1</td>
</tr>
</tbody>
</table>

   each correct row (1) [3]

(b) (i) equal numbers of protons and electrons of positive and negative charges or charges cancel/balance
   or net charge = 0 [1]
Q# 5/ iGCSE Chemistry/2007/w/Paper 3/  
2 (a) $^{23}_{11}$Na

$^{40}_{18}$Ar

$^{31}_{15}$P$^{3+}$ [1] for charge and [1] for symbol etc.  

$^{27}_{13}$Al$^{3+}$ [1] for charge and [1] for symbol etc.  

ACCEPT +3 and −3  

NOTE Only the above are to be awarded the mark

(b) particle B or $^{23}_{11}$Na or sodium  

COND they have the same proton number or the same number of protons  

or the same atomic number  

NOT the same number of electrons  

Accept same number of electrons and protons

Q# 6/ iGCSE Chemistry/2006/s/Paper 3/ QiGCSE Chemistry/201 (b)

(ii) 26p and 30n

Q# 7/ iGCSE Chemistry/2006/s/Paper 3/ Q6 (b)

(ii) treatment of cancer, autoradiographs, tracer, sterilising food, surgical equipment, measuring thickness, checking welds

Q# 8/ iGCSE Chemistry/2005/w/Paper 3/  
Question 5

(a)(i) 38p 38e 50n

38p 38e 62n

30p 28e 35n

(ii) Same number of protons and different number of neutrons

(iii) 8+ 2

Q# 9/ iGCSE Chemistry/2002/w/Paper 3/ Q2 (a)

(ii) 13

Q# 10/ iGCSE Chemistry/2012/w/Paper 31/ Q5

(c) each chlorine 1bp and 3nbps;  

4e between carbon atom and oxygen atom;  

2nbps on oxygen atom;

Q# 11/ iGCSE Chemistry/2012/w/Paper 31/  

(ii) strontium loses 2e;  

sulfur gains 2e;
Q# 12/ iGCSE Chemistry/2012/s/Paper 31/Q3

(b) (i) Li⁺

(ii) N³⁻

(iii) regular arrangement of ions / particles / positive and negative ions alternate; not: atoms

(iv) 3:1; ratio to balance charges / reason in terms of valency;

Q# 13/ iGCSE Chemistry/2011/w/Paper 31/

(c) (i) strontium oxide
   accept: aluminium oxide

(ii) use correct formula
   cond: charges on ions
   6x and 2o around oxygen
   ignore: electrons around Li

Q# 14/ iGCSE Chemistry/2011/s/Paper 31/ Q2

(b) (i) correct formula

   cond following marks conditional on correct formula
   If covalent mark 1 only
   correct charges
   6x and 2o around anion
   do NOT penalise for incorrect coding
   ignore: electrons around potassium

Q# 15/ iGCSE Chemistry/2009/s/Paper 31/ Q3

(b) (i) CF₂ or CaI₂

   cond next two marks conditional on correct formula
   C²⁺ and F⁻ or Ca²⁺ and I⁻
   7x and 1o round F/I
   NOTE covalent = 0
   Ignore electrons around Ca
   accept arrow notation arrow from electron on calcium atom to iodine

(ii) high melting point or boiling point
    conducts when molten or in solution
    brittle
    correct chemical properties
    hard
    Any TWO
    NOT crystalline solid NOT does not conduct as a solid
Q# 16/ iGCSE Chemistry/2008/w/Paper 31/
2 (a) $3Na : 1N$ correct ratio
   correct charges
   8e around N

if no symbols then must have correct key
if covalent only mark 1
ignore electrons around sodium
if the response includes both a correct and an incorrect answer
do not select correct one, mark = 0

Q# 17/ iGCSE Chemistry/2007/w/Paper 3/
3 (a) Correct ratio $MgBr_2$ or $Mg^{2+}$ 2$Br^-$
Accept anywhere in space
IF formula suggests covalency then [1] only for $MgBr_2$
or $Mg^{2+}$ 2$Br^-$
correct charges $Mg^{2+}$ and $Br^-$
Do not be concerned about location of minus sign
8e around bromine
NOTE do not require correct coding – just 7 and 1 coded differently
NOTE ignore electrons around magnesium

(b) (i) pattern or order or regular or repeat or alternate
   COND positive and negative ions or atoms or molecules or particles
   NOTE Accept a sketch that shows the above, that is particles arranged in a regular way, e.g. any ionic compound such as sodium chloride

   (ii) Any reason from the list:
   charges must balance
   or based on valencies
   or group II and group VII
   or 2e in outer level and 7e in outer level
   or magnesium loses 2 electrons and bromine gains 1 electron (per atom)

Q# 18/ iGCSE Chemistry/2008/s/Paper 31/
4 (a) (i) $BaO$
   (ii) $B_2O_3$

(b) (i) $S^{2-}$
   (ii) $Ga^{3+}$

Q# 19/ iGCSE Chemistry/2008/s/Paper 31/
2 good
   named example e.g. sodium chloride
   ACCEPT correct formula

Q# 20/ iGCSE Chemistry/2006/w/Paper 3/
(ii) $D$
   (i) $D$
Q# 21/
Question 1

(a)(i) lattice

(ii) high melting point or high fixed points
poor conductor as solid
good conductor as liquid, accept either aqueous or molten hard
soluble in water
Any TWO

(b)(i) Mg$^{2+}$

(ii) N$^{3-}$

(iii) Mg$_3$N$_2$

(iv) opposite charges
Do NOT accept "attract" it is in the question
accept electrostatic attraction as a phrase

Q# 22/ iGCSE Chemistry/2003/s/Paper 3/ Q5
(e) alternating (positive and negative) pattern

Q# 23/ iGCSE Chemistry/2003/s/Paper 3/Q5
(d) correct formula 1Ba to 2Cl
charges correct
8e around the anion
All three points
Two points ONLY [1]
If covalent [0] out [2]

Q# 24/ iGCSE Chemistry/2002/w/Paper 3/ Q3
(c) 3Na to 1P
COND next two marks
correct charges
8e around P
If covalent then only one mark for 3Na to 1P

Q# 25/ iGCSE Chemistry/2001/w/Paper 3/ Q5
(c) 2+ on Mg
2- and 8e on sulphur
1Mg : 1S

Q# 26/ iGCSE Chemistry/2012/w/Paper 31/
(iv) molten strontium chloride has ions / ionic compound;
which can move;
sulfur chloride has no ions / only molecules / molecular / covalent;
Q# 27/ iGCSE Chemistry/2012/w/Paper 31/

4  (a) giant covalent;  
or: polymer made from monomers;  

(b)  (i) any three from:  
high mp / bp;  
hard;  
brITTLE;  
insoluble (in water);  
poor conductor of electricity / heat;  

(ii) carbon / diamond / silicon / boron;  
not: graphite  

Q# 28/ iGCSE Chemistry/2011/s/Paper 31/ Q2

(ii) correct formula  

If ionic mark 1 only  
cond  
2 bp and 2 nbp around selenium  
1 bp and 3 nbp around both chlorine atoms  

(iii) the ionic compound  
higher melting point / boiling point / less volatile  
conducts when molten or aqueous, covalent compound does not  
is soluble in water, covalent is not / ionic insoluble in organic solvents, covalent soluble  
in organic solvents  
harder  
any two  
not: note there has to be comparison between the ionic compound and the covalent compound  
not: density  

Q# 29/ iGCSE Chemistry/2010/w/Paper 31/ Q6

(c)  (i) LiF  
NF₃  

(ii) LiF has higher mp / bp  
LiF is a (crystalline) solid, NF₃ is probably a gas / a liquid  
/LiF is less volatile  
as liquids only LiF conducts  
LiF is soluble in water, NF₃ is not  
when both solids LiF is harder  
any two  

(iii) LiF is an ionic compound  
NF₃ is a covalent/molecular compound  
for stating that one is ionic and the other covalent [1] without specifying which is which  

Q# 30/ iGCSE Chemistry/2010/w/Paper 31/

4  (a)  (i) nitrogen 2+5  

(ii) needs three electrons  
to complete energy level  

[1]
Q# 31/ iGCSE Chemistry/2010/w/Paper 31/ Q6 (a)
  (iii) any two from nitrogen, oxygen and fluorine
       accept symbols / molecular formulae

Q# 32/ iGCSE Chemistry/2010/s/Paper 31/ Q5 (a)
  (b) (i) 4e between carbon and oxygens
       2 non-bonding pairs on both oxygens
       cond correct coding – only scored if marks 1 and 2 awarded
       ignore O₂ in atom

Q# 33/ iGCSE Chemistry/2009/w/Paper 3/ Q4
  (c) (i) correct structural skeleton
       COND 4bp around both carbon atoms
       2bp and 2nbp around sulfur atom
       NOTE marks 2 and 3 can only be awarded if mark 1 has been scored

Q# 34/ iGCSE Chemistry/2009/w/Paper 3/
  (ii) silicon
       four

  (b) diagram to include:
      each germanium atom bonded 4 oxygen atoms
      each oxygen to 2 germanium atoms
      looks or stated to be tetrahedral
      “tetrahedral” scores mark even if diagram does not look tetrahedral
      independent marking of three points

Q# 35/ iGCSE Chemistry/2008/w/Paper 31/ Q6
  (b) (i) potassium has one valency electron
       or loses one electron
       calcium has two valency electrons
       or loses two electrons

Q# 36/ iGCSE Chemistry/2008/w/Paper 31/
  (c) (i) tetrahedral
       1Si : 4O bonded/surrounded, etc.
       1O : 2 Si

       NOT molecules of oxygen, etc.
       NOT intermolecular forces
       ONLY tetrahedral can score for either of the above

Despite what the question states, ACCEPT a clear accurate diagram which shows the
above three points.

(ii) hard
    high mp or bp
    colourless (NOT clear) or shiny or translucent
    non/poor conductor (of electricity)
    brittle
    insoluble
    any TWO

    NOT crystalline or strong
Q# 37/ iGCSE Chemistry/2008/s/Paper 31/ Q5

(d) 8e around both chlorine atoms
  4e between carbon and oxygen atoms
  8e around carbon atom
  8e around oxygen
  if a bond contains a line with no electrons, no marks for atoms joined by that line
  ignore keying [1]

Q# 38/ iGCSE Chemistry/2008/s/Paper 31/

(c) NC\textsubscript{3}
  COND 8e (1bp and 3nbp) around each chlorine [1]
  COND 8e (3bp and 1nbp) around nitrogen [1]

Q# 39/ iGCSE Chemistry/2008/s/Paper 31/

silica or silicon(IV) oxide or sand or silicon oxide
named polymer only TWO elements [1]

Q# 40/ iGCSE Chemistry/2006/w/Paper 3/ Q5

(d) Correct diagram for urea
  one error ONLY [2]
  two errors ONLY [1]
  three errors 0

Q# 41/ iGCSE Chemistry/2005/s/Paper 3/ 4 (b)

(iii) 2H to 1S
  COND 8e around sulphur atom
  2e per hydrogen atom
  THREE correct [2]
  TWO from above [1]
  Ionic structure = [0]

Q# 42/ iGCSE Chemistry/2004/w/Paper 3/

5 (a) Group II metals will lose 2e
  Group VI elements will gain 2e [1]

(b) SCl\textsubscript{2}
  COND 8e around both chlorine atoms [1]
  8e around sulphur with 2nbp and 2bp [1]
  If x and o reversed ignore if this is the only error

(c) (i) Ions cannot move in solid or can move in liquid [1]

(ii) No ions in sulphur chloride or it is covalent or only molecules or only strontium chloride has ions. OR [1]

Q# 43/ iGCSE Chemistry/2004/s/Paper 3/ QiGCSE Chemistry/201

(b) (i) both have four outer or valency electrons
  need to share four more
  or need four more to complete energy level
  NOT four bonds [1]

(ii) hard
  brittle
  high melting or boiling point
  poor conductor of electricity or semi-conductor
  any TWO
  NOT insoluble in water, NOT tough
  NOT appearance [2]

(iii) germanium or carbon
  NOT graphite [1]
(c)

(iii) 4 oxygen atoms around 1 silicon atom
2 silicon atoms around 1 oxygen
If some wrong chemistry, such as ionic MAX
2/3

Q# 44/ iGCSE Chemistry/2004/s/Paper 3/ Q3

(b) 6 electrons in bond between two nitrogen atoms
2 electrons on each nitrogen
ignore any coding of electrons with dots or crosses

Q# 45/ iGCSE Chemistry/2003/w/Paper 3/ QIGCSE Chemistry/201

(c) (i) correct structural formula

(ii) 8e around nitrogen
2e around each hydrogen

Q# 46/ iGCSE Chemistry/2003/s/Paper 3/

2 (a) (i) ignore any charges
(iii) high melting or boiling point
hard
poor conductor of electricity or heat
brittle
Any TWO
NOT insoluble, dull, or malleable
(iii) carbon, graphite diamond silicon, germanium
silicon (IV) oxide or silica or silicon dioxide or silicon oxide
or sand or silicon carbide or named polymer
(iv) four around one
cond looks tetrahedral or shows continuation
For graphite layers [1] weak bonds between layers [1]
Accept any macromolecule, no link with (iii)
For polymer repeat unit [1] continuation [1]

Q# 47/ iGCSE Chemistry/2002/s/Paper 3/ Q4

(c) P and 3Br
COND upon first mark being awarded
3bp and labp around phosphorus
8e around each bromine
if charges then first mark only

Q# 48/ iGCSE Chemistry/2001/w/Paper 3/ Q5

(b) (i) double
(ii) both electrons from sulphur or equivalent
Q# 49/ iGCSE Chemistry/2009/w/Paper 3/

5 (a) (i) strong
   hard
   light or low density
   high melting point or high fixed points
   Accept high strength to weight ratio for [2]
   it includes marks 1 and 3
   any THREE

Q# 50/ iGCSE Chemistry/2011/s/Paper 31/ Q3

(c) (i) strong attractive forces / strong bonds / bonds hard to break / requires a lot of energy to break bonds
   not between ions, not between positive and negative ions,
   not between electrons
   between positive ions and (negative) electrons / opposite charges attract

   (ii) because the layers, lattice or rows of ions/cations
        accept sheets of ions
        not atoms / molecules / protons / nuclei
        can move / slip / slide past each other

Q# 51/ iGCSE Chemistry/2010/w/Paper 31/

2 (a) (i) harder / stronger / any sensible suggestion which relates to better properties for purpose
        e.g. stays sharp longer / cuts better / more corrosion resistant

       (ii) zinc

(b) (i) lattice

       (ii) regular pattern of one type of atom
            with different atom interspersed
            can show the difference – size, shading, label etc.

       (iii) can change its shape by force / plastically deform / can be hammered into sheets / can bend etc.

       (iv) particles / ions / atoms / layers
            cond can slide past each other
            or metallic bond is non-directional
            particles can move past each other

Q# 52/ iGCSE Chemistry/2010/s/Paper 31/ Q5 (a)

   (iii) layer structure / sheets
        molecules / ions in layers = [0]
        layers can slide (over each other)

   (iv) lubricant / pencils / electrodes
        mark first use offered
b

(ii) 4O around each Si
2Si around each O
must refer to diagram not valencies or electron distributions

(iii) SiO₂ has higher mp or bp
SiO₂ is a solid, CO₂ is a gas (at rtp)
(when both are solids) then SiO₂ is harder
has higher density
SiO₂ insoluble, CO₂ soluble
any two, comparison needed

Q# 53/ iGCSE Chemistry/2010/s/Paper 31/

5 (a) (i) macromolecular / giant covalent / giant atomic
all atoms held in position / in tetrahedral structure / to four other carbon
atoms / all strong bonds

(ii) jewellery / drilling / cutting / engraving / cutting edges in scalpels
mark first use offered

Q# 54/ iGCSE Chemistry/2008/w/Paper 31/

(b) (i) positive ions or cations
NOT atoms or cores or nuclei
layers or lattice or regular pattern
delocalised or free or mobile electrons or sea

OR positive ions or cations
NOT atoms or cores or nuclei
attraction between ions and electrons
delocalised or free or mobile electrons or sea
the attraction/electrostatic bonding must be between ions and
delocalised electrons, between cations and anions does not score
ACCEPT bond if qualified - electrostatic bond, etc.
if molecular or molecules then cannot score cation mark

(ii) delocalised/free/mobile electrons
or electrons can move

layers or ions or atoms or particles
NB more flexible than 2(b)(i)
can slip or move past each other or bonding non-directional

electrons [1] and positive ions [1]
good

Q# 55/ iGCSE Chemistry/2008/s/Paper 31/

Q# 56/ iGCSE Chemistry/2006/w/Paper 3/Q6

(c) Copper has delocalised electrons
In sulphur the electrons are localised or cannot move in the piece of sulphur

In copper there are layers of copper atoms/ions
Which can slip
In sulphur there are no layers

Q# 57/ iGCSE Chemistry/2006/w/Paper 3/

(v) A
Q# 58/ iGCSE Chemistry/2006/s/Paper 3/

4 (a) 4 Ge atoms around 1 Ge
Looks tetrahedral or stated to be

(b) (i) Graphite has layers
COND that can move/slip
or weak bonds between layers

Graphite has delocalised/free/mobile electrons

(ii) property and use
soft lubricant or pencils
OR good conductor electrodes or in electric motors

(c) (i) CO₂ and SiO₂ or XO₂

(ii) CO₂ molecular or simple molecules or simple covalent
SiO₂ macromolecular or giant covalent

(d) Ge₂H₆

Q# 59/ iGCSE Chemistry/2004/s/Paper 3/

5. (a) Has to be three different uses.

any use that depends on malleability or ductility-
jewellery, pipes, wires, sheets, roofing, ornaments
NOT that it is malleable or ductile

electrical wires or cooking utensils or electrodes (good) conductor

making alloys or named alloy

Q# 60/ iGCSE Chemistry/2003/w/Paper 3/ Q2 (b)

(ii) lattice or layers of (positive) ions
delocalised or free or mobile electrons
layers/atoms/particles can slip
7.1 Essential End of Topic 3 Review and Reflection

Looking at the goals you could have achieved and the goals you actually achieved try to reflect on your progress.

Try to be as honest and as detailed as possible. Sometimes you may think you have thought about an idea well, but when you talk with someone else, or write it out, it helps you better understand and allows you think more completely and more clearly.

Did you achieve more goals this topic than last topic?

Fill in this table

<table>
<thead>
<tr>
<th>Level</th>
<th>Number of goals achieved at each level</th>
<th>Success rate, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>FUNDAMENTAL</td>
<td>/5</td>
<td></td>
</tr>
<tr>
<td>ESSENTIAL</td>
<td>/10</td>
<td></td>
</tr>
<tr>
<td>EXTENSION</td>
<td>/13</td>
<td></td>
</tr>
<tr>
<td>EXCEPTIONAL</td>
<td>/10</td>
<td></td>
</tr>
</tbody>
</table>

Do you feel you tried harder? If yes, what helped you to do so? If not, why not?

What could you do differently next time, in addition to what you are already doing to improve, not only your score in the end of topic tests and other assessed activities, but also in how you learn. How could you become a more effective student to get more learning out of the time you are investing in your studies?

What did you enjoy most about this topic?

What did you find most difficult?

What did you find easiest?

On a scale of 1 being hardest and 5 being most difficult, circle how challenging you found this topic

1  2  3  4  5

What could be done to make this topic easier to understand?

Do you have any questions about this topic?
## 8.1 End of Topic 4.1 Goals Checklist

For each topic you ought to try to do as many of the following things to get the most out of your time, the resources available to you and to help you grow as a student. Tick each goal off as you complete it. Growth is difficult and uncomfortable, but you should choose to do these things, and the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win!

<table>
<thead>
<tr>
<th>Aspect</th>
<th>What you should have done</th>
<th>Yes/No</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interacted with your teacher</td>
<td>Ask your teacher 1 question, about anything, once a week</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Try to answer one question asked by your teacher at least once a week</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Ask your teacher one question about something you do not understand in science once a week</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Ask your teacher one question about something to do with science every lesson</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td>Notes and follow up notes</td>
<td>Complete set of class note</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Attempted</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Completed</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Completed to an exemplary standard</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Attempted the Mind Map for this topic</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Completed the Mind Map for this topic</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td>Textbook</td>
<td>Read ahead before the topic has been started</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Highlighted key ideas and translate new words</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Completed the questions at the end of each 2 page spread in your exercise book</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Added to your class notes ideas and important information from the textbook that you learnt</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td>Past Exam Questions</td>
<td>Worked on at least 25% of the exam questions in this workbook</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Attempted more than 25% of the questions and those questions you have completed you have marked in a different colour pen</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Completed and marked all questions here</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Completed, marked and additional key ideas where you have located the most difficult marks added to your notebook</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Used the resources available online to answer additional questions not found in this workbook on the current topic.</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Ask your teacher about an exam question that they cannot answer</td>
<td></td>
<td>EXCEPTIONALLY SMASHING!!!</td>
</tr>
<tr>
<td>Assessed Activities</td>
<td>Complete the word list activity using the word list at the front of each topic as little as possible</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities, either in class or as homework</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 70% on average</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 80% on average</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 90% on average</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td>End of Topic Test</td>
<td>Revised sufficiently well to improve upon your score from the previous test (except if you are scoring over 90%, then just write Y for this goal)</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Scored 10% higher than your current average</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Scored 15% or more than your previous end of topic average</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Scored over 90%</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Scored over 95%</td>
<td></td>
<td>SMASHING!!!</td>
</tr>
</tbody>
</table>
### Topic 4.1 Syllabus

**4 Stoichiometry**

#### 4.1 Stoichiometry

**Core**
- Use the symbols of the elements and write the formulae of simple compounds
- Deduce the formula of a simple compound from the relative numbers of atoms present
- Deduce the formula of a simple compound from a model or a diagrammatic representation
- Construct word equations and simple balanced chemical equations
- Define relative atomic mass, \( A_r \), as the average mass of naturally occurring atoms of an element on a scale where the \(^{12}\text{C} \) atom has a mass of exactly 12 units
- Define relative molecular mass, \( M_r \), as the sum of the relative atomic masses. (Relative formula mass or \( M \), will be used for ionic compounds.)

(Calculations involving reacting masses in simple proportions may be set. Calculations will not involve the mole concept.)

**Supplement**
- Determine the formula of an ionic compound from the charges on the ions present
- Construct equations with state symbols, including ionic equations
- Deduce the balanced equation for a chemical reaction, given relevant information
## 8.3 ESSENTIAL Glossary for Keywords for this topic (4.1 Stoichiometry)

<table>
<thead>
<tr>
<th>Topic #</th>
<th>English</th>
<th>Chinese</th>
</tr>
</thead>
<tbody>
<tr>
<td>balanced chemical (symbol) equation</td>
<td>a summary of a chemical reaction using chemical formulae – the total number of any of the atoms involved is the same on both the reactant and product sides of the equation</td>
<td>平衡化学（符号）方程式·使用化学式进行化学反应的摘要–涉及的任何原子总数在方程式的反应物和产物侧均相同</td>
</tr>
<tr>
<td>chemical reaction</td>
<td>a change in which a new substance is formed</td>
<td>化学反应形成新物质的变化</td>
</tr>
<tr>
<td>formula (chemical)</td>
<td>a shorthand method of representing chemical elements and compounds using the symbols of the elements</td>
<td>公式（化学）：使用元素符号表示化学元素和化合物的简写方法</td>
</tr>
<tr>
<td>ionic equation</td>
<td>the simplified equation for a reaction involving ionic substances: only those ions which take part in the reaction are shown</td>
<td>离子方程式涉及离子物质的反应的简化方程式：仅显示那些参与反应的离子</td>
</tr>
<tr>
<td>law of conservation of mass</td>
<td>matter cannot be lost or gained in a chemical reaction – the total mass of the reactants equals the total mass of the products</td>
<td>物质守恒定律在化学反应中不会丢失或获得–反应物的总质量等于产物的总质量</td>
</tr>
<tr>
<td>molecular formula</td>
<td>a formula which shows the actual number of atoms of each element present in a molecule of the compound</td>
<td>分子式，表示化合物分子中存在的每种元素的实际原子数的分子式</td>
</tr>
<tr>
<td>molecular mass</td>
<td>another, less precise, name for relative molecular mass</td>
<td>分子量相对不太精确的另一个称呼是相对分子量</td>
</tr>
<tr>
<td>products</td>
<td>(in a chemical reaction) the substance(s) produced by a chemical reaction</td>
<td>产品（在化学反应中）由化学反应产生的物质</td>
</tr>
<tr>
<td>reactants</td>
<td>(in a chemical reaction) the chemical substances that react together in a chemical reaction</td>
<td>反应物（在化学反应中）在化学反应中一起反应的化学物质</td>
</tr>
<tr>
<td>spectator ions</td>
<td>these are present in a chemical reaction but take no part in it. They are not included in ionic equations</td>
<td>这些离子存在于化学反应中，但不参与其中。它们不包含在离子方程式中</td>
</tr>
<tr>
<td>standard atom</td>
<td>the atom against which the relative atomic masses of all other atoms are measured using the mass spectrometer; one atom of the carbon-12 isotope is given a mass of exactly 12</td>
<td>标准原子使用质谱仪测量所有其他原子的相对原子质量的原子；碳12同位素的一个原子的质量刚好为12</td>
</tr>
<tr>
<td>state symbols</td>
<td>these are used to show the physical state of the reactants and products in a chemical reaction: they are (s) solid, (l) liquid, (g) gas and (aq) dissolved in solution in water</td>
<td>状态符号，用于显示化学反应中反应物和产物的物理状态：它们是（s）固体，（l）液体，（g）气体和（aq）溶解在水中的溶液</td>
</tr>
<tr>
<td>symbol (chemical)</td>
<td>a simple letter, or group of letters, that represents an element in a chemical formula</td>
<td>符号（化学）一个简单的字母或一组字母，代表化学式中的元素</td>
</tr>
<tr>
<td>word equation</td>
<td>a summary of a chemical reaction using the chemical names of the reactants and products</td>
<td>词方程式，是使用反应物和产物的化学名称进行的化学反应的摘要</td>
</tr>
<tr>
<td>relative formula mass (Mr)</td>
<td>the sum of all the relative atomic masses of the atoms present in a ‘formula unit’ of a substance</td>
<td>相对公式质量（Mr）物质“公式单位”中存在的所有原子的相对原子质量的总和</td>
</tr>
<tr>
<td>relative molecular mass (Mr)</td>
<td>the sum of all the relative atomic masses of the atoms present in a molecule</td>
<td>相对分子质量（Mr）分子中所有原子的所有相对原子质量的总和</td>
</tr>
</tbody>
</table>
### Other Keywords that are needed for Topic 4.2 which will be covered later on in your studies:

<table>
<thead>
<tr>
<th>English</th>
<th>Chinese</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Topic #</strong></td>
<td><strong>English</strong></td>
</tr>
<tr>
<td>1</td>
<td><strong>concentration</strong> a measure of how much solute is dissolved in a solvent. Solutions can be dilute (with a high proportion of the solvent), or concentrated (with a high proportion of the solute)</td>
</tr>
<tr>
<td>1</td>
<td><strong>empirical formula</strong> a formula for a compound which shows the simplest ratio of atoms present</td>
</tr>
<tr>
<td>1</td>
<td><strong>hydrated salts</strong> ionic compounds that contain water of crystallisation between the ions within the solid</td>
</tr>
<tr>
<td>1</td>
<td><strong>molar concentration</strong> the measure of the concentration of a solution in terms of the number of moles of the solute dissolved per cubic decimetre of solution (mol/dm3)</td>
</tr>
<tr>
<td>1</td>
<td><strong>molar mass</strong> the mass, in grams, of one mole of a substance</td>
</tr>
<tr>
<td>1</td>
<td><strong>molar volume of a gas</strong> one mole of any gas has the same volume under the same conditions of temperature and pressure (24 dm3 at one atmosphere and room temperature)</td>
</tr>
<tr>
<td>1</td>
<td><strong>mole</strong> the measure of amount of substance in chemistry; one mole of a substance has a mass equal to its relative formula mass in grams – that amount of substance contains 6.02 × 10^23 (the Avogadro constant) atoms, molecules or formula units depending on the substance considered</td>
</tr>
<tr>
<td>1</td>
<td><strong>percentage purity</strong> a measure of the purity of the product from a reaction carried out experimentally: percentage purity = mass of pure product mass of impure product ×100</td>
</tr>
<tr>
<td>1</td>
<td><strong>percentage yield</strong> a measure of the actual yield of a reaction when carried out experimentally compared to the theoretical yield calculated from the equation: percentage yield = actual yield predicted yield ×100</td>
</tr>
<tr>
<td>1</td>
<td><strong>standard solution</strong> a solution whose concentration is known precisely – this solution is then used to find the concentration of another solution by titration</td>
</tr>
<tr>
<td>1</td>
<td><strong>structural formula</strong> the structural formula of an organic molecule shows how the atoms and bonds in a molecule are arranged in space: all the atoms and covalent bonds must be shown</td>
</tr>
<tr>
<td>1</td>
<td><strong>titration</strong> a method of quantitative analysis using solutions: one solution is slowly added to a known volume of another solution using a burette until an end-point is reached</td>
</tr>
<tr>
<td>1</td>
<td><strong>water of crystallisation</strong> water included in the structure of certain salts as they crystallise; for example, copper(II) sulfate pentahydrate (CuSO4.5H2O) contains five molecules of water of crystallisation per molecule of copper(II) sulfate</td>
</tr>
</tbody>
</table>
8.4 EXTENSION Keywords
You do not need to understand these words to score a good A, or even a low A* but if you are aiming for a good or high A* then understanding words like these here will be helpful.

<table>
<thead>
<tr>
<th>Avogadro constant another name for a mole</th>
<th>Avogadro常数的另一个名字</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>mass concentration</strong> the measure of the concentration of a solution in terms of the mass of the solute, in grams, dissolved per cubic decimetre of solution (g/dm3)</td>
<td>质量浓度，以每立方分米溶液中溶解的溶质质量（克）为单位的溶液浓度的量度（g/dm3）</td>
</tr>
<tr>
<td><strong>relative atomic mass (Ar)</strong> the average mass of an atom of an element, taking account of the isotopes of the element, on a scale where a carbon-12 atom has a mass of exactly 12</td>
<td>相对原子质量（Ar）元素的原子平均质量，考虑到元素的同位素，碳12原子的质量恰好为12</td>
</tr>
</tbody>
</table>

8.5 ESSENTIAL Active Learning Activity 1 Balancing chemical equations
Part 1

1. \( \text{____ Fe} + \text{____ H}_2\text{SO}_4 \rightarrow \text{____ Fe}_2(\text{SO}_4)_3 + \text{____ H}_2 \)

2. \( \text{____ C}_2\text{H}_6 + \text{____ O}_2 \rightarrow \text{____ H}_2\text{O} + \text{____ CO}_2 \)

3. \( \text{____ KOH} + \text{____ H}_3\text{PO}_4 \rightarrow \text{____ K}_3\text{PO}_4 + \text{____ H}_2\text{O} \)

4. \( \text{____ SnO}_2 + \text{____ H}_2 \rightarrow \text{____ Sn} + \text{____ H}_2\text{O} \)

5. \( \text{____ NH}_3 + \text{____ O}_2 \rightarrow \text{____ NO} + \text{____ H}_2\text{O} \)

6. \( \text{____ KNO}_2 + \text{____ H}_2\text{CO}_3 \rightarrow \text{____ K}_2\text{CO}_3 + \text{____ HNO}_3 \)

7. \( \text{____ B}_2\text{Br}_6 + \text{____ HNO}_3 \rightarrow \text{____ B(NO}_3)_3 + \text{____ HBr} \)

8. \( \text{____ BF}_3 + \text{____ Li}_2\text{SO}_3 \rightarrow \text{____ B}_2(\text{SO}_3)_3 + \text{____ LiF} \)

9. \( \text{____ (NH}_4)_2\text{PO}_4 + \text{____ Pb(NO}_3)_4 \rightarrow \text{____ Pb}_2(\text{PO}_4)_4 + \text{____ NH}_4\text{NO}_3 \)

10. \( \text{____ SeCl}_6 + \text{____ O}_2 \rightarrow \text{____ SeO}_2 + \text{____ Cl}_2 \)
Part 2

1. _____ CH₄ + _____ O₂ → _____ CO₂ + _____ H₂O

2. _____ Na⁺ + _____ Cl⁻ → _____ NaCl

3. _____ Al + _____ O₂ → _____ Al₂O₃

4. _____ N₂⁺ + _____ H₂ → _____ NH₃

5. _____ CO(g) + _____ H₂(g) → _____ C₆H₁₃(l) + _____ H₂O

6. _____ FeO₃(s) + _____ CO(g) → _____ Fe(l) + _____ CO₂(g)

7. _____ H₂SO₄ + _____ Pb(OH)₄ → _____ Pb(SO₄)₂ + _____ H₂O

8. _____ Al + _____ HCl → _____ AlCl₃ + _____ H₂

9. _____ Ca₅(PO₄)₂ + _____ H₂SO₄ → _____ CaSO₄ + _____ Ca(H₂PO₄)₂

10. _____ H₃PO₄ + _____ HCl → _____ PCl₅ + _____ H₂O

**Extension activity**

Name as many of the chemicals above as you can.
8.6 FUNDAMENTAL Active Learning Activity 2 Table of Common, and Not-So Common Ions

Fundamental Activity

Use the information on the next page to find these ions and write out their chemical formula:

<table>
<thead>
<tr>
<th>Ion</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbonate</td>
<td></td>
</tr>
<tr>
<td>Phosphate</td>
<td></td>
</tr>
<tr>
<td>Sulfate</td>
<td></td>
</tr>
<tr>
<td>Nitrate</td>
<td></td>
</tr>
<tr>
<td>Ammonium</td>
<td></td>
</tr>
<tr>
<td>Silver</td>
<td></td>
</tr>
</tbody>
</table>

Exceptional Reflection:

Transition metals are commonly said, at iGCSE to all have variable oxidation states, but some transition metals listed here are only given one charge. Can you think of why this may be? Is it accurate to call elements like Zn and Cd transition metals? If you go onto a website like ChemGuide find out if these metals really are considered transition metals (this is A-level material) either by scanning this code or clicking the link below:

https://www.chemguide.co.uk/inorganic/transition/features.html#top
Table of Ions and Charges

**Polyatomic Ions**

<table>
<thead>
<tr>
<th>-1 charge</th>
<th>-2 charge</th>
<th>+1 charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>acetate, $\text{C}_2\text{H}_3\text{O}_2^-$</td>
<td>carbonate, $\text{CO}_3^{2-}$</td>
<td>ammonium, $\text{NH}_4^+$</td>
</tr>
<tr>
<td>chlorate, $\text{ClO}_3^-$</td>
<td>chromate, $\text{CrO}_4^{2-}$</td>
<td></td>
</tr>
<tr>
<td>chlorite, $\text{ClO}_2^-$</td>
<td>dichromate, $\text{Cr}_2\text{O}_7^{2-}$</td>
<td></td>
</tr>
<tr>
<td>cyanide, $\text{CN}^-$</td>
<td>sulfate, $\text{SO}_4^{2-}$</td>
<td></td>
</tr>
<tr>
<td>hydrogen carbonate, $\text{HCO}_3^-$ (also called bicarbonate)</td>
<td>sulfite, $\text{SO}_3^{2-}$</td>
<td></td>
</tr>
<tr>
<td>hydroxide, $\text{OH}^-$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>hypochlorite, $\text{ClO}^-$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>iodate, $\text{IO}_3^-$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>nitrate, $\text{NO}_3^-$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>nitrite, $\text{NO}_2^-$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>permanganate, $\text{MnO}_4^-$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>perchlorate, $\text{ClO}_4^-$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Transition Metals without varying charges:**

<table>
<thead>
<tr>
<th>Ion</th>
<th>Systematic Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{Ag}^+ $</td>
<td>silver</td>
</tr>
<tr>
<td>$\text{Cd}^{2+} $</td>
<td>cadmium</td>
</tr>
<tr>
<td>$\text{Zn}^{2+} $</td>
<td>zinc</td>
</tr>
</tbody>
</table>

**Transition Metals with varying charges:**

<table>
<thead>
<tr>
<th>Ion</th>
<th>Systematic Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{Fe}^{3+} $</td>
<td>iron(III)</td>
</tr>
<tr>
<td>$\text{Fe}^{2+} $</td>
<td>iron(II)</td>
</tr>
<tr>
<td>$\text{Cu}^{2+} $</td>
<td>copper(II)</td>
</tr>
<tr>
<td>$\text{Cu}^+ $</td>
<td>copper(I)</td>
</tr>
<tr>
<td>$\text{Co}^{3+} $</td>
<td>cobalt(III)</td>
</tr>
<tr>
<td>$\text{Co}^{2+} $</td>
<td>cobalt(II)</td>
</tr>
<tr>
<td>$\text{Sn}^{4+} $</td>
<td>tin(IV)</td>
</tr>
<tr>
<td>$\text{Sn}^{2+} $</td>
<td>tin(II)</td>
</tr>
<tr>
<td>$\text{Pb}^{4+} $</td>
<td>lead(IV)</td>
</tr>
<tr>
<td>$\text{Pb}^{2+} $</td>
<td>lead(II)</td>
</tr>
</tbody>
</table>
ESSENTIAL Active Learning Activity Naming Chemical Compounds

Use the table from the last page to name the following compounds:

1. The formulas and common names for several substances are given below. Give the systematic names for these substances. (see ion name table on the last page.)

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Chemical Formula</th>
<th>Systematic Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Sugar of lead</td>
<td>Pb(C₂H₂O₂)₂</td>
<td>Lead (II) Ethanoate</td>
</tr>
<tr>
<td>b. Blue vitrol</td>
<td>CuSO₄</td>
<td></td>
</tr>
<tr>
<td>c. Epsom salts</td>
<td>MgSO₄</td>
<td></td>
</tr>
<tr>
<td>d. Milk of magnesia</td>
<td>Mg(OH)₂</td>
<td></td>
</tr>
<tr>
<td>e. Gypsum</td>
<td>CaSO₄</td>
<td></td>
</tr>
<tr>
<td>f. Laughing gas</td>
<td>N₂O</td>
<td></td>
</tr>
</tbody>
</table>

2. Write the formula for each of the following compounds:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Sulfur difluoride</td>
<td></td>
<td>g. Ammonium acetate</td>
</tr>
<tr>
<td>b. Sulfur hexafluoride</td>
<td></td>
<td>h. Ammonium hydrogen carbonate</td>
</tr>
<tr>
<td>c. Sodium phosphate</td>
<td></td>
<td>i. Cobalt (III) nitrate</td>
</tr>
<tr>
<td>d. Lithium nitride</td>
<td></td>
<td>j. Copper (II) chloride</td>
</tr>
<tr>
<td>e. Chromium (III) carbonate</td>
<td></td>
<td>k. Potassium sulfite</td>
</tr>
<tr>
<td>f. Tin (II) fluoride</td>
<td></td>
<td>l. Sodium hydroxide</td>
</tr>
</tbody>
</table>

3. EXTENSION Name each of the following compounds:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. CuF</td>
<td></td>
<td>i. NaNO₃</td>
</tr>
<tr>
<td>b. CdI₂</td>
<td></td>
<td>j. Ca(NO₂)₂</td>
</tr>
<tr>
<td>c. HI</td>
<td></td>
<td>k. Mg₃(PO₄)₂</td>
</tr>
<tr>
<td>d. NO</td>
<td></td>
<td>l. H₃P</td>
</tr>
<tr>
<td>e. NF₃</td>
<td></td>
<td>m. Na₂SO₄</td>
</tr>
<tr>
<td>f. N₂Cl₂</td>
<td></td>
<td>n. Ca(HCO₃)₂</td>
</tr>
<tr>
<td>g. CF₄</td>
<td></td>
<td></td>
</tr>
<tr>
<td>h. KCl</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
8.7.1 Naming Chemical Compounds Mark Scheme

1. a. lead (II) acetate
   b. copper (II) sulfate
   c. magnesium sulfate
   d. magnesium hydroxide
   e. calcium sulfate
   f. dinitrogen monoxide

2. a. SF₂
   b. SF₆
   c. Na₃PO₄
   d. Li₃N
   e. Cr₂(CO₃)₃
   f. SnF₂
   g. NH₄C₂H₅O₂ or NH₄CH₂COO
   h. NH₄HCO₃
   i. Co(NO₃)₃
   j. CuCl₂
   k. K₂SO₃
   l. NaOH

8.8 EXCEPTIONAL INFORMATION Naming compounds (Nomenclature) – The Complete Set of Rules

These rules go into even more detail than is needed at A level, but knowing that these rules exist is important for the very ablest students and hopefully will allow you to make sense of the names you will throughout your career in chemistry.

From: https://chemed.chem.purdue.edu/genchem/topicreview/bp/ch2/names.html

Long before chemists knew the formulas for chemical compounds, they developed a system of nomenclature that gave each compound a unique name. Today we often use chemical formulas, such as NaCl, C₁₂H₂₂O₁₁, and Co(NH₃)₆(ClO₄)₃, to describe chemical compounds. But we still need unique names that unambiguously identify each compound.

Common Names

Some compounds have been known for so long that a systematic nomenclature cannot compete with well-established common names. Examples of compounds for which common names are used include water (H₂O), ammonia (NH₃), and methane (CH₄).

Naming Ionic Compounds

(Metals with Non-metals)

The names of ionic compounds are written by listing the name of the positive ion followed by the name of the negative ion.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>NaCl</td>
<td>sodium chloride</td>
</tr>
<tr>
<td>(NH₄)₂SO₄</td>
<td>ammonium sulfate</td>
</tr>
<tr>
<td>NaHCO₃</td>
<td>sodium bicarbonate</td>
</tr>
</tbody>
</table>
We therefore need a series of rules that allow us to unambiguously name positive and negative ions before we can name the salts these ions form.

**Naming Positive Ions**

Monatomic positive ions have the name of the element from which they are formed.

<table>
<thead>
<tr>
<th>Ion</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na⁺</td>
<td>sodium</td>
</tr>
<tr>
<td>Ca²⁺</td>
<td>calcium</td>
</tr>
<tr>
<td>K⁺</td>
<td>potassium</td>
</tr>
</tbody>
</table>

Some metals form positive ions in more than one oxidation state. One of the earliest methods of distinguishing between these ions used the suffixes -ous and -ic added to the Latin name of the element to represent the lower and higher oxidation states, respectively.

<table>
<thead>
<tr>
<th>Ion</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe²⁺</td>
<td>ferrous</td>
</tr>
<tr>
<td>Sn²⁺</td>
<td>stannous</td>
</tr>
<tr>
<td>Cu⁺</td>
<td>cuprous</td>
</tr>
</tbody>
</table>

Chemists now use a simpler method, in which the charge on the ion is indicated by a Roman numeral in parentheses immediately after the name of the element.

<table>
<thead>
<tr>
<th>Ion</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe²⁺</td>
<td>iron(II)</td>
</tr>
<tr>
<td>Sn²⁺</td>
<td>tin(II)</td>
</tr>
<tr>
<td>Cu⁺</td>
<td>copper(I)</td>
</tr>
</tbody>
</table>

Polyatomic positive ions often have common names ending with the suffix -onium.

<table>
<thead>
<tr>
<th>Ion</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₃O⁺</td>
<td>hydronium</td>
</tr>
<tr>
<td>NH₄⁺</td>
<td>ammonium</td>
</tr>
</tbody>
</table>

**Naming Negative Ions**

Negative ions that consist of a single atom are named by adding the suffix -ide to the stem of the name of the element.

<table>
<thead>
<tr>
<th>Ion</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>F⁻</td>
<td>fluoride</td>
</tr>
<tr>
<td>Cl⁻</td>
<td>chloride</td>
</tr>
<tr>
<td>Br⁻</td>
<td>bromide</td>
</tr>
<tr>
<td>I⁻</td>
<td>iodide</td>
</tr>
<tr>
<td>H⁻</td>
<td>hydride</td>
</tr>
<tr>
<td>O²⁻</td>
<td>oxide</td>
</tr>
<tr>
<td>S²⁻</td>
<td>sulfide</td>
</tr>
<tr>
<td>N³⁻</td>
<td>nitride</td>
</tr>
<tr>
<td>P³⁻</td>
<td>phosphide</td>
</tr>
<tr>
<td>C⁴⁻</td>
<td>carbide</td>
</tr>
</tbody>
</table>
Common Polyatomic Negative Ions

-1 ions

\[ \text{HCO}_3^- \quad \text{bicarbonate} \]
\[ \text{HSO}_4^- \quad \text{hydrogen sulfate (bisulfate)} \]
\[ \text{CH}_3\text{CO}_2^- \quad \text{acetate} \]
\[ \text{ClO}_4^- \quad \text{perchlorate} \]
\[ \text{NO}_3^- \quad \text{nitrate} \]
\[ \text{ClO}_3^- \quad \text{chlorate} \]
\[ \text{NO}_2^- \quad \text{nitrite} \]
\[ \text{ClO}_2^- \quad \text{chlorite} \]
\[ \text{MnO}_4^- \quad \text{permanganate} \]
\[ \text{ClO}^- \quad \text{hypochlorite} \]
\[ \text{CN}^- \quad \text{cyanide} \]
\[ \text{OH}^- \quad \text{hydroxide} \]

-2 ions

\[ \text{CO}_3^{2-} \quad \text{carbonate} \]
\[ \text{O}_2^{2-} \quad \text{peroxide} \]
\[ \text{SO}_4^{2-} \quad \text{sulfate} \]
\[ \text{CrO}_4^{2-} \quad \text{chromate} \]
\[ \text{SO}_3^{2-} \quad \text{sulfite} \]
\[ \text{Cr}_2\text{O}_7^{2-} \quad \text{dichromate} \]
\[ \text{S}_2\text{O}_3^{2-} \quad \text{thiosulfate} \]
\[ \text{HPO}_4^{2-} \quad \text{hydrogen phosphate} \]

-3 ions

\[ \text{PO}_4^{3-} \quad \text{phosphate} \]
\[ \text{AsO}_4^{3-} \quad \text{arsenate} \]
\[ \text{BO}_3^{3-} \quad \text{borate} \]

Naming Polyatomic Ions

At first glance, the nomenclature of the polyatomic negative ions in the table above seems hopeless. There are several general rules, however, that can bring some order out of this apparent chaos.

The name of the ion usually ends in either -ite or -ate. The -ite ending indicates a low oxidation state. Thus, the NO$_2^-$ ion is the nitrite ion.

The -ate ending indicates a high oxidation state. The NO$_3^-$ ion, for example, is the nitrate ion.

The prefix hypo- is used to indicate the very lowest oxidation state. The ClO$^-$ ion, for example, is the hypochlorite ion.

The prefix per- (as in hyper-) is used to indicate the very highest oxidation state. The ClO$_4^-$ ion is therefore the perchlorate ion.

There are only a handful of exceptions to these generalizations. The names of the hydroxide (OH$^-$), cyanide (CN$^-$), and peroxide (O$_2^{2-}$) ions, for example, have the -ide ending because they were once thought to be monatomic ions.
Naming Simple Covalent Compounds

(Non-metals with non-metals)

Oxidation states also play an important role in naming simple covalent compounds. The name of the atom in the positive oxidation state is listed first. The suffix -ide is then added to the stem of the name of the atom in the negative oxidation state.

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCl</td>
<td>hydrogen chloride</td>
</tr>
<tr>
<td>NO</td>
<td>nitrogen oxide</td>
</tr>
<tr>
<td>BrCl</td>
<td>bromine chloride</td>
</tr>
</tbody>
</table>

As a rule, chemists write formulas in which the element in the positive oxidation state is written first, followed by the element(s) with negative oxidation numbers.

The number of atoms of an element in simple covalent compounds is indicated by adding one of the following Greek prefixes to the name of the element.

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Number of Atoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>mono-</td>
<td>1</td>
</tr>
<tr>
<td>di-</td>
<td>2</td>
</tr>
<tr>
<td>tri-</td>
<td>3</td>
</tr>
<tr>
<td>tetra-</td>
<td>4</td>
</tr>
<tr>
<td>penta-</td>
<td>5</td>
</tr>
<tr>
<td>hexa-</td>
<td>6</td>
</tr>
<tr>
<td>hepta-</td>
<td>7</td>
</tr>
<tr>
<td>octa-</td>
<td>8</td>
</tr>
<tr>
<td>nona-</td>
<td>9</td>
</tr>
<tr>
<td>deca-</td>
<td>10</td>
</tr>
</tbody>
</table>

The prefix mono- is seldom used because it is redundant. The principal exception to this rule is carbon monoxide (CO).

Naming Acids

Simple covalent compounds that contain hydrogen, such as HCl, HBr, and HCN, often dissolve in water to produce acids. These solutions are named by adding the prefix hydro- to the name of the compound and then replacing the suffix -ide with -ic. For example, hydrogen chloride (HCl) dissolves in water to form hydrochloric acid; hydrogen bromide (HBr) forms hydrobromic acid; and hydrogen cyanide (HCN) forms hydrocyanic acid.

Many of the oxygen-rich polyatomic negative ions in Table 2.1 form acids that are named by replacing the suffix -ate with -ic and the suffix -ite with -ous.

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cl⁻</td>
<td>chloride</td>
</tr>
<tr>
<td>F⁻</td>
<td>fluoride</td>
</tr>
<tr>
<td>S²⁻</td>
<td>sulfide</td>
</tr>
<tr>
<td>HCl</td>
<td>hydrochloric acid</td>
</tr>
<tr>
<td>HF</td>
<td>hydrofluoric acid</td>
</tr>
<tr>
<td>H₂S</td>
<td>hydrosulfuric acid</td>
</tr>
<tr>
<td>Ion</td>
<td>Acid Name</td>
</tr>
<tr>
<td>------------</td>
<td>--------------------</td>
</tr>
<tr>
<td>CH₃CO₂⁻</td>
<td>acetate</td>
</tr>
<tr>
<td>CO₃²⁻</td>
<td>carbonate</td>
</tr>
<tr>
<td>BO₃³⁻</td>
<td>borate</td>
</tr>
<tr>
<td>NO₃⁻</td>
<td>nitrate</td>
</tr>
<tr>
<td>SO₄²⁻</td>
<td>sulfate</td>
</tr>
<tr>
<td>ClO₄⁻</td>
<td>perchlorate</td>
</tr>
<tr>
<td>PO₄³⁻</td>
<td>phosphate</td>
</tr>
<tr>
<td>MnO₄⁺</td>
<td>permanganate</td>
</tr>
<tr>
<td>CrO₄²⁻</td>
<td>chromate</td>
</tr>
<tr>
<td>ClO₃⁻</td>
<td>chlorate</td>
</tr>
</tbody>
</table>

Acids containing ions ending with *ite* usually become **-ous acid**

<table>
<thead>
<tr>
<th>Ion</th>
<th>Acid Name</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>ClO₂⁻</td>
<td>chlorite</td>
<td>HClO₂</td>
</tr>
<tr>
<td>NO₂⁻</td>
<td>nitrite</td>
<td>HNO₂</td>
</tr>
<tr>
<td>SO₃²⁻</td>
<td>sulfite</td>
<td>H₂SO₃</td>
</tr>
<tr>
<td>ClO⁻</td>
<td>hypochlorite</td>
<td>HClO</td>
</tr>
</tbody>
</table>

Complex acids can be named by indicating the presence of an acidic hydrogen as follows.

- **NaHCO₃**  sodium hydrogen carbonate (also known as sodium bicarbonate)
- **NaHSO₃**  sodium hydrogen sulfite (also known as sodium bisulfite)
- **KH₂PO₄**  potassium dihydrogen phosphate
8.9  Active Learning Activity 4 Word and Symbol Equations

Task 1: Complete the following word equations

1. Calcium carbonate + hydrochloric acid → calcium chloride + water + __________
2. _______________ + sulfuric acid → magnesium sulfate + hydrogen
3. Magnesium + nitric acid → ________________________ + hydrogen
4. Zinc hydroxide + ____________________________ → zinc chloride + water
5. _______________ + hydrochloric acid → magnesium chloride + water + carbon Dioxide
6. Aluminium + hydrochloric acid → _______________ + hydrogen
7. Sodium hydroxide + hydrochloric acid → ___________ + _______________
8. Sodium carbonate + ________________________ → sodium sulfate + water + __________
   ____________
9. _______________ + nitric acid → calcium nitrate + water + carbon dioxide
10. ______________________ + sulfuric acid → iron(II) sulfate + hydrogen

Task 2: Complete the following word equations

1- Hydrochloric acid + sodium hydroxide → _____________________ + ________________________
2- Sodium + water → _______________________________ + _____________________________
3- Magnesium + oxygen → _________________________________
4- Sulfuric acid + magnesium carbonate → _____________________ + _________________________ +
   ______________________
5- Zinc + copper sulfate → ___________________________ + _____________________________
6- Sulfuric acid + sodium hydroxide → _________________________ + ____________________________
7- Hydrogen + oxygen → _______________________________
8- Carbon + oxygen → _______________________________
9- Aluminium + nitric acid → _____________________________ + _____________________________
10- Sodium + sulfur → .................................................................

**Task 3: Complete and balance the symbol equations**
(you are allowed to write in the spaces only)

1. _______________ + 2HCl\(_{(aq)}\) → MgCl\(_2\)\(_{(aq)}\) + H\(_2\)O\(_{(l)}\) + _______________

2. Mg(OH)\(_2\)\(_{(s)}\) + H\(_2\)SO\(_4\)\(_{(aq)}\) → _______________ + _______________

3. CuO\(_{(s)}\) + _______________ → Cu(NO\(_3\))\(_2\)\(_{(aq)}\) + H\(_2\)O\(_{(l)}\)

4. _______________ + H\(_2\)SO\(_4\)\(_{(aq)}\) → MgSO\(_4\)\(_{(aq)}\) + H\(_2\)O\(_{(l)}\)

5. _______________ + H\(_2\)SO\(_4\)\(_{(aq)}\) → MgSO\(_4\)\(_{(aq)}\) + H\(_2\)O\(_{(l)}\) + CO\(_2\)\(_{(g)}\)

6. Zn(OH)\(_2\)\(_{(s)}\) + 2HCl\(_{(aq)}\) → ZnCl\(_2\)\(_{(aq)}\) + _______________

7. Mg\(_{(s)}\) + H\(_2\)SO\(_4\)\(_{(aq)}\) → _______________ + _______________

**Task 4: Complete the following word equations and write balanced symbol equations**

1- Calcium carbonate + hydrochloric acid → .................................................................

   Symbol equation:
   .................................................................

2- Iron (III) oxide + sulfuric acid → .................................................................

   Symbol equation:
   .................................................................

3- Sodium carbonate + sulfuric acid → .................................................................

   Symbol equation:
   .................................................................

4- Zinc + hydrochloric acid → .................................................................

   Symbol equation:
   .................................................................

5- Aluminium + nitric acid → .................................................................

   Symbol equation:
   .................................................................
Extension Word and Symbol Equations

Task 5: Read the following paragraphs about some chemical processes. Write word and balanced chemical symbol equations for reactions 1 to 8

(reactants and products are underlined):

Reaction 1:
In car engines, where the temperature is very high, nitrogen gas reacts with oxygen to form different oxides, one of these oxides is nitrogen dioxide which contributes to acid rain.

……………………………………………………………………………………………………………… (3)

Reaction 2
Carbon monoxide, a poisonous gas, is also formed by the reaction of oxygen and carbon (present in fuels).
Car manufactures use catalytic convertors to change these gases into the less harmful products nitrogen, oxygen and carbon dioxide.

……………………………………………………………………………………………………………… (3)

Reaction 3
During the process of photosynthesis, plant combine carbon dioxide gas from the atmosphere and water from the soil to produce glucose (C₆H₁₂O₆) and oxygen gas.

……………………………………………………………………………………………………………… (3)

Reaction 4
In respiring, some living organisms burn glucose to produce carbon dioxide gas and water vapor. (Reaction4).

………………………………………………………………………………………………………………

Reaction 5
In an industrial process, limestone (calcium carbonate) is strongly heated to produce quicklime (calcium oxide) and carbon dioxide gas (reaction 5).

……………………………………………………………………………………………………………… (3)

Reaction 6
In the presence of water, iron (and steel) articles react with oxygen in the air to form iron (III) oxide (Reaction 6).

|………………………………………………………………………………………………………………………………………………………… (3) |

Reaction 7
In industry, zinc metal is extracted from zinc blend (zinc sulfide) by heating the blend in air. The products are sulfur dioxide and zinc oxide (reaction7)

|………………………………………………………………………………………………………………………………………………………… (3) |

Reaction 8
The metal oxide from the previous equations is then heated with carbon to produce the pure metal and a colourless gas (reaction 8)

|………………………………………………………………………………………………………………………………………………………… (3) |
8.9.1 Word and symbol equations mark scheme

**Task 1**

1. Carbon dioxide
2. Magnesium
3. Magnesium nitrate
4. Hydrochloric acid
5. Magnesium carbonate
6. Aluminium chloride
7. Sodium chloride + water
8. Sulfuric acid → carbon dioxide
9. Calcium carbonate
10. Iron

**Task 2**

1. Sodium hydroxide + water
2. Sodium hydroxide + hydrogen
3. Magnesium oxide
4. Magnesium sulfate + carbon dioxide + water
5. Zinc sulfate + copper
6. Sodium sulfate + water
7. Water
8. Carbon dioxide
9. Aluminium nitrate + hydrogen
10. Sodium sulfide

**Task 3**

1. MgCO$_3$(aq) → CO$_2$(g)
2. MgSO$_4$(aq) + H$_2$O(l)
3. 2HNO$_2$(aq)
4. Mg(OH)$_2$(s)
5. MgCO$_3$(s)
6. H$_2$O(l)
7. MgSO$_4$(s) + H$_2$(g)

**Task 4**

1. Calcium chloride + water + carbon dioxide
   CaCO$_3$(s) + 2HCl(aq) → CaCl$_2$(aq) H$_2$O(l) + CO$_2$(g)

2. Iron (III) Sulfate + water
   Fe$_2$O$_3$(s) + 3H$_2$SO$_4$(aq) → Fe$_2$(SO$_4$)$_3$ + 3H$_2$O(l)

3. Sodium Carbonate + Sulfuric acid → Sodium sulfate + carbon dioxide + water
   Na$_2$CO$_3$(s) + H$_2$SO$_4$(aq) → Na$_2$SO$_4$(aq) + CO$_2$(g) + H$_2$O(l)

4. Zinc + hydrochloric acid → Zinc chloride + hydrogen
   Zn(s) + 2HCl(aq) → ZnCl$_2$(aq) + H$_2$(g)

5. Aluminium + Nitric acid → Aluminum nitrate + hydrogen
   2Al(s) + 6HNO$_3$(aq) → 2Al(NO$_3$)$_3$(aq) + 3H$_2$(g)

**Task 6**

1. 2N$_2$(g) + O$_2$(g) → 2NO$_2$(g)
2. 2C(s) + O$_2$(g) → 2CO(g)
3. 6CO$_2$(aq) + 6H$_2$O(l) → C$_6$H$_12$O$_6$(aq) + 6O$_2$(g)
4. C$_6$H$_12$O$_6$(aq) + 6O$_2$(g) → 6CO$_2$(aq) + 6H$_2$O(l)
5. CaCO$_3$(s) → CaO(s) + CO$_2$(g)
6. 4Fe(s) + 3O$_2$(g) → 2Fe$_2$O$_3$(s)
7. 2ZnS(s) → 2ZnO(s) + SO$_2$(g)
8. C(s) + 2ZnO(s) → 2Zn(s) + 2ZnCl(aq) CO$_2$(g)
8.10 FUNDAMENTAL EXAM QUESTIONS T4.1 Paper 1 12 marks

All of these questions in this section come from Paper 1, which only assesses Core syllabus material and they are designed to all be answerable by students who can only achieve a C grade.

Q# 16/ iGCSE Chemistry/2004/w/Paper 1/

9 When propane is burned, carbon dioxide and water are formed, as shown.

\[
\text{C}_3\text{H}_8 + 5\text{O}_2 \rightarrow r\text{CO}_2 + s\text{H}_2\text{O}
\]

Which values of \( r \) and \( s \) balance the equation?

<table>
<thead>
<tr>
<th></th>
<th>( r )</th>
<th>( s )</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>C</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>D</td>
<td>3</td>
<td>8</td>
</tr>
</tbody>
</table>

Q# 17/ iGCSE Chemistry/2004/s/Paper 1/

9 The oxide \( \text{Pb}_2\text{O}_4 \) reacts with dilute nitric acid to form lead(II) nitrate, lead(IV) oxide and another product.

What is the equation for this reaction?

A \( \text{Pb}_2\text{O}_4 + 4\text{HNO}_3 \rightarrow 2\text{Pb(NO}_3\text{)_2} + \text{PbO}_2 + 2\text{H}_2\text{O} \)

B \( \text{Pb}_2\text{O}_4 + 2\text{HNO}_3 \rightarrow 2\text{Pb(NO}_3\text{)_2} + \text{PbO}_4 + \text{H}_2 \)

C \( \text{Pb}_2\text{O}_4 + 4\text{HNO}_3 \rightarrow \text{Pb(NO}_3\text{)_4} + 2\text{PbO} + 2\text{H}_2\text{O} \)

D \( 2\text{Pb}_2\text{O}_4 + 2\text{HNO}_3 \rightarrow 2\text{Pb}_2\text{O}_3 + 2\text{PbO}_2 + \text{H}_2 \)

Q# 18/ iGCSE Chemistry/2004/s/Paper 1/

10 The compound ethyl mercaptan, \( \text{C}_2\text{H}_5\text{SH} \), has a very unpleasant smell.

What is its relative molecular mass?

A 34  B 50  C 61  D 62

Q# 19/ iGCSE Chemistry/2003/w/Paper 1/

10 Two gases react as shown.

\[
\text{X}_2 + \text{Y}_2 \rightarrow 2\text{XY}
\]

When measured at the same temperature and pressure, what is the value of

\[
\frac{\text{volume of product}}{\text{volume of reactants}}
\]
11. Carbon and chlorine form a chloride.

What is the formula of this chloride?

A. $\text{CCl}_2$
B. $\text{CCl}_4$
C. $\text{CaCl}_2$
D. $\text{CaCl}_4$

Q# 20/ iGCSE Chemistry/2003/s/Paper 1/

9. The relative atomic mass of oxygen is 16 and that of hydrogen is 1.

This means that …(i)… of oxygen has the same mass as …(ii)… of hydrogen.

Which words correctly complete the gaps?

<table>
<thead>
<tr>
<th>gap (i)</th>
<th>gap (ii)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A an atom</td>
<td>thirty-two molecules</td>
</tr>
<tr>
<td>B an atom</td>
<td>eight molecules</td>
</tr>
<tr>
<td>C a molecule</td>
<td>sixteen atoms</td>
</tr>
<tr>
<td>D a molecule</td>
<td>eight atoms</td>
</tr>
</tbody>
</table>

10. The diagram shows a model of a molecule containing carbon, hydrogen and oxygen.

![Diagram of a molecule containing carbon, hydrogen and oxygen.]

How many atoms of each element are in the molecule?

<table>
<thead>
<tr>
<th></th>
<th>carbon</th>
<th>hydrogen</th>
<th>oxygen</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>2</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>C</td>
<td>2</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>D</td>
<td>6</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>
Q# 21/ iGCSE Chemistry/2002/w/Paper 1/

9. One method of producing carbon dioxide is to react calcium carbonate with dilute hydrochloric acid.

What is the balanced chemical equation for the reaction?

A. \( \text{CaCO}_3 + \text{HCl} \rightarrow \text{CaO} + \text{CO}_2 + \text{HCl} \)
B. \( \text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{CO}_2 + \text{H}_2\text{O} \)
C. \( \text{CaCO}_3 + 4\text{HCl} \rightarrow \text{CaCl}_4 + \text{CO}_2 + \text{H}_2 + \text{H}_2\text{O} \)
D. \( \text{Ca(HCO}_3)_2 + \text{HCl} \rightarrow \text{CaCl} + 2\text{CO}_2 + \text{H}_2\text{O} \)

10. A gas has the molecular formula NOCl.

Which diagram could show molecules of the pure gas NOCl?

A. 
B. 
C. 
D. 

key

- N
- Cl
- O

11. Butenedioic acid has the structure shown.

What is the molecular formula of butenedioic acid?

A. \( \text{CHO} \)
B. \( \text{C}_4\text{H}_4\text{O}_4 \)
C. \( \text{C}_6\text{H}_4\text{O}_2 \)
D. \( \text{C}_6\text{H}_6\text{O}_6 \)

Q# 22/ iGCSE Chemistry/2002/s/Paper 1/

10. What is the formula of copper(II) oxide and of sulphur hexafluoride?

<table>
<thead>
<tr>
<th></th>
<th>copper(II) oxide</th>
<th>sulphur hexafluoride</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>CuO</td>
<td>\text{S}_6\text{F}</td>
</tr>
<tr>
<td>B</td>
<td>CuO</td>
<td>\text{SF}_6</td>
</tr>
<tr>
<td>C</td>
<td>Cu\textsubscript{2}O</td>
<td>\text{S}_6\text{F}</td>
</tr>
<tr>
<td>D</td>
<td>Cu\textsubscript{2}O</td>
<td>\text{SF}_6</td>
</tr>
</tbody>
</table>
8.10.1 FUNDAMENTAL EXAM QUESTIONS
T4.1 Paper 1 12marks Mark Scheme
Q# 1/ iGCSE Chemistry/2012/w/Paper 11/
4 B
Q# 2/ iGCSE Chemistry/2012/s/Paper 11/
9 C
Q# 3/ iGCSE Chemistry/2011/w/Paper 11/
8 B
Q# 4/ iGCSE Chemistry/2011/s/Paper 11/
8 D
Q# 5/ iGCSE Chemistry/2010/w/Paper 11/
10 B
Q# 6/ iGCSE Chemistry/2010/s/Paper 11/
10 C
Q# 7/ iGCSE Chemistry/2009/w/Paper 11/
10 C
11 B
Q# 8/ iGCSE Chemistry/2009/s/Paper 11/
10 C
11 D
Q# 9/ iGCSE Chemistry/2008/w/Paper 1/
10 B
11 B
Q# 10/ iGCSE Chemistry/2008/s/Paper 1/
11 D
Q# 11/ iGCSE Chemistry/2007/w/Paper 1/
10 D
11 B
Q# 12/ iGCSE Chemistry/2007/s/Paper 1/
10 D
11 B
Q# 13/ iGCSE Chemistry/2007/s/Paper 1/
10 D
11 B
Q# 14/ iGCSE Chemistry/2006/w/Paper 1/
9 D
10 C
Q# 15/ iGCSE Chemistry/2006/s/Paper 1/
10 D
9 C
Q# 16/ iGCSE Chemistry/2005/s/Paper 1/
10 D
9 A
Q# 17/ iGCSE Chemistry/2004/s/Paper 1/
10 D
11 B
Q# 18/ iGCSE Chemistry/2004/s/Paper 1/
10 D
11 B
Q# 19/ iGCSE Chemistry/2003/w/Paper 1/
10 B
11 B
Q# 20/ iGCSE Chemistry/2003/s/Paper 1/
9 D
10 C
Q# 21/ iGCSE Chemistry/2002/w/Paper 1/
9 D
10 B
Q# 22/ iGCSE Chemistry/2002/s/Paper 1/
11 B

8.11 FUNDAMENTAL EXAM QUESTIONS Paper 2 9marks

Q# 1/ iGCSE Chemistry/2018/w/Paper 23/

9 Iron(III) chromate is a yellow solid. It contains the ions Fe$^{3+}$ and CrO$_4^{2-}$.

What is the formula of iron(III) chromate?

A FeCrO$_4$  B Fe$_3$(CrO$_4$)$_2$  C Fe$_2$CrO$_4$  D Fe$_2$(CrO$_4$)$_3$

Q# 2/ iGCSE Chemistry/2018/w/Paper 22/

9 The formulae of some ions are shown.

<table>
<thead>
<tr>
<th>positive ion</th>
<th>negative ion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ti$^{4+}$</td>
<td>PO$_4^{2-}$</td>
</tr>
<tr>
<td>Al$^{3+}$</td>
<td>SO$_4^{2-}$</td>
</tr>
<tr>
<td>Mg$^{2+}$</td>
<td>NO$_3^{-}$</td>
</tr>
<tr>
<td>K$^+$</td>
<td>Cl$^-$</td>
</tr>
</tbody>
</table>

Which formula is not correct?

A Al$_3$(SO$_4$)$_2$  B K$_2$PO$_4$  C Mg(NO$_3$)$_2$  D TiCl$_4$

Q# 3/ iGCSE Chemistry/2018/w/Paper 21/

9 Iron can react with sulfur to form two ionic compounds.

The iron is present as Fe$^{2+}$ in one compound and as Fe$^{3+}$ in the other compound.

The sulfur ion is present as S$^{2-}$ in both compounds.

What are the formulae of the two compounds?

A FeS and Fe$_2$S$_3$  B FeS and Fe$_3$S$_2$  C FeS$_2$ and Fe$_3$S$_2$  D FeS$_2$ and Fe$_2$S$_3$

Q# 4/ iGCSE Chemistry/2017/w/Paper 23/

8 A compound contains 34.5% calcium, 24.1% silicon and 41.4% oxygen by mass.

What is its empirical formula?

A Ca$_2$SiO$_3$  B CaSiO$_3$  C CaSi$_2$O$_3$  D CaSiO$_4$
Q# 5/ IGCSE Chemistry/2017/w/Paper 22/  

7 The equation for the reaction between phosphorus and oxygen is shown.

\[ xP_4 + yO_2 \rightarrow zP_2O_5 \]

Which values of \( x \), \( y \) and \( z \) balance the equation?

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>C</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>D</td>
<td>2</td>
<td>10</td>
</tr>
</tbody>
</table>

Q# 6/ IGCSE Chemistry/2017/s/Paper 23/  

7 Aqueous iron(III) sulfate and aqueous sodium hydroxide react to give a precipitate of iron(III) hydroxide and a solution of sodium sulfate.

What is the balanced equation for this reaction?

A \( \text{Fe}_2(\text{SO}_4)_3(\text{aq}) + 2\text{NaOH}(\text{aq}) \rightarrow \text{Fe(OH)}_3(\text{s}) + \text{Na}_2\text{SO}_4(\text{aq}) \)

B \( \text{Fe}_2(\text{SO}_4)_3(\text{aq}) + 3\text{NaOH}(\text{aq}) \rightarrow \text{Fe(OH)}_3(\text{s}) + 3\text{Na}_2\text{SO}_4(\text{aq}) \)

C \( \text{Fe}_2(\text{SO}_4)_3(\text{aq}) + 6\text{NaOH}(\text{aq}) \rightarrow 2\text{Fe(OH)}_3(\text{s}) + 3\text{Na}_2\text{SO}_4(\text{aq}) \)

D \( 2\text{Fe}_2(\text{SO}_4)_3(\text{aq}) + 6\text{NaOH}(\text{aq}) \rightarrow 4\text{Fe(OH)}_3(\text{s}) + 6\text{Na}_2\text{SO}_4(\text{aq}) \)

Q# 7/ IGCSE Chemistry/2017/s/Paper 22/  

7 Which equations are balanced?

1 \( \text{Fe}_2\text{O}_3 + 3\text{CO} \rightarrow 2\text{Fe} + 3\text{CO}_2 \)

2 \( \text{ZnCO}_3 + 2\text{HCl} \rightarrow \text{ZnCl}_2 + \text{CO}_2 + 2\text{H}_2\text{O} \)

3 \( \text{Mg(NO}_3)_2 + \text{NaOH} \rightarrow \text{Mg(OH)}_2 + 2\text{NaNO}_3 \)

4 \( \text{CaCO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{CaSO}_4 + \text{H}_2\text{O} + \text{CO}_2 \)

A  1 and 2  B  1 and 4  C  2 and 3  D  3 and 4

Q# 8/ IGCSE Chemistry/2017/s/Paper 21/  

7 Aluminium reacts with fluorine.

\[ x\text{Al}(s) + y\text{F}_2(g) \rightarrow z\text{AlF}_3(s) \]

Which values of \( x \), \( y \) and \( z \) balance the equation?

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>C</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>D</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>
Q# 9/ iGCSE Chemistry/2016/m/Paper 22/

9 Magnesium nitride is formed when magnesium burns in air. Magnesium nitride is an ionic compound.

What is the formula of magnesium nitride?

A MgN₂ B Mg₂N₂ C Mg₂N₃ D Mg₃N₂

8.11.1 FUNDAMENTAL EXAM QUESTIONS Paper 2 9marks mark Scheme

Q# 1/ iGCSE Chemistry/2018/w/Paper 23/

9 B

Q# 2/ iGCSE Chemistry/2018/w/Paper 22/

9 A

Q# 3/ iGCSE Chemistry/2018/w/Paper 21/

9 A

Q# 4/ iGCSE Chemistry/2017/w/Paper 23/

8 B

Q# 5/ iGCSE Chemistry/2017/w/Paper 22/

7 A

Q# 6/ iGCSE Chemistry/2017/s/Paper 23/

7 C

Q# 7/ iGCSE Chemistry/2017/s/Paper 22/

8 A

Q# 8/ iGCSE Chemistry/2017/s/Paper 21/

7 B

Q# 9/ iGCSE Chemistry/2016/m/Paper 22/

9 D

8.12 ESSENTIAL EXAM QUESTIONS T4.1 Paper 4 9marks

Q# 1/ iGCSE Chemistry/2014/w/Paper 31/

7 Nitrogen can form ionic compounds with reactive metals and covalent compounds with non-metals.

(a) Nitrogen reacts with lithium to form the ionic compound lithium nitride, Li₃N.

(i) Write the equation for the reaction between lithium and nitrogen.

.................................................................................................................................................. [2]

Q# 2/ iGCSE Chemistry/2013/s/Paper 31/Q6

Ammonia is a compound with the molecular formula NH₃

(c) Another compound which contains only nitrogen and hydrogen is hydrazine, N₂H₄.

Complete the equation for the preparation of hydrazine from ammonia.

........NH₃ + NaCl/O → N₂H₄ + ............ + H₂O [2]
Q# 3/ iGCSE Chemistry/2013/s/Paper 31/

3 A small piece of marble, CaCO₃, was added to 5.0 cm³ of hydrochloric acid, concentration 1.0 mol/dm³, at 25 °C. The time taken for the reaction to stop was measured. The experiment was repeated using 5.0 cm³ of different solutions of acids. The acid was in excess in all of the experiments.

Typical results are given in the table.

<table>
<thead>
<tr>
<th>experiment</th>
<th>temperature/°C</th>
<th>acid solution</th>
<th>time/min</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25</td>
<td>hydrochloric acid 1.0 mol/dm³</td>
<td>3</td>
</tr>
</tbody>
</table>

(b) The equation for the reaction in experiment 1 is:

\[
\text{CaCO}_3(s) + 2\text{HCl}(aq) \rightarrow \text{CaCl}_2(aq) + \text{CO}_2(g) + \text{H}_2\text{O}(l)
\]

Complete the following ionic equation.

\[
\text{CaCO}_3(s) + 2\text{H}^+(aq) \rightarrow \ldots \ldots \ldots + \ldots \ldots \ldots + \ldots \ldots \ldots \ldots \ldots [1]
\]

Q# 4/ iGCSE Chemistry/2004/s/Paper 3/

3 An organic compound decomposes to form nitrogen.

\[
\text{C}_6\text{H}_3\text{N}_2\text{Cl}(aq) \rightarrow \text{C}_6\text{H}_3\text{Cl}(l) + \text{N}_2(g)
\]

(a) Explain the state symbols.

aq ........................................................................................................................................ [1]

l ........................................................................................................................................ [1]

g ........................................................................................................................................ [1]

Q# 5/ iGCSE Chemistry/2002/w/Paper 3/ Q3

(b) The following compounds contain two elements. Predict their formulae.

aluminium sulphide .............................................................................................................

silicon phosphide ................................................................................................................. [2]

8.12.1 EXAM QUESTIONS T4.1 Paper 4 9marks Mark Scheme

Q# 1/ iGCSE Chemistry/2014/w/Paper 31/

7 (a) (i) 6\text{Li} + \text{N}_2 = 2\text{Li}_3\text{N}

species (1) balancing (1)

Q# 2/ iGCSE Chemistry/2013/s/Paper 31/ Q6

(c) 2\text{NH}_3 + \text{NaClO} \rightarrow \text{N}_2\text{H}_4 + \text{NaCl} + \text{H}_2\text{O}

not balanced only 1

Q# 3/ iGCSE Chemistry/2013/s/Paper 31/ Q3

(b) experiment 1 \text{Ca}^{2+} + \text{CO}_2 + \text{H}_2\text{O} .................................................. [1]

Q# 4/ iGCSE Chemistry/2004/s/Paper 3/
8.13 FUNDAMENTAL Assessed Activity 1 Keyword Test

<table>
<thead>
<tr>
<th>English</th>
<th>Chinese</th>
</tr>
</thead>
<tbody>
<tr>
<td>law of conservation of mass</td>
<td></td>
</tr>
<tr>
<td>molecular formula</td>
<td></td>
</tr>
<tr>
<td>relative molecular mass ($Mr$)</td>
<td></td>
</tr>
<tr>
<td>relative formula mass ($Mr$)</td>
<td></td>
</tr>
<tr>
<td>balanced chemical (symbol) equation</td>
<td></td>
</tr>
<tr>
<td>standard atom</td>
<td></td>
</tr>
<tr>
<td>chemical reaction</td>
<td></td>
</tr>
<tr>
<td>molecular mass</td>
<td></td>
</tr>
<tr>
<td>state symbols</td>
<td></td>
</tr>
<tr>
<td>symbol (chemical)</td>
<td></td>
</tr>
<tr>
<td>formula (chemical)</td>
<td></td>
</tr>
</tbody>
</table>

3. (a) **dissolved or solution in water**
   **NOT aqueous NOT soluble in water**
   **1 liquid and g gas**

   Q# 5/ iGCSE Chemistry/2002/w/Paper 3/ Q3

   (b) $\text{Al}_2\text{S}_3$
   $\text{Si}_2\text{P}_4$
English | Chinese
--- | ---
reactants | 
ionic equation | 
products | 
word equation | 
spectator ions | 

8.14 ESSENTIAL Assessed Activity 2 T4.1 Paper 1 (Core only material) 15marks

Q# 1/
8 A compound has the formula CH₃CO₂H.

How should the relative molecular mass, \( M_r \), of this compound be calculated?

A  \( 12 + 1 + 16 \)

B  \( 3(12 + 1) + 2(12 + 16) + 1 \)

C  \( (4 \times 12) + (2 \times 1) + 16 \)

D  \( (2 \times 12) + (4 \times 1) + (2 \times 16) \)

Q# 2/
9 The equation for the reaction between magnesium and dilute sulfuric acid is shown.

\[ \text{Mg} + \text{H}_2\text{SO}_4 \rightarrow \text{MgSO}_4 + \text{H}_2 \]

\( M_r \) of \( \text{MgSO}_4 \) is 120

Which mass of magnesium sulfate will be formed if 12 g of magnesium are reacted with sulfuric acid?

A 5 g  B 10 g  C 60 g  D 120 g

Q# 3/
8 The relative formula mass, \( M_r \), of copper(II) sulfate, \( \text{CuSO}_4 \), is 160.

Which mass of sulfur is present in 160 g of copper(II) sulfate?

A 16 g  B 32 g  C 64 g  D 128 g

Q# 4/
8 What is the relative molecular mass \( (M_r) \) of \( \text{HNO}_3 \)?

A 5  B 31  C 32  D 63
Q# 5/
10 The chemical compositions of two substances, \( W \) and \( X \), are given.

\[
\begin{align*}
W & : \text{Na(AlSi)}_8 \\
X & : \text{Ca(Al}_2\text{Si}_2\text{)}_8
\end{align*}
\]

Which statements are correct?

1. \( W \) and \( X \) contain the same amount of oxygen.
2. \( W \) contains three times as much silicon as \( X \).
3. \( X \) contains twice as much aluminium as \( W \).

A 1 and 2  B 1 and 3  C 2 and 3  D 1, 2 and 3

Q# 6/

10 Hydrogen and chlorine react as shown.

\[ \text{1 molecule of hydrogen} + \text{1 molecule of chlorine} \rightarrow \text{2 molecules of hydrogen chloride} \]

What is the equation for this reaction?

A \( 2H + 2Cl \rightarrow 2HCl \)
B \( 2H + 2Cl \rightarrow H_2Cl_2 \)
C \( H_2 + Cl_2 \rightarrow 2HCl \)
D \( H_2 + Cl_2 \rightarrow H_2Cl_2 \)

Q# 7/

10 For each atom of carbon present in a molecule, there is an equal number of atoms of oxygen but twice as many atoms of hydrogen.

What is the formula of the molecule?

A \( \text{C}_2\text{H}_2\text{O}_2 \)  B \( \text{C}_2\text{H}_2\text{O}_4 \)  C \( \text{C}_2\text{H}_4\text{O}_2 \)  D \( \text{C}_2\text{H}_6\text{O} \)

11 Water is formed when 48 g of oxygen combine with 6 g of hydrogen.

What mass of oxygen combines with 2 g of hydrogen?

A 12 g  B 16 g  C 96 g  D 144 g

Q# 8/

10 Nitrogen and hydrogen react together to form ammonia.

\[ \text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3 \]

When completely converted, 7 tonnes of nitrogen gives 8.5 tonnes of ammonia.

How much nitrogen will be needed to produce 34 tonnes of ammonia?

A 7 tonnes  B 8.5 tonnes  C 28 tonnes  D 34 tonnes
11 Which relative molecular mass, \( M_r \), is **not** correct for the molecule given?

<table>
<thead>
<tr>
<th></th>
<th>molecule</th>
<th>( M_r )</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>ammonia, ( \text{NH}_3 )</td>
<td>17</td>
</tr>
<tr>
<td>B</td>
<td>carbon dioxide, ( \text{CO}_2 )</td>
<td>44</td>
</tr>
<tr>
<td>C</td>
<td>methane, ( \text{CH}_4 )</td>
<td>16</td>
</tr>
<tr>
<td>D</td>
<td>oxygen, ( \text{O}_2 )</td>
<td>16</td>
</tr>
</tbody>
</table>

Q# 9/

10 Lead(II) nitrate can be decomposed as shown.

\[
x \text{Pb(NO}_3\text{)}_2 \rightarrow y \text{PbO} + z \text{NO}_2 + \text{O}_2
\]

Which numbers \( x \), \( y \) and \( z \) balance the equation?

<table>
<thead>
<tr>
<th></th>
<th>( x )</th>
<th>( y )</th>
<th>( z )</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>C</td>
<td>2</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>D</td>
<td>4</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

11 Carbon and chlorine form a chloride.

What is the formula of this chloride?

A \( \text{CCl}_2 \)  \ B \( \text{CCl}_4 \)  \ C \( \text{CaCl}_2 \)  \ D \( \text{CaCl}_4 \)

Q# 10/

11 The diagram shows a molecule of vinyl chloride (used to make pvc).

![Diagram of vinyl chloride molecule]

What is the formula of vinyl chloride?

A \( \text{CH}_2\text{Cl}_3 \)  \ B \( \text{CH}_3\text{Cl}_2 \)  \ C \( \text{C}_2\text{HCl}_3 \)  \ D \( \text{C}_2\text{H}_3\text{Cl} \)
Q# 11/
10 The diagram shows a model of a molecule of an organic acid.

What is the relative molecular mass of this acid?
A  11  B  40  C  58  D  74

11 For complete combustion, one molecule of an organic compound needs 8 molecules of oxygen.
What could the formula of this compound be?
A  C₆H₁₁OH  B  C₆H₁₂OH  C  C₆H₁₀OH  D  C₆H₁₂

Q# 12/
10 Boron, B, forms an oxide.

Which equation is correctly balanced?
A  2B + 3O₂ → B₂O₃  B  2B + 3O₂ → 2B₂O₃  C  4B + 2O₂ → 2B₂O₃  D  4B + 3O₂ → 2B₂O₃

Q# 13/
11 Students are asked to state

- the number of atoms in one molecule of ethanoic acid,
- the relative molecular mass, Mᵣ, of this acid.

Which line is correct?

<table>
<thead>
<tr>
<th>number of atoms</th>
<th>Mᵣ</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 8</td>
<td>32</td>
</tr>
<tr>
<td>B 8</td>
<td>60</td>
</tr>
<tr>
<td>C 9</td>
<td>26</td>
</tr>
<tr>
<td>D 9</td>
<td>46</td>
</tr>
</tbody>
</table>
Q# 14/

9 Magnesium and sulphur each form a chloride.

What could be the formulae of these chlorides?

<table>
<thead>
<tr>
<th></th>
<th>magnesium</th>
<th>sulphur</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Mg$_2$Cl</td>
<td>S$_2$Cl</td>
</tr>
<tr>
<td>B</td>
<td>Mg$_2$Cl</td>
<td>SC$_2$</td>
</tr>
<tr>
<td>C</td>
<td>MgCl$_2$</td>
<td>S$_2$Cl</td>
</tr>
<tr>
<td>D</td>
<td>MgCl$_2$</td>
<td>SC$_2$</td>
</tr>
</tbody>
</table>

10 A gas has the molecular formula NOCl.

Which diagram could show molecules of the pure gas NOCl?

A

B

C

D

key

○ Cl

● N

○ O

Q# 15/

10 For which compound is the formula correct?

<table>
<thead>
<tr>
<th></th>
<th>compound</th>
<th>formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>ammonia</td>
<td>NH$_4$</td>
</tr>
<tr>
<td>B</td>
<td>carbon monoxide</td>
<td>CO$_2$</td>
</tr>
<tr>
<td>C</td>
<td>iron(III) oxide</td>
<td>Fe$_3$O$_2$</td>
</tr>
<tr>
<td>D</td>
<td>zinc hydroxide</td>
<td>Zn(OH)$_2$</td>
</tr>
</tbody>
</table>
8.15 Extension Assessed Activity 3 T4.1 Stoichiometry 11 marks

Q# 1/

(c) Deduce the formula of iron(III) sulfate.

................................................................. [1]

Q# 2/

2 Choose from the following list of gases. A gas may be chosen once, more than once or not at all.

sulfur dioxide hydrogen methane carbon monoxide
argon ethene butane

(b) When burned in oxygen, the only product is water. ................................................................. [1]
(e) When reacted with oxygen, the only product is carbon dioxide. ........................................... [1]

Q# 3/

1 Use your copy of the Periodic Table to help you answer some of these questions.

(c) Use the following ions to determine the formulae of the compounds.

ions OH⁻ Cr₃⁺ Ba²⁺ SO₄²⁻

compounds

(i) chromium(III) sulfate .................................................................

(ii) barium hydroxide ................................................................. [2]

Q# 4/

5 The law of constant composition states that all pure samples of a compound contain the same elements in the same proportion by weight.

A typical experiment to test this law is to prepare the same compound by different methods and then show that the samples have the same composition.

Methods of making copper(II) oxide include:

• heating copper carbonate,
• heating copper hydroxide,
• heating copper nitrate,
• heating copper foil in air.
(c) The table below shows the results obtained by reducing the copper(II) oxide produced by different methods to copper.

(i) Complete the table.

<table>
<thead>
<tr>
<th>source of copper(II) oxide</th>
<th>mass of copper(II) oxide/g</th>
<th>mass of copper/g</th>
<th>percentage copper/%</th>
</tr>
</thead>
<tbody>
<tr>
<td>CuCO₃</td>
<td>2.37</td>
<td>1.89</td>
<td>79.7</td>
</tr>
<tr>
<td>Cu(OH)₂</td>
<td>2.51</td>
<td>1.99</td>
<td></td>
</tr>
<tr>
<td>Cu(NO₃)₂</td>
<td>2.11</td>
<td>1.68</td>
<td></td>
</tr>
<tr>
<td>Cu and O₂</td>
<td>2.29</td>
<td>1.94</td>
<td></td>
</tr>
</tbody>
</table>

(ii) One of the samples of copper(II) oxide is impure.

Identify this sample and suggest an explanation why the percentage of copper in this sample is bigger than in the other three samples.

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__________________ [2]

Q# 5/

(b) In the lattice of calcium nitride, the ratio of calcium ions to nitride ions is 3 : 2.

(ii) In terms of ionic charges, explain why the ratio of ions is 3 : 2.

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[2]

8.16 Extension Mind Map for Topic 4.1 Chemical equations
8.17 Essential End of Topic 4.1 Review and Reflection

Looking at the goals you could have achieved and the goals you actually achieved try to reflect on your progress.

Try to be as honest and as detailed as possible. Sometimes you may think you have thought about an idea well, but when you talk with someone else, or write it out, it helps you better understand and allows you think more completely and more clearly.

Did you achieve more goals this topic than last topic?

Fill in this table

<table>
<thead>
<tr>
<th>Level</th>
<th>Number of goals achieved at each level</th>
<th>Success rate, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>FUNDAMENTAL</td>
<td>/5</td>
<td></td>
</tr>
<tr>
<td>ESSENTIAL</td>
<td>/10</td>
<td></td>
</tr>
<tr>
<td>EXTENSION</td>
<td>/13</td>
<td></td>
</tr>
<tr>
<td>EXCEPTIONAL</td>
<td>/10</td>
<td></td>
</tr>
</tbody>
</table>

Do you feel you tired harder? If yes, what helped you to do so? If not, why not?

What could you do differently next time, in addition to what you are already doing to improve, not only your score in the end of topic tests and other assessed activities, but also in how you learn. How could you become a more effective student to get more learning out of the time you are investing in your studies?

What did you enjoy most about this topic?

What did you find most difficult?

What did you find easiest?

On a scale of 1 being hardest and 5 being most difficult, circle how challenging you found this topic

1 2 3 4 5

What could be done to make this topic easier to understand?

Do you have any questions about this topic?
8.18 Exceptional Stretch and Challenge Activities and Additional Reading

The SI System

The Mole is the unit for amount of substance. When you are writing out chemical equations you are in fact dealing with molar amounts.

<table>
<thead>
<tr>
<th>Name</th>
<th>Symbol</th>
<th>Measure</th>
<th>Current (2005) formal definition</th>
<th>Historical origin / justification</th>
<th>Dimension symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>metre</td>
<td>m</td>
<td>length</td>
<td>&quot;The metre is the length of the path travelled by light in vacuum during a time interval of (1/299792458) of a second.&quot; 17th CGPM (1983, Resolution 1, CR, 97)</td>
<td>1/10,000,000 of the distance from the Earth's equator to the North Pole measured on the circumference through Paris.</td>
<td>L</td>
</tr>
<tr>
<td>kilogram</td>
<td>kg</td>
<td>mass</td>
<td>&quot;The kilogram is the unit of mass; it is equal to the mass of the international prototype of the kilogram.&quot; 3rd CGPM (1901, CR, 70)</td>
<td>The mass of one litre of water at the temperature of melting ice. A litre is one thousandth of a cubic metre.</td>
<td>M</td>
</tr>
<tr>
<td>second</td>
<td>s</td>
<td>time</td>
<td>&quot;The second is the duration of (9192631770) periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium 133 atom.&quot; 13th CGPM (1967/68, Resolution 1; CR, 103) &quot;This definition refers to a caesium atom at rest at a temperature of 0 K.&quot; (Added by CIPM in 1997)</td>
<td>The day is divided in 24 hours, each hour divided in 60 minutes, each minute divided in 60 seconds. A second is (1/(24 \times 60 \times 60)) of the day.</td>
<td>T</td>
</tr>
<tr>
<td>ampere</td>
<td>A</td>
<td>electric current</td>
<td>&quot;The ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed 1 metre apart in vacuum, would produce between these conductors a force equal to (2 \times 10^{-7}) newton per metre of length.&quot; 9th CGPM (1948)</td>
<td>The original &quot;International Ampere&quot; was defined electrochemically as the current required to deposit 1.118 milligrams of silver per second from a solution of silver nitrate. Compared to the SI ampere, the difference is 0.015%.</td>
<td>I</td>
</tr>
<tr>
<td>kelvin</td>
<td>K</td>
<td>thermodynamic temperature</td>
<td>&quot;The kelvin, unit of thermodynamic temperature, is the fraction (1/273.16) of the thermodynamic temperature of the triple point of water.&quot; 13th CGPM (1967/68, Resolution 4; CR, 104) &quot;This definition refers to water having the isotopic composition defined exactly by the following amount of substance ratios: (0.000\ 155\ 76) mole of (^2)H per mole of (^1)H, (0.000\ 379\ 9) mole of (^17)O per mole of (^16)O, and (0.002\ 005) 2 mole of (^18)O per mole of (^16)O.&quot; (Added by CIPM in 2005)</td>
<td>The Celsius scale: the Kelvin scale uses the degree Celsius for its unit increment, but is a thermodynamic scale (0 K is absolute zero).</td>
<td>Θ</td>
</tr>
<tr>
<td>Name</td>
<td>Symbol</td>
<td>Measure</td>
<td>Current (2005) formal definition[1]</td>
<td>Historical origin / justification</td>
<td>Dimension symbol</td>
</tr>
<tr>
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<td>-----------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------</td>
<td>------------------</td>
</tr>
</tbody>
</table>
| mole   | mol    | amount of substance         | "1. The mole is the amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kilogram of carbon 12; its symbol is 'mol'.  
2. When the mole is used, the elementary entities must be specified and may be atoms, molecules, ions, electrons, other particles, or specified groups of such particles."  
14th CGPM (1971, Resolution 3; CR, 78)  
"In this definition, it is understood that unbound atoms of carbon 12, at rest and in their ground state, are referred to."  
(Added by CIPM in 1980)                                                                 | Atomic weight or molecular weight divided by the molar mass constant, 1 g/mol.                                                                                     | N                |
| candela| cd     | luminous intensity          | "The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540×10¹² hertz and that has a radiant intensity in that direction of 1/683 watt per steradian."  
16th CGPM (1979, Resolution 3; CR, 100)                                                                 | The candlepower, which is based on the light emitted from a burning candle of standard properties.                                                              | J                |

To find out more about the SI system click on this link: [https://www.nist.gov/pml/weights-and-measures/metric-si/si-units](https://www.nist.gov/pml/weights-and-measures/metric-si/si-units) Or scan this QR code:

**Exceptional Reflection**

Why do you think the SI units exist? Do any countries not use this system? Who gets to decide on these standards?

One of these, until 2019 is not based on a universal law, the Kilogram. To find out more about this exceptional unit and how and why it changed in 2019 read these articles:

- [https://www.sciencealert.com/it-s-official-the-definition-of-a-kilogram-has-changed](https://www.sciencealert.com/it-s-official-the-definition-of-a-kilogram-has-changed)

For an alternate version of the kilogram, which was not adopted can be found by finding out about the world’s roundest object:


Exceptional Activity – Create a short 2-3 minute presentation about any part of an SI unit you find most interesting. You should try to explain as much as possible, rather than just describing facts to show analysis, which is a higher order thinking skill that becomes increasingly important as you progress through your education.
### 9.1 End of Topic 4.2 Goals Checklist

For each topic you ought to try to do as many of the following things to get the most out of your time, the resources available to you and to help you grow as a student. Tick each goal off as you complete it. Growth is difficult and uncomfortable, but you should choose to do these things, and the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win!

<table>
<thead>
<tr>
<th>Aspect</th>
<th>What you should have done</th>
<th>Yes/No</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interacted with your teacher</td>
<td>Ask your teacher 1 question, about anything, once a week</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Try to answer one question asked by your teacher at least once a week</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Ask your teacher one question about something you do not understand in science once a week</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Ask your teacher one question about something to do with science every lesson</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td>Notes and follow up notes</td>
<td>Complete set of class note</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Attempted</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Completed</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Completed to an exemplary standard</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Attempted the Mind Map for this topic</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Completed the Mind Map for this topic</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td>Textbook</td>
<td>Read ahead before the topic has been started</td>
<td></td>
<td>FUNDAMENTION</td>
</tr>
<tr>
<td></td>
<td>Highlighted key ideas and translate new words</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Completed the questions at the end of each 2 page spread in your exercise book</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Added to your class notes ideas and important information from the textbook that you learnt</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td>Past Exam Questions</td>
<td>Worked on at least 25% of the exam questions in this workbook</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Attempted more than 25% of the questions and those questions you have completed you have marked in a different colour pen</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Completed and marked all questions here</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Completed, marked and additional key ideas where you have located the most difficult marks added to your notebook</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Used the resources available online to answer additional questions not found in this workbook on the current topic.</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Ask your teacher about an exam question that they cannot answer</td>
<td></td>
<td>EXCEPTIONALLY SMASHING!!!</td>
</tr>
<tr>
<td>Assessed Activities</td>
<td>Complete the word list activity using the word list at the front of each topic as little as possible</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities, either in class or as homework</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 70% on average</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 80% on average</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 90% on average</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td>End of Topic Test</td>
<td>Revised sufficiently well to improve upon your score from the previous test (except if you are scoring over 90%, then just write Y for this goal)</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Scored 10% higher than your current average</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Scored 15% or more than your previous end of topic average</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Scored over 90%</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Scored over 95%</td>
<td></td>
<td>SMASHING!!!</td>
</tr>
<tr>
<td>Aspect</td>
<td>What you should have done</td>
<td>Yes/No</td>
<td>Level</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------------------------------------------------------------------------------------</td>
<td>---------</td>
<td>-------------</td>
</tr>
<tr>
<td>Reading</td>
<td>Spend more than 1 hour a week reading a book <strong>you enjoy</strong> (in any language) about anything.</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Spend more than 3 hours a week reading a book <strong>you enjoy</strong> (in any language) about anything.</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Spend more than 5 hours a week reading a book <strong>you enjoy</strong> (in any language) about anything.</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Spend at least one hour a week reading a book <strong>you enjoy</strong> in English about anything.</td>
<td></td>
<td>EXCEPTION</td>
</tr>
<tr>
<td></td>
<td>Spend more than 3 hours a week reading a book <strong>you enjoy</strong> in English about anything.</td>
<td></td>
<td>EXCEPTION</td>
</tr>
<tr>
<td>Reflection</td>
<td>You completed this goal setting table</td>
<td>FUNDAMENTAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>You have looked at the goals you have achieved and the ones you have not and added them up and entered them into the table in the Review and Reflection section</td>
<td>ESSENTIAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>You have given an answer for every question in the Review and Reflection section at the end of this topic</td>
<td>EXTENSION</td>
<td></td>
</tr>
<tr>
<td></td>
<td>You have Given good and thoughtful answers for every question in the Review and Reflection section at the end of this topic</td>
<td>EXCEPTIONAL</td>
<td></td>
</tr>
</tbody>
</table>

9.2 Topic 4.2 Syllabus

4 Stoichiometry

4.2 The mole concept

**Supplement**
- Define the **mole** and the **Avogadro constant**
- Use the molar gas volume, taken as 24 dm³ at room temperature and pressure
- Calculate stoichiometric reacting masses, volumes of gases and solutions, and concentrations of solutions expressed in g/dm³ and mol/dm³. (Calculations involving the idea of limiting reactants may be set. Questions on the gas laws and the conversion of gaseous volumes to different temperatures and pressures will **not** be set.)
- Calculate empirical formulae and molecular formulae
- Calculate percentage yield and percentage purity
9.3 **ESSENTIAL Glossary for Keywords for this topic**

Many words used in science have a meaning that is slightly different to their common everyday English meaning, for instance a salt is the product of an acid and base reacting together in chemistry, but normally thought of as table salt (NaCl) in common use.

The keywords have been auto translated into Chinese, so the translations will not be perfect but they should hopefully make sense. If there is a better translation you can simply write it out yourself on a Post-it note and stick it over the printed one.

<table>
<thead>
<tr>
<th>Topic #</th>
<th>English</th>
<th>Chinese</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>balanced chemical (symbol) equation a summary of a chemical reaction using chemical formulae – the total number of any of the atoms involved is the same on both the reactant and product sides of the equation</td>
<td>平衡化学（符号）方程式-使用化学式进行化学反应的摘要-涉及的任何原子总数在方程式的反应物和产物侧均相同</td>
</tr>
<tr>
<td>4</td>
<td>chemical reaction a change in which a new substance is formed</td>
<td>化学反应形成新物质的变化</td>
</tr>
<tr>
<td>4</td>
<td>concentration a measure of how much solute is dissolved in a solvent. Solutions can be dilute (with a high proportion of the solvent), or concentrated (with a high proportion of the solute)</td>
<td>浓度衡量溶质溶解在溶剂中的量度-溶液可以是稀溶液（高比例的溶剂）-也可以是浓缩液（高比例的溶质）</td>
</tr>
<tr>
<td>4</td>
<td>empirical formula a formula for a compound which shows the simplest ratio of atoms present</td>
<td>经验公式化合物的公式・显示存在的最简单的原子比</td>
</tr>
<tr>
<td>4</td>
<td>formula (chemical) a shorthand method of representing chemical elements and compounds using the symbols of the elements</td>
<td>公式（化学）：使用元素符号表示化学元素和化合物的简写方法</td>
</tr>
<tr>
<td>4</td>
<td>hydrated salts ionic compounds that contain water of crystallisation between the ions within the solid</td>
<td>在固体中离子之间含有结晶水的水合盐离子化合物</td>
</tr>
<tr>
<td>4</td>
<td>ionic equation the simplified equation for a reaction involving ionic substances: only those ions which take part in the reaction are shown</td>
<td>离子方程式涉及离子物质的反应的简化方程式：仅显示那些参与反应的离子</td>
</tr>
<tr>
<td>4</td>
<td>law of conservation of mass matter cannot be lost or gained in a chemical reaction – the total mass of the reactants equals the total mass of the products</td>
<td>物质守恒定律在化学反应中不会丢失或获得-反应物的总质量等于产物的总质量</td>
</tr>
<tr>
<td>4</td>
<td>molar concentration the measure of the concentration of a solution in terms of the number of moles of the solute dissolved per cubic decimetre of solution (mol/dm³)</td>
<td>摩尔浓度溶液浓度的量度，以每立方米溶液中溶解的溶质的摩尔数表示（mol / dm³）</td>
</tr>
<tr>
<td>4</td>
<td>molar mass the mass, in grams, of one mole of a substance</td>
<td>摩尔质量-摩尔物质的质量，以克为单位</td>
</tr>
<tr>
<td>4</td>
<td>molar volume of a gas one mole of any gas has the same volume under the same conditions of temperature and pressure (24 dm³ at one atmosphere and room temperature)</td>
<td>气体的摩尔体积-摩尔的任何气体在相同温度和压力条件下（在一个大气压和室温下为24 dm³）具有相同的体积</td>
</tr>
<tr>
<td>4</td>
<td>mole the measure of amount of substance in chemistry; one mole of a substance has a mass equal to its relative formula mass in grams – that amount of substance contains</td>
<td>摩尔化学中物质含量的量度-一摩尔物质的质量等于其相对分子式的质量（以克为单位）-该物质的数量包含</td>
</tr>
<tr>
<td>4</td>
<td>molecular formula</td>
<td>a formula which shows the actual number of atoms of each element present in a molecule of the compound</td>
</tr>
<tr>
<td>---</td>
<td>-------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>4</td>
<td>molecular mass</td>
<td>another, less precise, name for relative molecular mass</td>
</tr>
<tr>
<td>4</td>
<td>percentage purity</td>
<td>a measure of the purity of the product from a reaction carried out experimentally: percentage purity = mass of pure product mass of impure product ( \times 100 )</td>
</tr>
<tr>
<td>4</td>
<td>percentage yield</td>
<td>a measure of the actual yield of a reaction when carried out experimentally compared to the theoretical yield calculated from the equation: percentage yield = actual yield predicted yield ( \times 100 )</td>
</tr>
<tr>
<td>4</td>
<td>products</td>
<td>(in a chemical reaction) the substance(s) produced by a chemical reaction</td>
</tr>
<tr>
<td>4</td>
<td>reactants</td>
<td>(in a chemical reaction) the chemical substances that react together in a chemical reaction</td>
</tr>
<tr>
<td>4</td>
<td>relative formula mass (( M_r ))</td>
<td>the sum of all the relative atomic masses of the atoms present in a ‘formula unit’ of a substance</td>
</tr>
<tr>
<td>4</td>
<td>relative molecular mass (( M_r ))</td>
<td>the sum of all the relative atomic masses of the atoms present in a molecule</td>
</tr>
<tr>
<td>4</td>
<td>spectator ions</td>
<td>these are present in a chemical reaction but take no part in it. They are not included in ionic equations</td>
</tr>
<tr>
<td>4</td>
<td>standard atom</td>
<td>the atom against which the relative atomic masses of all other atoms are measured using the mass spectrometer; one atom of the carbon-12 isotope is given a mass of exactly 12</td>
</tr>
<tr>
<td>4</td>
<td>standard solution</td>
<td>a solution whose concentration is known precisely – this solution is then used to find the concentration of another solution by titration</td>
</tr>
<tr>
<td>4</td>
<td>state symbols</td>
<td>these are used to show the physical state of the reactants and products in a chemical reaction: they are (s) solid, (l) liquid, (g) gas and (aq) dissolved in solution in water</td>
</tr>
<tr>
<td>4</td>
<td>structural formula</td>
<td>the structural formula of an organic molecule shows how the atoms and bonds in a molecule are arranged in space: all the atoms and covalent bonds must be shown</td>
</tr>
<tr>
<td>4</td>
<td>symbol (chemical)</td>
<td>a simple letter, or group of letters, that represents an element in a chemical formula</td>
</tr>
</tbody>
</table>
**Titration** a method of quantitative analysis using solutions: one solution is slowly added to a known volume of another solution using a burette until an end-point is reached.

**Water of Crystallisation** water included in the structure of certain salts as they crystallise; for example, copper(II) sulfate pentahydrate (CuSO₄·5H₂O) contains five molecules of water of crystallisation per molecule of copper(II) sulfate.

**Word Equation** a summary of a chemical reaction using the chemical names of the reactants and products.

---

### 9.4 ESSENTIAL EXAM QUESTIONS

**Topic 4.2**

**Paper 3/4**

148 marks

**Subtopic Chem 4.2 Q# 1/ iGCSE Chemistry/2015/w/Paper 31/

5 (a) A compound, X, contains 55.85% carbon, 6.97% hydrogen and 37.18% oxygen.

(i) How does this prove that compound X contains only carbon, hydrogen and oxygen?

.......................................................................................................................................................... [1]

(ii) Use the above percentages to calculate the empirical formula of compound X.

.......................................................................................................................................................... [2]

(iii) The $M_r$ of X is 86.

What is its molecular formula?

.......................................................................................................................................................... [2]

**Subtopic Chem 4.2 Q# 2/ iGCSE Chemistry/2015/s/Paper 31/ Q3**

(d) Calculate the maximum mass of zinc which will react with 50 cm$^3$ of hydrochloric acid, of concentration 2.0 mol/dm$^3$.

\[
\text{Zn} + 2\text{HCl} \rightarrow \text{ZnCl}_2 + \text{H}_2
\]

Show your working.
Subtopic Chem 4.2 Q# 3/ IGCSE Chemistry/2014/s/Paper 31/

6 Hydrogen peroxide decomposes to form water and oxygen. This reaction is catalysed by manganese(IV) oxide.

(d) In the first experiment, the maximum volume of oxygen produced was 96 cm$^3$ measured at r.t.p. Calculate the concentration of the aqueous hydrogen peroxide in mol/dm$^3$.

$$2\text{H}_2\text{O}_2(\text{aq}) \rightarrow 2\text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g})$$

number of moles of $\text{O}_2$ formed = ................................................................. [1]

number of moles of $\text{H}_2\text{O}_2$ in 40 cm$^3$ of solution = .................................................. [1]

concentration of the aqueous hydrogen peroxide in mol/dm$^3$ = ............................................ [1]

Subtopic Chem 4.2 Q# 4/ IGCSE Chemistry/2013/w/Paper 31/ Q4

(d) Calculate the maximum mass of carbon dioxide given off when 20.0 g of small lumps of calcium carbonate react with 40 cm$^3$ of hydrochloric acid, concentration 2.0 mol/dm$^3$.

$$\text{CaCO}_3(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow \text{CaCl}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$$

number of moles of HCl used =

mass of carbon dioxide = ................. g [4]
Subtopic Chem 4.2 Q# 5/ IGCSE Chemistry/2013/w/Paper 31/

(c) Basic lead(II) carbonate has a formula of the type $x\text{PbCO}_3 \cdot y\text{Pb(OH)}_2$ where $x$ and $y$ are whole numbers.

Determine $x$ and $y$ from the following information.

$\text{PbCO}_3 \rightarrow \text{PbO} + \text{CO}_2$

$\text{Pb(OH)}_2 \rightarrow \text{PbO} + \text{H}_2\text{O}$

When heated, the basic lead(II) carbonate gave 2.112 g of carbon dioxide and 0.432 g of water.

Mass of one mole of $\text{CO}_2 = 44 \text{ g}$
Mass of one mole of $\text{H}_2\text{O} = 18 \text{ g}$

Number of moles of $\text{CO}_2$ formed = ......................... [1]

Number of moles of $\text{H}_2\text{O}$ formed = ......................... [1]

$x = ....................... \text{ and } y = .......................$

Formula of basic lead(II) carbonate is .................................................. [1]

Subtopic Chem 4.2 Q# 6/ IGCSE Chemistry/2012/w/Paper 31/ Q7

Strontium chloride-6-water can be made from the insoluble compound, strontium carbonate, by the following reactions.

$\text{SrCO}_3(s) + 2\text{HCl}(aq) \rightarrow \text{SrCl}_2(aq) + \text{CO}_2(g) + \text{H}_2\text{O}(l)$

$\text{SrCl}_2(aq) + 6\text{H}_2\text{O}(l) \rightarrow \text{SrCl}_2.6\text{H}_2\text{O}(s)$

The following method was used to prepare the crystals.

(c) In the above experiment, 50.0 cm$^3$ of hydrochloric acid of concentration 2.0 mol/dm$^3$ was used. 6.4 g of $\text{SrCl}_2.6\text{H}_2\text{O}$ was made.

Calculate the percentage yield.

number of moles of $\text{HCl}$ used = .........................

number of moles of $\text{SrCl}_2.6\text{H}_2\text{O}$ which could be formed = .........................

mass of one mole of $\text{SrCl}_2.6\text{H}_2\text{O}$ is 267 g

theoretical yield of $\text{SrCl}_2.6\text{H}_2\text{O} = ......................... \text{ g}$

percentage yield = .........................\% [4]
Subtopic Chem 4.2 Q# 7/ IGCSE Chemistry/2012/w/Paper 31/ Q2

(c) Fluorine, the most reactive halogen, forms compounds with the other halogens. It forms two compounds with bromine.
Deduce their formulae from the following information.

compound 1
The mass of one mole of this compound is 137 g.
Its formula is ........................................... [1]

compound 2
0.02 moles of this compound contain 0.02 moles of bromine atoms and 0.1 moles of fluorine atoms.
Its formula is ........................................... [1]

Subtopic Chem 4.2 Q# 8/ IGCSE Chemistry/2012/s/Paper 31/

8 Iron and steel rust when exposed to water and oxygen. Rust is hydrated iron(III) oxide.
(b) A sample of rust had the following composition:

51.85 g of iron    22.22 g of oxygen    16.67 g of water.
Calculate the following and then write the formula for this sample of rust.

number of moles of iron atoms, Fe = .................... [1]

number of moles of oxygen atoms, O = .................... [1]

number of moles of water molecules, H₂O = ................ [1]

simplest mole ratio Fe : O : H₂O is ............ : ............ : ...........

formula for this sample of rust is .................... [1]

Subtopic Chem 4.2 Q# 9/ IGCSE Chemistry/2012/s/Paper 31/

6 Butane is an alkane. It has the following structural formula.

\[
\begin{align*}
&\text{H} \quad \text{H} \quad \text{H} \\
&\text{H} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{C} \\
&\text{H} \quad \text{H} \quad \text{H} \quad \text{H}
\end{align*}
\]

(a) The equation for the complete combustion of butane is given below. Insert the two missing volumes.

\[2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(g)\]

............  ...........  40 volume of gas/cm³ [2]
There are three possible equations for the thermal decomposition of sodium hydrogen carbonate.

$$2\text{NaHCO}_3(s) \rightarrow \text{Na}_2\text{O}(s) + 2\text{CO}_2(g) + \text{H}_2\text{O}(g)$$  \text{equation 1}

$$\text{NaHCO}_3(s) \rightarrow \text{NaOH}(s) + \text{CO}_2(g)$$  \text{equation 2}

$$2\text{NaHCO}_3(s) \rightarrow \text{Na}_2\text{CO}_3(s) + \text{CO}_2(g) + \text{H}_2\text{O}(g)$$  \text{equation 3}

The following experiment was carried out to determine which one of the above is the correct equation.

A known mass of sodium hydrogen carbonate was heated for ten minutes. It was then allowed to cool and weighed.

**Results**

Mass of sodium hydrogen carbonate = 3.36 g

Mass of the residue = 2.12 g

**Calculation**

\(M_r\) for \(\text{NaHCO}_3 = 84\) g; \(M_r\) for \(\text{Na}_2\text{O} = 62\) g; \(M_r\) for \(\text{NaOH} = 40\) g

\(M_r\) for \(\text{Na}_2\text{CO}_3 = 106\) g

(i) Number of moles of \(\text{NaHCO}_3\) used = \[\text{[1]}\]

(ii) If residue is \(\text{Na}_2\text{O}\), number of moles of \(\text{Na}_2\text{O}\) = \[\text{[2]}\]

\[\text{If residue is } \text{NaOH}, \text{ number of moles of } \text{NaOH} = \text{[2]}\]

\[\text{If residue is } \text{Na}_2\text{CO}_3, \text{ number of moles of } \text{Na}_2\text{CO}_3 = \text{[2]}\]

(iii) Use the number of moles calculated in (i) and (ii) to decide which one of the three equations is correct. Explain your choice.
Subtopic Chem 4.2 Q# 11/ iGCSE Chemistry/2011/s/Paper 31/ Q5

(d) 20.0 cm³ of aqueous sodium hydroxide, 2.00 mol/dm³, was placed in a beaker. The temperature of the alkali was measured and 1.0 cm³ portions of hydriodic acid were added. After each addition, the temperature of the mixture was measured. Typical results are shown on the graph.

\[ \text{temperature} \]
\[ \text{18.0 cm³} \quad \text{volume of acid added} \]

\[
\text{NaOH(aq)} + \text{HI(aq)} \rightarrow \text{NaI(aq)} + \text{H}_2\text{O(l)}
\]

(iii) In another experiment, it was shown that 15.0 cm³ of the acid neutralised 20.0 cm³ of aqueous sodium hydroxide, 1.00 mol/dm³. Calculate the concentration of the acid.

Subtopic Chem 4.2 Q# 12/ iGCSE Chemistry/2010/w/Paper 31/ Q5

(b) 6.0 g of cobalt(II) carbonate was added to 40 cm³ of hydrochloric acid, concentration 2.0 mol/dm³. Calculate the maximum yield of cobalt(II) chloride-6-water and show that the cobalt(II) carbonate was in excess.

\[
\text{CoCO}_3 + 2\text{HCl} \rightarrow \text{CoCl}_2 + \text{CO}_2 + \text{H}_2\text{O}
\]

\[
\text{CoCl}_2 + 6\text{H}_2\text{O} \rightarrow \text{CoCl}_2.6\text{H}_2\text{O}
\]

Maximum yield

Number of moles of HCl used = .........................

Number of moles of CoCl₂ formed = .........................

Number of moles of CoCl₂·6H₂O formed = .........................

Mass of one mole of CoCl₂·6H₂O = 238 g

Maximum yield of CoCl₂·6H₂O = ......................... g
To show that cobalt(II) carbonate is in excess

Number of moles of HCl used = ........................................ (use value from above)

Mass of one mole of CoCO₃ = 119 g

Number of moles of CoCO₃ in 6.0 g of cobalt(II) carbonate = ................................... [1]

Explain why cobalt(II) carbonate is in excess .................................................................................................................. [1]

Subtopic Chem 4.2 Q# 13/ iGCSE Chemistry/2010/s/Paper 31/ Q7

(e) The titanium ore contains 36.8% iron, 31.6% titanium and the remainder is oxygen.

(i) Determine the percentage of oxygen in this titanium compound.

percentage of oxygen = ........................................................................................................ % [1]

(ii) Calculate the number of moles of atoms for each element.
The number of moles of Fe is shown as an example.

number of moles of Fe = 36.8/56 = 0.66

number of moles of Ti = .................................................................................................................. [1]

number of moles of O = .................................................................................................................. [1]

(iii) What is the simplest ratio for the moles of atoms?

Fe : Ti : O


(iv) What is the formula of this titanium compound?

............................................................................................................................................... [1]
Subtopic Chem 4.2 Q# 14/ iGCSE Chemistry/2009/w/Paper 3/ Q6

(c) 9.12 g of anhydrous iron(II) sulfate was heated. Calculate the mass of iron(III) oxide formed and the volume of sulfur trioxide, at r.t.p., formed.

\[ 2\text{FeSO}_4(s) \rightarrow \text{Fe}_2\text{O}_3(s) + \text{SO}_2(g) + \text{SO}_3(g) \]

mass of one mole of \( \text{FeSO}_4 \) = 152 g

number of moles of \( \text{FeSO}_4 \) used = ..................

number of moles of \( \text{Fe}_2\text{O}_3 \) formed = ..................

mass of one mole of \( \text{Fe}_2\text{O}_3 \) = .................. g

mass of iron(III) oxide formed = .................. g

number of moles of \( \text{SO}_3 \) formed = ..................

volume of sulfur trioxide formed = .................. dm\(^3\)

Subtopic Chem 4.2 Q# 15/ iGCSE Chemistry/2009/s/Paper 31/

9 Quantities of chemicals, expressed in moles, can be used to find the formula of a compound, to establish an equation and to determine reacting masses.

(a) A compound contains 72% magnesium and 28% nitrogen. What is its empirical formula?

..........................................................................................................................

..........................................................................................................................

.......................................................................................................................... [2]

(b) A compound contains only aluminium and carbon. 0.03 moles of this compound reacted with excess water to form 0.12 moles of \( \text{Al}([\text{OH}])_3 \) and 0.09 moles of \( \text{CH}_4 \).

Write a balanced equation for this reaction.

..........................................................................................................................

..........................................................................................................................

.......................................................................................................................... [2]
(c) 0.07 moles of silicon reacts with 25 g of bromine.

\[ \text{Si} + 2\text{Br}_2 \rightarrow \text{SiBr}_4 \]

(i) Which one is the limiting reagent? Explain your choice.

.......................................................................................................................... [3]

(ii) How many moles of \( \text{SiBr}_4 \) are formed?

.......................................................................................................................... [1]

4 Across the world, food safety agencies are investigating the presence of minute traces of the toxic hydrocarbon, benzene, in soft drinks. It is formed by the reduction of sodium benzoate by vitamin C.

(b) Benzene contains 92.3% of carbon and its relative molecular mass is 78.

(i) What is the percentage of hydrogen in benzene?

.......................................................................................................................... [1]

(ii) Calculate the ratio of moles of C atoms: moles of H atoms in benzene.

.......................................................................................................................... [2]

(iii) Calculate its empirical formula and then its molecular formula.

The empirical formula of benzene is ........................................................................

The molecular formula of benzene is ...................................................................... [2]

3 Steel is an alloy made from impure iron.

(a) Both iron and steel rust. The formula for rust is \( \text{Fe}_2\text{O}_3 \cdot 2\text{H}_2\text{O} \). It is hydrated iron(III) oxide.
(c) (i) Calculate the mass of one mole of $\text{Fe}_2\text{O}_3.2\text{H}_2\text{O}$.

\[ \text{[1]} \]

(ii) Use your answer to (i) to calculate the percentage of iron in rust.

\[ \text{[2]} \]

Subtopic Chem 4.2 Q# 18/ iGCSE Chemistry/2008/w/Paper 31/ 7

The alkanes are generally unreactive. Their reactions include combustion, substitution and cracking.

(a) The complete combustion of an alkane gives carbon dioxide and water.

(i) $10 \text{ cm}^3$ of butane is mixed with $100 \text{ cm}^3$ of oxygen, which is an excess. The mixture is ignited. What is the volume of unreacted oxygen left and what is the volume of carbon dioxide formed?

\[
\text{C}_4\text{H}_{10}(g) + 6\frac{1}{2}\text{O}_2(g) \rightarrow 4\text{CO}_2(g) + 5\text{H}_2\text{O}(l)
\]

Volume of oxygen left = \[ \text{cm}^3 \]  
Volume of carbon dioxide formed = \[ \text{cm}^3 \]  

\[ \text{[2]} \]

Subtopic Chem 4.2 Q# 19/ iGCSE Chemistry/2008/s/Paper 31/ Q7

(b) Using $25.0 \text{ cm}^3$ of aqueous sodium hydroxide, $2.24 \text{ mol} / \text{dm}^3$, 3.86 g of crystals were obtained. Calculate the percentage yield.

\[
\text{2NaOH} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}
\]

\[
\text{Na}_2\text{SO}_4 + 10\text{H}_2\text{O} \rightarrow \text{Na}_2\text{SO}_4.10\text{H}_2\text{O}
\]

Number of moles of NaOH used = \[ \text{ } \]

Maximum number of moles of $\text{Na}_2\text{SO}_4.10\text{H}_2\text{O}$ that could be formed = \[ \text{ } \]

Mass of one mole of $\text{Na}_2\text{SO}_4.10\text{H}_2\text{O} = 322 \text{g}$

Maximum yield of sodium sulphate-10-water = \[ \text{g} \]

Percentage yield = \[ \% \]  

\[ \text{[4]} \]

Subtopic Chem 4.2 Q# 20/ iGCSE Chemistry/2007/w/Paper 3/ 7

(a) A small piece of marble, calcium carbonate, was added to $5 \text{ cm}^3$ of hydrochloric acid at $25 ^\circ \text{C}$. The time taken for the reaction to stop was measured.

\[
\text{CaCO}_3(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow \text{CaCl}_2(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(l)
\]

Similar experiments were performed always using $5 \text{ cm}^3$ of hydrochloric acid.
(b)

(ii) One piece of marble, 0.3 g, was added to 5 cm$^3$ of hydrochloric acid, concentration 1.00 mol/dm$^3$. Which reagent is in excess? Give a reason for your choice.

mass of one mole of CaCO$_3$ = 100 g

number of moles of CaCO$_3$ = ................................................................. [ ]

number of moles of HCl = ................................................................. [ ]

reagent in excess is ................................................................. [4]

reason ................................................................. [ ]

(iii) Use your answer to (ii) to calculate the maximum volume of carbon dioxide produced measured at r.t.p.

................................................................. [1]

Subtopic Chem 4.2 Q# 21/ iGCSE Chemistry/2007/s/Paper 3/ Q7

(d) A better way of measuring the degree of unsaturation is to find the iodine number of the unsaturated compound. This is the mass of iodine that reacts with all the double bonds in 100 g of the fat.

Use the following information to calculate the number of double bonds in one molecule of the fat.

*Mass of one mole of the fat is 884 g.*

One mole of I$_2$ reacts with one mole $\overset{\text{C}}{\text{C}}\overset{\text{C}}{\text{C}}$

*The iodine number of the fat is 86.2 g.*

Complete the following calculation.

100 g of fat reacts with 86.2 g of iodine.

884 g of fat reacts with ................................................................. g of iodine.

One mole of fat reacts with ................................................................. moles of iodine molecules.

Number of double bonds in one molecule of fat is ................................................................. [3]

Subtopic Chem 4.2 Q# 22/ iGCSE Chemistry/2006/w/Paper 3/ Q3

(b) When calcium carbonate is heated strongly, it decomposes.

$\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$

(i) Calculate the relative formula mass of:

CaCO$_3$ ................................................................. [ ]

CaO ................................................................. [ ]

[2]
(ii) 7.00 kg of calcium oxide was formed. What mass of calcium carbonate was heated?

6 An ore of copper is the mineral, chalcopyrite. This is a mixed sulphide of iron and copper.

(a) Analysis of a sample of this ore shows that 13.80 g of the ore contained 4.80 g of copper, 4.20 g of iron and the rest sulphur.

Complete the table and calculate the empirical formula of chalcopyrite.

<table>
<thead>
<tr>
<th></th>
<th>copper</th>
<th>iron</th>
<th>sulphur</th>
</tr>
</thead>
<tbody>
<tr>
<td>composition by mass/g</td>
<td>4.80</td>
<td>4.20</td>
<td></td>
</tr>
<tr>
<td>number of moles of atoms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>simplest mole ratio of atoms</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The empirical formula is

(d) Propene reacts with hydrogen iodide to form 2-iodopropene.

\[
\text{CH}_3\text{CH} = \text{CH}_2 + \text{HI} \rightarrow \text{CH}_3\text{CHI} - \text{CH}_3
\]

1.4 g of propene produced 4.0 g of 2-iodopropene.

Calculate the percentage yield.

moles of \(\text{CH}_3\text{CH} = \text{CH}_2\) reacted =

maximum moles of \(\text{CH}_3\text{CHI} - \text{CH}_3\) that could be formed =

mass of one mole of \(\text{CH}_3\text{CHI} - \text{CH}_3\) = 170 g

maximum mass of 2-iodopropene that could be formed =

percentage yield = \(\%\)
6 (a) The following method is used to make crystals of hydrated nickel sulphate.

An excess of nickel carbonate, 12.0 g, was added to 40 cm³ of sulphuric acid, 2.0 mol/dm³. The unreacted nickel carbonate was filtered off and the filtrate evaporated to obtain the crystals.

\[
\text{NiCO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{NiSO}_4 + \text{CO}_2 + \text{H}_2\text{O} \\
\text{NiSO}_4 + 7\text{H}_2\text{O} \rightarrow \text{NiSO}_4.7\text{H}_2\text{O}
\]

Mass of one mole of NiSO₄.7H₂O = 281 g
Mass of one mole of NiCO₃ = 119 g

(i) Calculate the mass of unreacted nickel carbonate.

Number of moles of H₂SO₄ in 40 cm³ of 2.0 mol/dm³ acid = 0.08

Number of moles of NiCO₃ reacted = .............................................................

Mass of nickel carbonate reacted = ............................................................. g

Mass of unreacted nickel carbonate = ............................................................. g [3]

(ii) The experiment produced 10.4 g of hydrated nickel sulphate. Calculate the percentage yield.

The maximum number of moles of NiSO₄.7H₂O that could be formed = .............................................................

The maximum mass of NiSO₄.7H₂O that could be formed = ............................................................. g

The percentage yield = ............................................................. % [3]

(c) 0.015 moles of iodine react with 0.045 moles of chlorine to form 0.030 moles of a single product. Complete the equation.

\[\text{I}_2 + \text{C}_2\text{Cl}_2 \rightarrow \text{I}_2 \text{Cl}_2\] [2]

(d) Gypsum is hydrated calcium sulphate, CaSO₄·xH₂O. It contains 20.9% water by mass. Calculate x.

\[M: \text{CaSO}_4, 136; \text{H}_2\text{O}, 18.\]

79.1 g of CaSO₄ = ............................................................. moles

20.9 g of H₂O = ............................................................. moles

\[x = \text{.............................................................} \] [3]
Subtopic Chem 4.2 Q# 28/ iGCSE Chemistry/2004/w/Paper 3/ Q7

(c) Iron(III) sulphate decomposes when heated. Calculate the mass of iron(III) oxide formed and the volume of sulphur trioxide produced when 10.0 g of iron(III) sulphate was heated.

Mass of one mole of Fe$_2$(SO$_4$)$_3$ is 400 g.

Fe$_2$(SO$_4$)$_3$ (s) $\rightarrow$ Fe$_2$O$_3$ (s) + 3SO$_3$ (g)

| Number of moles of Fe$_2$(SO$_4$)$_3$ = |  |  
| Number of moles of Fe$_2$O$_3$ formed = |  |  
| Mass of iron(III) oxide formed = | g |  
| Number of moles of SO$_3$ produced = |  |  
| Volume of sulphur trioxide at r.t.p. = | dm$^3$ | [5] 

Subtopic Chem 4.2 Q# 29/ iGCSE Chemistry/2004/s/Paper 3/

7 Chemists use the concept of the mole to calculate the amounts of chemicals involved in a reaction.

(a) Define mole. 

........................................................................................................................................................................... [1]

(b) 3.0 g of magnesium was added to 12.0 g of ethanoic acid.

Mg + 2CH$_3$COOH → (CH$_3$COO)$_2$Mg + H$_2$

The mass of one mole of Mg is 24 g.

The mass of one mole of CH$_3$COOH is 60 g.

(i) Which one, magnesium or ethanoic acid, is in excess? You must show your reasoning.

........................................................................................................................................................................... [3]

(ii) How many moles of hydrogen were formed? 

........................................................................................................................................................................... [1]

(iii) Calculate the volume of hydrogen formed, measured at r.t.p. 

........................................................................................................................................................................... [2]
(c) In an experiment, 25.0 cm$^3$ of aqueous sodium hydroxide, 0.4 mol/dm$^3$, was neutralised by 20.0 cm$^3$ of aqueous oxalic acid, H$_2$C$_2$O$_4$.

\[2\text{NaOH} + \text{H}_2\text{C}_2\text{O}_4 \rightarrow \text{Na}_2\text{C}_2\text{O}_4 + \text{2H}_2\text{O}\]

Calculate the concentration of the oxalic acid in mol/dm$^3$.

(i) Calculate the number of moles of NaOH in 25.0 cm$^3$ of 0.4 mol/dm$^3$ solution.

(ii) Use your answer to (i) and the mole ratio in the equation to find out the number of moles of H$_2$C$_2$O$_4$ in 20 cm$^3$ of solution.

(iii) Calculate the concentration, mol/dm$^3$, of the aqueous oxalic acid.

(d) Sulphur dioxide reacts with chlorine in an addition reaction to form sulphuryl chloride.

\[\text{SO}_2 + \text{Cl}_2 \rightarrow \text{SO}_2\text{Cl}_2\]

8.0 g of sulphur dioxide was mixed with 14.2 g of chlorine. The mass of one mole of SO$_2$Cl$_2$ is 135 g.

Calculate the mass of sulphuryl chloride formed by this mixture.

Calculate the number of moles of SO$_2$ in the mixture = .................

Calculate the number of moles of Cl$_2$ in the mixture = .................

Which reagent was not in excess? .........................

How many moles of SO$_2$Cl$_2$ were formed = .................

Calculate the mass of sulphuryl chloride formed = ................. g

2 Calcium and other minerals are essential for healthy teeth and bones. Tablets can be taken to provide these minerals.

(c) Each tablet contains the same number of moles of CaCO$_3$ and MgCO$_3$. One tablet reacted with excess hydrochloric acid to produce 0.24 dm$^3$ of carbon dioxide at r.t.p.

\[\text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{CO}_2 + \text{H}_2\text{O}\]

\[\text{MgCO}_3 + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{CO}_2 + \text{H}_2\text{O}\]

(i) Calculate how many moles of CaCO$_3$ there are in one tablet.

\[
\text{number of moles CO}_2 = \text{number of moles of CaCO}_3 \text{ and MgCO}_3 = \text{number of moles of CaCO}_3 = \]

\[3\]
(ii) Calculate the volume of hydrochloric acid, 1.0 mol/dm$^3$, needed to react with one tablet.

number of moles of CaCO$_3$ and MgCO$_3$ in one tablet = .................

Use your answer to (c)(i).

number of moles of HCl needed to react with one tablet = .................

volume of hydrochloric acid, 1.0 mol/dm$^3$, needed to react with one tablet = ................. [2]

---

(f) Sodium reacts with sulphur to form sodium sulphide.

$$2\text{Na} + \text{S} \rightarrow \text{Na}_2\text{S}$$

An 11.5 g sample of sodium is reacted with 10 g of sulphur. All of the sodium reacted but there was an excess of sulphur. Calculate the mass of sulphur left unreacted.

(i) Number of moles of sodium atoms reacted = ......................

[2 moles of Na react with 1 mole of S]

(ii) Number of moles of sulphur atoms that reacted = ......................

(iii) Mass of sulphur reacted = ......................g

(iv) Mass of sulphur left unreacted = ......................g [4]

---

Subtopic Chem 4.2 Q# 33/ iGCSE Chemistry/2002/s/Paper 3/ Q5

(c) A 20 cm$^3$ sample of butyne, C$_4$H$_6$, is burnt in 150 cm$^3$ of oxygen. This is an excess of oxygen.

$$2\text{C}_4\text{H}_6(g) + 11\text{O}_2(g) \rightarrow 8\text{CO}_2(g) + 6\text{H}_2\text{O}(l)$$

(i) What volume of oxygen reacts? 

...........................................................................................................[1]

(ii) What volume of carbon dioxide is produced? 

...........................................................................................................[1]

(iii) What is the total volume of gases left at the end of the reaction? 

...........................................................................................................[1]
(d) Calculate the mass of water formed when 9.0 g of butyne is burnt. The mass of one mole of butyne is 54 g.

from the above equation, 1 mole of butyne forms 3 moles of water

number of moles of butyne reacted .................

number of moles of water formed ............... 

mass of water formed ................ g  

[3]

Subtopic Chem 4.2 Q# 34/ iGCSE Chemistry/2001/w/Paper 3/ Q2

(c) Potassium chlorate, which has a formula of the type, KClO₃, decomposes to form oxygen. 2.45 g of the chlorate produced 1.49 g of potassium chloride and 0.72 dm³ of oxygen at r.t.p. Find the value of n.

\[ \text{KClO}_n \rightarrow \text{KCl} + \frac{n}{2} \text{O}_2 \]

Mass of one mole of KCl = 74.5 g

Number of moles of KCl formed = .......................

Number of moles of oxygen molecules formed = .......................

Number of moles of oxygen atoms = .......................

Mole ratio KCl: O is ..........................

\[ n = .................................. \]

[4]

Subtopic Chem 4.2 Q# 35/ iGCSE Chemistry/2001/w/Paper 3/

3 Propane is an alkane. It has the structural formula:

\[ \text{H} - \text{C} - \text{C} - \text{C} - \text{H} \]

\[ \text{H} - \text{H} - \text{H} \]

\[ \text{H} - \text{H} - \text{H} \]

\[ \text{H} - \text{H} - \text{H} \]

(a) The equation for the complete combustion of propane is given below. Insert the two missing volumes.

\[ \text{C}_3\text{H}_8(g) + 5\text{O}_2(g) \rightarrow 3\text{CO}_2(g) + 4\text{H}_2\text{O}(l) \]

volume of gas/cm³ ........ ......... 15  

[2]

9.4.1 ESSENTIAL EXAM QUESTIONS Topic 4.2 Paper 3/4 148marks Mark Scheme
Q# 1/ iGCSE Chemistry/2015/w/Paper 31/

5(a)(i)  adds up to 100%:  
1

5(a)(ii)  M 1 55.85/12 and 6.97/1 and 37.2/16, or evaluation 4.656 6.970 2.325; 
M 2 O:H;2O;  
correct answer with no working = [2]  
1

5(a)(iii)  M 1 (86)/x3;  
M 2 C6H12O6;  
correct answer with no working = [2]  
1

Q# 2/ iGCSE Chemistry/2015/s/Paper 31/ Q3

3(d)  M 1 mol of HCl = 0.1 (mol);  
M 2 mol of Zn = 0.05 (mol);  
mass of zinc = 3.25 g;  
A ECF for M1 × ½  
3 A ECF for M2 × 65  
Unit required for M3

Q# 3/ iGCSE Chemistry/2014/s/Paper 31/ Q6

(d)  number of moles of O2 formed = 0.096/24 = 0.004 (1)  
number of moles of H2O2 in 40 cm3 of solution = 0.004 × 2 = 0.008 (1)  
concentration of the hydrogen peroxide in mol/dm3 = 0.008/0.04 = 0.2 (1)  
[3]

Q# 4/ iGCSE Chemistry/2013/w/Paper 31/ Q4

(d)  number of moles of HCl in 40 cm3 of hydrochloric acid,  
concentration 2.0 mol / dm3 = 0.04 × 2.0 = 0.08 (1)  
maximum number of moles of CO2 formed = 0.04 (1)  
mass of one mole of CO2 = 44 g (1)  
maximum mass of CO2 lost = 0.04 × 44 = 1.76 g (1)  
[1]

Q# 5/ iGCSE Chemistry/2013/w/Paper 31/ Q6

(c)  number of moles of CO2 formed = 2.112 / 44 = 0.048 (1)  
number of moles of H2O formed = 0.432 / 18 = 0.024 (1)  
x = 2 and y = 1 NOT:  ecf from this line  
formula is 2PbCO3; Pb(OH)2 / Pb(OH)2; 2PbCO3  
[1]

Q# 6/ iGCSE Chemistry/2012/w/Paper 31/ Q7

(c)  number of moles of HCl used = 0.05 × 2 = 0.1 (1)  
number of moles of SrCl2.6H2O which could be formed = 0.05 (1)  
mass of one mole of SrCl2.6H2O is 267 g (1)  
thetical yield of SrCl2.6H2O = 0.05 × 267 = 13.35 g (1)  
percentage yield = 6.4/13.35 × 100 = 47.9% (1)  
accept: 48%  
allow: ecf

Q# 7/ iGCSE Chemistry/2012/w/Paper 31/ Q2

(c)  BrF3 / F5Br;  
BrF5 / F5Br;  
[1]

Q# 8/ iGCSE Chemistry/2012/s/Paper 31/

(b)  moles of Fe = 51.85/56 = 0.926 (0.93);  
moles of O = 22.22/16 = 1.389 (1.39);  
moles of H2O = 16.67/18 = 0.926 (0.93);  
if given as 0.9 1.4 0.9  
three of the above correct = [2]  
two of the above correct = [1]  
simplest whole mole ratio Fe : O : H2O is 2: 3: 2 / Fe2O3; 2H2O;  
allow: ecf for a formula based on an incorrect whole mole ratio  
[1]
Q# 9/ iGCSE Chemistry/2012/s/Paper 31/

6 (a) 10 cm³; 65 cm³; [1]

Q# 10/ iGCSE Chemistry/2011/w/Paper 31/ Q7

(c) calculation:
- $M_f$ for NaHCO₃ = 84 g; $M_f$ for Na₂O = 62 g; $M_f$ for NaOH = 40 g
- $M_f$ for Na₂CO₃ = 106 g

(i) number of moles of NaHCO₃ used = $\frac{3.36}{84} = 0.04$ [1]

(ii) if residue is Na₂O, number of moles of Na₂O = $\frac{2.12}{62} = 0.034 / 0.03$

if residue is NaOH, number of moles of NaOH = $\frac{2.12}{40} = 0.053 / 0.05$

if residue is Na₂CO₃, number of moles of Na₂CO₃ = $\frac{2.12}{106} = 0.02$ all three correct

note: two correct = 1 [2]

(iii) equation 3
- mole ratio 2:1 agrees with equation

Q# 11/ iGCSE Chemistry/2011/s/Paper 31/ Q5 (d)

(iii) 1.33 / 1.3 / 1.3333 (mol/dm³) scores both marks not 1.34 [2]
- for a correct method – $\frac{M_1 V_1}{\text{moles of NaOH}} = 0.02$
- with an incorrect answer only [1]

Q# 12/ iGCSE Chemistry/2010/w/Paper 31/ Q5

(b) number of moles of HCl used = $0.04 \times 2 = 0.08$
- number of moles CoCl₂ formed = 0.04
- number of moles CoCl₂·6H₂O formed = 0.04
- mass of one mole of CoCl₂·6H₂O = 238 g
- maximum yield of CoCl₂·6H₂O = 9.52g
- accept 9.5 g
- mark ecf to moles of HCl
- do not mark ecf to integers

- to show that cobalt(II) carbonate is in excess

- number of moles of HCl used = 0.08 must use value above ecf
- mass of one mole of CoCO₃ = 119g
- number of moles of CoCO₃ in 6.0g of cobalt(II) carbonate = $\frac{6.0}{119} = 0.050$ [1]
- reason why cobalt(II) carbonate is in excess 0.05 > 0.06/2 [1]
Q# 13/ iGCSE Chemistry/2010/s/Paper 31/ Q7

(e) (i) percentage of oxygen = 31.6% [1]

(ii) calculate the number of moles of atoms for each element

number of moles of Ti = 31.6/48 = 0.66

number of moles of O = 31.6/16 = 1.98 accept 2

both correct for one mark [1]

(iii) the simplest whole number ratio for moles of atoms:

Fe : Ti : O
1 : 1 : 3

(iv) formula is FeTiO₃ accept TiFeO₃

must be whole numbers from (iii) or cancelled numbers from (iii)

mark ecf throughout [1]

Q# 14/ iGCSE Chemistry/2009/w/Paper 3/ Q6

(c) number of moles of FeSO₄ used = 9.12/152 = 0.06 [1]

number of moles of Fe₂O₃ formed = 0.03* [1]

mass of one mole of Fe₂O₃ = 160 g [1]

mass of iron(III) oxide formed = 0.03 × 160 = 4.8 g [1]

number of moles of SO₃ formed = 0.03 [1]

volume of sulfur trioxide formed = 0.03 × 24 = 0.72 dm³ [1]

If mass of iron(III) oxide greater than 9.12 g, then only marks 1 and 2 available

Apply ecf to number of moles of Fe₂O₃* when calculating volume of sulfur trioxide.

Do not apply ecf to integers

Q# 15/ iGCSE Chemistry/2009/s/Paper 31/ Q9

(a) 72/24 = 3 and 28/14 = 2

Mg₃N₂ [1]

Accept just formula for [2] even with incorrect or no working

NOT ecf [1]

(b) Al₂C₃ + 12H₂O = 4Al(OH)₃ + 3CH₄

For Al₂C₃ ONLY [1]

(c) (i) silicon is limiting reagent [1]

0.07 moles of Si and 25/160 = 0.156 moles of Br₂ [1]

because 0.14 (2 × 0.07) < 0.156

If 80 used to find moles of Br₂ the mark 1 and 3 still available arguments based on masses can be used [1]

(ii) 0.07

NOT ecf [1]

Q# 16/ iGCSE Chemistry/2008/w/Paper 31/ Q4

(b) (i) 7.7% [1]

(ii) for any number: equal number ratio

for example 1:1 or 6:6 [2]

(iii) empirical formula is CH

molecular formula is C₂H₆

no e.c.f., award of marks not dependent on (ii) [1]
Q# 17/ iGCSE Chemistry/2008/w/Paper 31/ Q3

(c) (i) 196

(ii) \( \frac{112}{196} \times 100 = 57.1\% \)

ACCEPT 57 to nearest whole number

mark e.e.f. to (c)(i) provided percentage not greater than 100%

ONLY ACCEPT 112/answer (c)(i) \( \times 100 \)

otherwise [0]

Q# 18/ iGCSE Chemistry/2008/w/Paper 31/

7 (a) (i) \( 35 \text{cm}^3 \)

\( 40 \text{cm}^3 \)

Q# 19/ iGCSE Chemistry/2008/s/Paper 31/ Q7

(b) number of moles of NaOH used = 0.025 \times 2.24 = 0.056

maximum number of moles of Na\(_2\text{SO}_4\).10H\(_2\text{O}\) that could be formed = 0.028

mass of one mole of Na\(_2\text{SO}_4\).10H\(_2\text{O}\) = 322g

maximum yield of sodium sulphate – 10 - water = 9.02g

percentage yield = 42.8%

mark ecf but NOT to simple integers

if ecf marking, mark to at least one place of decimals

if percentage > 100\% then 3/4 maximum

Q# 20/ iGCSE Chemistry/2007/w/Paper 3/ Q7 (b)

(ii) mass of one mole of CaCO\(_3\) = 100

number of moles of CaCO\(_3\) = \( \frac{0.3}{100} = 0.003 \)

moles of HCl = \( 5/1000 \times 1 = 0.005 \)

reagent in excess is CaCO\(_3\)

ecf from above

would need 0.006 moles of HCl

or hydrochloric acid only reacts with 0.0025 moles of CaCO\(_3\)

NOTE this mark needs to show recognition of the 1:2 ratio

(iii) mark ecf to (ii), that is from moles of limiting reagent in (ii)

moles of CO\(_2\) = 0.005 \times 0.5 \times 24 = 0.06 \text{ dm}^3

NOT cm\(^3\) unless numerically correct. 60 \text{ cm}^3

Ignore other units

NOTE if both number of moles integers then no ecf for (ii) and (iii)

Q# 21/ iGCSE Chemistry/2008/s/Paper 31/ Q7

(d) 100g of fat react with 86.2g of iodine

884g of fat react with 762 g of iodine

limit 762 \times 2

one mole of fat reacts with 762/254 moles of iodine molecules

one mole of fat reacts with 3 moles of iodine molecules

number of double bonds in one molecule of fat is 3

limit 6

consequential marking allowed provided the number of double bonds is an integer.

Q# 22/ iGCSE Chemistry/2006/w/Paper 3/ Q3

(b) (i) 100

56 ignore units in both cases

(ii) 7.00kg is 1/8 of 56

1/8 of 100kg is 12.5kg

Give both marks for correct answer without explanation. Ignore missing units

but penalise wrong units
Q# 23/ iGCSE Chemistry/2006/w/Paper 3/

6 (a)

<table>
<thead>
<tr>
<th>composition by mass/g</th>
<th>copper (4.50)</th>
<th>iron (4.20)</th>
<th>sulphur 4.8 [1]</th>
</tr>
</thead>
<tbody>
<tr>
<td>number of moles of atoms</td>
<td>0.075</td>
<td>0.075</td>
<td>0.15 [1]</td>
</tr>
<tr>
<td>simplest mole ratio of atoms</td>
<td>1</td>
<td>1</td>
<td>2 [1]</td>
</tr>
</tbody>
</table>

The empirical formula is CuFeS₂ [3]

Q# 24/ iGCSE Chemistry/2006/s/Paper 3/ Q7

d) moles of CH₃-CH = CH₂ reacted = 1.4/42 = 0.033 [1]

conseq
maximum moles of CH₃-CH(1)-CH₃ that could be formed = 0.033 [1]

conseq
maximum mass of 2-iodopropane that could be formed = 5.61 g [1]
accept 170 x 0.033 = 5.61 and 170 x 0.033333 = 5.67 [1]

conseq unless greater than 100%
percentage yield 4.0/5.67 x 100 = 70.5% [1]

Do not mark consequently to a series of small integers. There has to be a serious attempt to answer the question, then consequential marking is appropriate. [1]

Q# 25/ iGCSE Chemistry/2005/w/Paper 3/

Question 6

(a)(i) moles of NiCO₃ reacted = 0.08 [1]

mass of nickel carbonate reacted = 9.52 g [1]

mass of nickel carbonate unreacted = 2.48 g [1]

(ii) maximum number of moles of hydrated salt = 0.08 [1]

maximum mass of salt = 0.08 x 281 = 22.48 g [1]

percentage yield 10/42/22.48 x 100 = 46.3% [1]

Q# 26/ iGCSE Chemistry/2005/s/Paper 3/ Q2/ iGCSE Chemistry/201

(c) l₂ + 3Cl₂ = 2ICl₃ [2]

For having either reactants or products correct ONLY [1]

Q# 27/ iGCSE Chemistry/2005/s/Paper 3/ Q4

(d) mass of one mole of CaSO₄ = 136 [1]

moles of CaSO₄ in 79.1 g = 0.58 accept 0.6 [1]

moles of H₂O in 20.9 g = 1.16 accept 1.2 [1]

conseq x = 2 x given as an integer [1]

Q# 28/ iGCSE Chemistry/2004/w/Paper 3/ 7 (c)

Mark consequentially to any error but not involving simple integers
There has to be some evidence that the candidate has attempted to work through the calculation and not merely inserted whole numbers.
For example 2, 1, 160 or 1, 0.5, 80

number of moles of Fe₂(SO₄)₃ = 1/40 or 0.025

number of moles of Fe₂O₅ formed = 1/40 or 0.025

mass of iron(III) oxide formed = 0.025 x 160 = 4g

number of moles of SO₃ produced = 3/40 or 0.075

volume of sulphur trioxide at r.t.p. = 0.075 x 25
= 1.8dm³ [5]
Q# 29/ iGCSE Chemistry/2004/s/Paper 3/

7  (a)  Avogadro’s Number of particles
or formula mass in grams
or 6 x 10^{23} particles accept atoms, ions and molecules
or as many particles as there are carbon atoms in 12.00g of ^{12}\text{C}.
ANY one  

[1]

(b)  (i)  moles of Mg = 3/24 = 0.125
moles of CH₃COOH = 12/60 = 0.200
magnesium is in excess

OR 3.0g of magnesium react with 15g of acid
only 12.0 g of acid present
magnesium is in excess

[3]

(ii)  Mark consequ to (i) but NOT to any simple integer
moles of H₂ = 0.1

[1]

(iii)  Mark consequ to (ii) but NOT to any simple integer
Volume of hydrogen = 0.1 x 24
= 2.4 dm³

[2]

(c)  (i)  moles of NaOH = 25/1000 x 0.4 = 0.01

[1]

(ii)  Mark consequ to (i) but NOT to any simple integer
moles of acid = 0.01/2 = 0.005

[1]

(iii)  Mark consequ to (ii) max 10M
concentration of acid = 0.005 x 1000/20
= 0.25 mol/dm³

[1]

Q# 30/ iGCSE Chemistry/2003/w/Paper 3/ Q5

(d)  the number of moles of SO₂ in the mixture = 0.125
the number of moles of Cl₂ in the mixture = 0.2
cond reagent was not in excess? SO₂
cond moles of SO₂Cl₂ formed = 0.125
cond the mass of sulphuryl chloride formed = 16.9g

[5]

Q# 31/ iGCSE Chemistry/2003/s/Paper 3/ Q2

(c)  (i)  number of moles CO₂ = 0.24/24 = 0.01
conseq number of moles of CaCO₃ and MgCO₃ = 0.01
conseq number of moles of CaCO₃ = 0.005

[3]

(ii)  Calculate the volume of hydrochloric acid, 1.0 mole/dm³, needed to react with
one tablet.
number of moles of CaCO₃ and MgCO₃ in one tablet = 0.01
Expect same as answer to (c)(i). NO marks to be awarded. Just mark
consequentially to this response
conseq number of moles of HCl needed
to react with one tablet = 0.02

[1]

conseq volume of hydrochloric acid, 1.0 mole/dm³, needed to react with one
tablet = 0.02 dm³ or 20 cm³

[1]
Q# 32/ iGCSE Chemistry/2002/w/Paper 3/ Q3
(f) (i) \(11.5/23 = 0.5\) 

(ii) \(0.25\) 
\(\text{conseq to (i)}\) 

(iii) \(0.25 \times 32 = 8\) g 
\(\text{conseq}\) 

(iv) \(2.0\) g 
\(\text{only conseq to (iii) if answer to (iii) is less than 10}\) 

NB If (ii) is 0.3(125), no excess is possible, (iv) ZERO

Q# 33/ iGCSE Chemistry/2002/s/Paper 3/ Q5 (c)
(i) \(110\) (cm³) 
(ii) \(80\) (cm³) 
(iii) Starting gases (170) of which 130 was used, so 40 left of O², 80 made of CO² and H²O is a liquid therefore 80

(d) 
0.167 
0.5 mol water 
9g of water 
3 marks

Q# 34/ iGCSE Chemistry/2001/w/Paper 3/ Q2
(c) \(0.02\) 
\(0.03\) \(\text{not conseq}\) 
\(0.05\) \(\text{conseq to above}\) 
\(3\) \(\text{accept either as ratio or on } n =\) 
\(\text{Accept ratio conseq to answers designated by } *\)

Q# 35/ iGCSE Chemistry/2001/w/Paper 3/
(a) 5 
25
9.1 Essential End of Topic 5 Review and Reflection

Looking at the goals you could have achieved and the goals you actually achieved try to reflect on your progress.

Try to be as honest and as detailed as possible. Sometimes you may think you have thought about an idea well, but when you talk with someone else, or write it out, it helps you better understand and allows you think more completely and more clearly.

Did you achieve more goals this topic than last topic?

Fill in this table

<table>
<thead>
<tr>
<th>Level</th>
<th>Number of goals achieved at each level</th>
<th>Success rate, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>FUNDAMENTAL</td>
<td>/5</td>
<td></td>
</tr>
<tr>
<td>ESSENTIAL</td>
<td>/10</td>
<td></td>
</tr>
<tr>
<td>EXTENSION</td>
<td>/13</td>
<td></td>
</tr>
<tr>
<td>EXCEPTIONAL</td>
<td>/10</td>
<td></td>
</tr>
</tbody>
</table>

Do you feel you tried harder? If yes, what helped you to do so? If not, why not?

__________________________________________________________________________

What could you do differently next time, in addition to what you are already doing to improve, not only your score in the end of topic tests and other assessed activities, but also in how you learn. How could you become a more effective student to get more learning out of the time you are investing in your studies?

__________________________________________________________________________

What did you enjoy most about this topic?

__________________________________________________________________________

What did you find most difficult?

__________________________________________________________________________

What did you find easiest?

__________________________________________________________________________

On a scale of 1 being hardest and 5 being most difficult, circle how challenging you found this topic

1  2  3  4  5

What could be done to make this topic easier to understand?

__________________________________________________________________________

Do you have any questions about this topic?

__________________________________________________________________________
## Topic 7.4 Redox

### 10.1 End of Topic 7.4 Goals Checklist

For each topic you ought to try to do as many of the following things to get the most out of your time, the resources available to you and to help you grow as a student. Tick each goal off as you complete it. Growth is difficult and uncomfortable, but you should choose to do these things, and the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win!

<table>
<thead>
<tr>
<th>Aspect</th>
<th>What you should have done</th>
<th>Yes/No</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interacted with your teacher</td>
<td>Ask your teacher 1 question, about anything, once a week</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Try to answer one question asked by your teacher at least once a week</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Ask your teacher one question about something you do not understand in science once a week</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Ask your teacher one question about something to do with science every lesson</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td>Notes and follow up notes</td>
<td>Complete set of class note</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Attempted</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Completed</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Completed to an exemplary standard</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Attempted the Mind Map for this topic</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Completed the Mind Map for this topic</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td>Textbook</td>
<td>Read ahead before the topic has been started</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Highlighted key ideas and translate new words</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Completed the questions at the end of each 2 page spread in your exercise book</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Added to your class notes ideas and important information from the textbook that you learnt</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td>Past Exam Questions</td>
<td>Worked on at least 25% of the exam questions in this workbook</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Attempted more than 25% of the questions and those questions you have completed you have marked in a different colour pen</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Completed and marked all questions here</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Completed, marked and additional key ideas where you have located the most difficult marks added to your notebook</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Used the resources available online to answer additional questions not found in this workbook on the current topic.</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Ask your teacher about an exam question that they cannot answer</td>
<td></td>
<td>EXCEPTIONALLY SMASHING!!!</td>
</tr>
<tr>
<td>Assessed Activities</td>
<td>Complete the word list activity using the word list at the front of each topic as little as possible</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities, either in class or as homework</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 70% on average</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 80% on average</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 90% on average</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td>End of Topic Test</td>
<td>Revised sufficiently well to improve upon your score from the previous test (except if you are scoring over 90%, then just write Y for this goal)</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Scored 10% higher than your current average</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Scored 15% or more than your previous end of topic average</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Scored over 90%</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Scored over 95%</td>
<td></td>
<td>SMASHING!!!</td>
</tr>
<tr>
<td>Aspect</td>
<td>What you should have done</td>
<td>Yes/No</td>
<td>Level</td>
</tr>
<tr>
<td>--------</td>
<td>---------------------------</td>
<td>--------</td>
<td>---------</td>
</tr>
<tr>
<td>Reading</td>
<td>Spend more than 1 hour a week reading a book <strong>you enjoy</strong> (in any language) about anything.</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Spend more than 3 hours a week reading a book <strong>you enjoy</strong> (in any language) about anything.</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Spend more than 5 hours a week reading a book <strong>you enjoy</strong> (in any language) about anything.</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Spend at least one hour a week reading a book <strong>you enjoy</strong> in English about anything.</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Spend more than 3 hours a week reading a book <strong>you enjoy</strong> in English about anything.</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td>Reflection</td>
<td>You completed this goal setting table</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>You have looked at the goals you have achieved and the ones you have not and added them up and entered them into the table in the Review and Reflection section</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>You have given an answer for every question in the Review and Reflection section at the end of this topic</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>You have Given good and thoughtful answers for every question in the Review and Reflection section at the end of this topic</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
</tbody>
</table>
### Core

- Define **oxidation and reduction** in terms of oxygen loss/gain. (Oxidation state limited to its use to name ions, e.g. iron(II), iron(III), copper(II), manganate(VII).)

### Supplement

- Define **redox** in terms of electron transfer
- Identify redox reactions by changes in oxidation state and by the colour changes involved when using acidified potassium manganate(VII) and potassium iodide. (Recall of equations involving KMnO₄ is not required.)
- Define **oxidising agent** as a substance which oxidises another substance during a redox reaction. Define **reducing agent** as a substance which reduces another substance during a redox reaction.
- Identify oxidising agents and reducing agents from simple equations

### 10.3 ESSENTIAL Glossary for Keywords for this topic

<table>
<thead>
<tr>
<th>Topic #</th>
<th>English</th>
<th>Chinese</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td><strong>oxidation state</strong> a number given to show whether an element has been oxidised or reduced; the oxidation state of an ion is simply the charge on the ion</td>
<td>氧化态表示元素是否被氧化或还原的数字；离子的氧化态只是离子上的电荷</td>
</tr>
<tr>
<td>7</td>
<td><strong>oxidation</strong> there are three definitions of oxidation: (i) a reaction in which oxygen is added to an element or compound; (ii) a reaction involving the loss of electrons from an atom, molecule or ion; (iii) a reaction in which the oxidation state of an element is increased</td>
<td>氧化氧化具有三个定义：(i) 将氧添加到元素或化合物中的反应；(ii) 涉及原子、分子或离子失去电子的反应；(iii) 增加元素的氧化态的反应</td>
</tr>
<tr>
<td>7</td>
<td><strong>oxidising agent</strong> a substance which will oxidise another in a redox reaction</td>
<td>氧化剂一种在氧化还原反应中会氧化另一种物质的物质</td>
</tr>
<tr>
<td>7</td>
<td><strong>redox reaction</strong> a reaction involving both reduction and oxidation reducing agent a substance which will reduce another in a redox reaction</td>
<td>氧化还原反应一种同时涉及还原剂和氧化还原剂的反应，一种物质将在氧化还原反应中还原另一种物质</td>
</tr>
<tr>
<td>7</td>
<td><strong>reduction</strong> there are three definitions of reduction: (i) a reaction in which oxygen is removed from a compound; (ii) a reaction involving the gain of electrons by an atom, molecule or ion; (iii) a reaction in which the oxidation state of an element is decreased</td>
<td>还原有三种还原的定义：(i) 从化合物中除去氧的反应；(ii) 涉及通过原子、分子或离子获得电子的反应；(iii) 使元素的氧化态降低的反应</td>
</tr>
</tbody>
</table>
10.4 ESSENTIAL Classroom Active Learning Task 1 Assigning Oxidation States

Oxidation number rules:

Elements have an oxidation number of 0
Group I and II – In addition to the elemental oxidation state of 0, Group I has an oxidation state of +1 and Group II has an oxidation state of +2.
Hydrogen – usually +1, except when bonded to Group I or Group II, when it forms hydrides, -1.
Oxygen – usually -2, except when it forms a O-O single bond, a peroxide, when it is -1.
Fluorine is always -1. Other halogens are usually -1, except when bonded to O.

1. Give the oxidation numbers of all the elements in the following molecules and ions:
   a. \( \text{SO}_2, \text{SO}_3, \text{SO}_3^{2-}, \text{SO}_4^{2-} \)
   b. \( \text{ClO}_2, \text{ClO}^-, \text{ClO}_2^-, \text{ClO}_3^-, \text{ClO}_4^- \)
   c. \( \text{N}_2\text{O}, \text{NO}, \text{NO}_2, \text{N}_2\text{O}_4, \text{N}_2\text{O}_5, \text{NO}_2^-, \text{NO}_3^- \)

2. Determine the oxidation number of the sulfur atom:
   a. \( \text{H}_2\text{S} \)  b. \( \text{S} \)  c. \( \text{H}_2\text{SO}_4 \)  d. \( \text{S}^{2-} \)  e. \( \text{HS}^- \)  f. \( \text{SO}_2 \)  g. \( \text{SO}_3 \)

3. Indicate the oxidation number of phosphorus in each of the following compounds:
   a. \( \text{H}_3\text{PO}_3 \)  d. \( \text{H}_3\text{PO}_4 \)
   b. \( \text{H}_3\text{PO}_2 \)  e. \( \text{H}_4\text{P}_2\text{O}_7 \)
   c. \( \text{H}_3\text{PO}_3 \)  f. \( \text{H}_6\text{P}_3\text{O}_{10} \)

4. Give oxidation numbers for the underlined atoms in these molecules and ions:
   a. \( \text{Cr}_2\text{O}_7 \)  f. \( \text{ClF}_3 \)  k. \( \text{MoO}_4^{2-} \)
   b. \( \text{PtCl}_6^{2-} \)  g. \( \text{H}_3\text{AsO}_3 \)  l. \( \text{MnO}_4^- \)
   c. \( \text{CaI}_2 \)  h. \( \text{SbF}_6^- \)  m. \( \text{PtCl}_4^{2-} \)
   d. \( \text{SnF}_2 \)  i. \( \text{TiO}_2 \)  n. \( \text{O}_2 \)
   e. \( \text{Al}_2\text{O}_3 \)  j. \( \text{P}_4 \)  o. \( \text{O}_3 \)
10.4.1 ESSENTIAL Classroom Active Learning Task 1 Assigning Oxidation States Mark Scheme

NOTE: The both terms Oxidation State and Oxidation Number effectively mean the same thing at iGCSE and A Level, although Oxidation Number in fact refers to the Roman numerals in the names of transition metal containing compounds, like Iron (III) oxide

1. Give the oxidation numbers of all the elements in the following molecules ions:

   a. SO₂, SO₃, SO₃²⁻, SO₄²⁻

   b. ClO₂, ClO⁻, ClO₂⁻, ClO₃⁻, ClO₄⁻

   c. N₂O, NO, NO₂, N₂O₄, N₂O₅, NO₂⁻, NO₃⁻

2. Determine the oxidation number of the sulfur atom:

   a. H₂S  b. S  c. H₂SO₄  d. S²⁻  e. HS⁻  f. SO₂  g. SO₃

3. Indicate the oxidation number of phosphorus in each of the following compounds:

   a. H₃PO₃  b. H₃PO₂  c. H₃PO₃

   d. H₅PO₄

4. Give oxidation numbers for the underlined atoms in these molecules and ions:

   a. CS₂O  f. ClF₃  k. MoO₄²⁻

   b. PtCl₆²⁻  g. H₃AsO₃  l. MnO₄⁻

   c. CaI₂  h. SbF₆⁻  m. PtCl₄²⁻

   d. SnF₂  i. TiO₂  n. O₂

   e. Al₂O₃  j. P₄  o. O₃
10.1 ESSENTIAL Classroom Active Learning Task 2 Assigning Oxidation States

1. Assign oxidation numbers to each of the atoms in the following compounds:

<table>
<thead>
<tr>
<th>Compound</th>
<th>Na</th>
<th>Cr</th>
<th>K</th>
<th>O</th>
<th>Cr</th>
<th>C</th>
<th>H</th>
<th>Cl</th>
<th>Mn</th>
<th>S</th>
<th>F</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na₂CrO₄</td>
<td>Na =</td>
<td></td>
<td>O =</td>
<td></td>
<td>Cr =</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K₂Cr₂O₇</td>
<td>K =</td>
<td></td>
<td>O =</td>
<td></td>
<td>Cr =</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂</td>
<td>O =</td>
<td></td>
<td>C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CH₄</td>
<td>H =</td>
<td></td>
<td>C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HClO₄</td>
<td>O =</td>
<td>H =</td>
<td>Cl</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MnO₂</td>
<td>O =</td>
<td></td>
<td>Mn =</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO₃²⁻</td>
<td>O =</td>
<td></td>
<td>S</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF₄</td>
<td>F =</td>
<td></td>
<td>S</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

   a. What is the range of oxidation states for carbon?
   b. Which compound has C in a +4 state?
   c. Which compound has C in a -4 state?

2. Nitrogen has 5 valence electrons (Group V). It can gain up to 3 electrons (-3), or lose up to 5 (+5) electrons. Fill in the missing names or formulas and assign an oxidation state to each of the following nitrogen-containing compounds:

<table>
<thead>
<tr>
<th>Name</th>
<th>Formula</th>
<th>Oxidation State of N</th>
</tr>
</thead>
<tbody>
<tr>
<td>NH₃</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrogen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO₃⁻</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dinitrogen monoxide</td>
<td>NO₂</td>
<td></td>
</tr>
<tr>
<td>Hydroxylamine</td>
<td>NH₂OH</td>
<td></td>
</tr>
<tr>
<td>Nitrogen monoxide</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrazine</td>
<td>N₂H₄</td>
<td></td>
</tr>
</tbody>
</table>
3. During chemical reactions, the oxidation state of atoms can change. This occurs when compounds gain or lose electrons, or when the bonds to an atom change. This is illustrated by the reaction between nitrogen and hydrogen to make ammonia:

\[ \text{N}_2(g) + 3 \text{H}_2(g) \rightarrow 2 \text{NH}_3(g) \]

a. Assign oxidation numbers to each of the atoms in this reaction.

\[
\begin{align*}
\text{N (in N}_2) &= \\
\text{N (in NH}_3) &= \\
\text{H (in H}_2) &= \\
\text{H (in NH}_3) &=
\end{align*}
\]

When an oxidation number increases, that species has been oxidized.

b. Which reactant undergoes an increase in its oxidation number?

When an oxidation number decreases, that species has been reduced.

c. Which reactant undergoes a decrease in its oxidation number?

The species that is oxidized is called the reducing agent because it gives up an electron, so that another species can gain an electron (be reduced).

d. What is the reducing agent in this reaction?

The species that is reduced is called the oxidizing agent because it takes an electron away from another group, raising that group’s oxidation number.

e. What is the oxidizing agent in this reaction?

4. In each of the following reactions, assign oxidation numbers to all of the elements and identify the oxidizing and reducing agents and the change in oxidation number.

a. \[ 4 \text{Fe} + 3 \text{O}_2 \rightarrow 2 \text{Fe}_2\text{O}_3 \]

change in oxidation number

oxidizing agent

reducing agent
10.3 EXCEPTIONAL Active Learning Activity 4 Balancing Redox Reactions

The material here does beyond the iGCSE syllabus, but if you are really interested in this topic this is what you would go on to cover at A Level.

\[
\begin{align*}
\text{c. } & \quad \text{NH}_4\text{NO}_2 \rightarrow \text{N}_2 + 2 \text{H}_2\text{O} \\
& \quad \text{oxidizing agent} \\
& \quad \text{reducing agent} \\
\text{d. } & \quad \text{P}_4 + 10 \text{Cl}_2 \rightarrow 4 \text{PCl}_5 \\
& \quad \text{oxidizing agent} \\
& \quad \text{reducing agent} \\
\text{e. } & \quad 2 \text{Cr}^{3+} + \text{H}_2\text{O} + 6 \text{ClO}_3^- \rightarrow \text{Cr}_2\text{O}_7^{2-} + 6\text{ClO}_2 + 2 \text{H}^+ \\
& \quad \text{oxidizing agent} \\
& \quad \text{reducing agent}
\end{align*}
\]

Balancing Redox Reactions

Oxidation/Reduction (Redox) reactions can be balanced using the oxidation state changes, as seen in the previous example. However, there is an easier method, which involves breaking a redox reaction into two half-reactions. This is best shown by working an example.

Hydrobromic acid will react with permanganate to form elemental bromine and the manganese(II) ion. The unbalanced, net reaction is shown below,

\[
\text{Br}^- + \text{MnO}_4^- \rightarrow \text{Br}_2 + \text{Mn}^{2+}
\]

5. Break this into two half-reactions, one involving bromine and the other involving manganese.

- **Bromine half-reaction**
  \[
  \text{Br}^- \rightarrow \text{Br}_2
  \]

- **Manganese half-reaction**
  \[
  \text{MnO}_4^- \rightarrow \text{Mn}^{2+}
  \]

6. First balance the bromine half-reaction first.

   a. Balance the **bromine** atoms of the reaction
   \[
   \text{___ Br}^- \rightarrow \text{___ Br}_2
   \]
b. Now balance charge by adding electrons (e⁻)

\[ \_ \text{Br}^- \rightarrow \_ \text{Br}_2 \]

This half-reaction is producing/consuming electrons. This is an oxidation/reduction half-reaction. Confirm this by assigning oxidation numbers to the bromine species.

7. Next, balance the manganese half-reaction.

a. Balance the manganese atoms of the half-reaction

\[ \_ \text{MnO}_4^- \rightarrow \_ \text{Mn}^{2+} \]

b. Next, balance oxygen by adding water molecules (H₂O)

\[ \_ \text{MnO}_4^- \rightarrow \_ \text{Mn}^{2+} \]

c. Next, balance hydrogen by adding protons (H⁺)

\[ \_ \text{MnO}_4^- \rightarrow \_ \text{Mn}^{2+} \]

d. Finally, balance charge by adding electrons (e⁻).

\[ \_ \text{MnO}_4^- \rightarrow \_ \text{Mn}^{2+} \]

This half-reaction is producing/consuming electrons. This is a oxidation/reduction half-reaction. Confirm this by assigning oxidation numbers to the manganese atoms.

Notice that the number of electrons equals the change in oxidation number.

8. Now put the two half-reactions together. The number of electrons produced must equal the number of electrons consumed.

\[ 2 \text{Br}^- \rightarrow \text{Br}_2 + 2e^- \quad 5e^- + 8\text{H}^+ + \text{MnO}_4^- \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O} \]

Multiply this half-reaction by ___ Multiply this half-reaction by ___

\[ \_ \text{Br}^- \rightarrow \_ \text{Br}_2 + \_ e^- \quad \_ e^- + \_ \text{H}^+ + \_ \text{MnO}_4^- \rightarrow \_ \text{Mn}^{2+} + \_ \text{H}_2\text{O} \]

Add the two half-reactions, canceling out species that appear on both sides (including electrons)

\[ \_ \text{Br}^- + \_ \text{H}^+ + \_ \text{MnO}_4^- \rightarrow \_ \text{Br}_2 + \_ \text{Mn}^{2+} + \_ \text{H}_2\text{O} \]

Which compound is the oxidizing agent?

Which compound is the reducing agent?
10.3.1 ESSENTIAL Classroom Active Learning Task 2,3 & 4 Mark Scheme

Worksheet 25 - Oxidation/Reduction Reactions

Oxidation number rules

Elements have an oxidation number of 0:
Group I and II – In addition to the elemental oxidation state of 0, Group I has an oxidation state of +1 and Group II has an oxidation state of +2.

Hydrogen – usually +1, except when bonded to Group I or Group II, when it forms hydrides, -1.

Oxygen – usually -2, except when it forms a O-O single bond, a peroxide, when it is +1.

Fluorine is always -1. Other halogens are usually -1, except when bonded to 0.

1. Assign oxidation numbers to each of the atoms in the following compounds:

   Na₂CO₃  Na = +1  O = -2  C = +4
   H₂O₂  H = +1  O = -2  O = +1
   CO₂  O = -2  C = +4
   CH₄  H = +1  C = +4
   H₂SO₄  H = +1  S = +6  O = +2
   SF₆  S = +6  F = -1

   a. What is the range of oxidation states for carbon?
      C (0 to +4)
   b. Which compound has C in a +4 state?
      CO₂
   c. Which compound has C in a -4 state?
      CH₄

   The species that is oxidized is called the reducing agent because it gives up an electron, so that another species can gain an electron (be reduced).

d. What is the reducing agent in this reaction?
   N₂

   The species that is reduced is called the oxidizing agent because it takes an electron away from another group, raising that group's oxidation number.

e. What is the oxidizing agent in this reaction?
   H₂

4. In each of the following reactions, assign oxidation numbers to all of the elements and identify the oxidizing and reducing agents and the change in oxidation number.

   a. 2Fe + 3Cl₂ → 2FeCl₃
      oxidizing agent Cl²⁻  reducing agent Fe
      change in oxidation number: Fe = +3 → +2  Cl₂⁻ = -1 → 0

   b. K₂Cr₂O₇ + 3H₂SO₄ → K₂SO₄ + Cr₂(SO₄)₃ + 3H₂O
      oxidizing agent K₂Cr₂O₇  reducing agent H₂SO₄
      change in oxidation number: Cr = +6 → +3  S = +6 → +4

   c. 2NH₄NO₃ + 2H₂O → 2NH₃ + 2H₂O + NO₂
      oxidizing agent NH₄NO₃  reducing agent H₂O
      change in oxidation number: N = +5 → +3  H = +1 → +2

   d. P₂ + 6O₂ → 2P₄O₁₀
      oxidizing agent O₂  reducing agent P₂
      change in oxidation number: P = +5 → +3

   e. 2CuCl₂ + H₂O → Cu₂(OH)₂Cl₂ + 2HCl
      oxidizing agent CuCl₂  reducing agent H₂O
      change in oxidation number: Cu = +2 → +1

2. Nitrogen has 5 valence electrons (Group V). It can gain up to 3 electrons (3), or lose up to 5 (=1) electrons. Fill in the missing names or formulas and assign an oxidation state to each of the following nitrogen containing compounds:

<table>
<thead>
<tr>
<th>Name</th>
<th>Formula</th>
<th>Oxidation state</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia</td>
<td>NH₃</td>
<td>-3</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>N₂</td>
<td>0</td>
</tr>
<tr>
<td>Nitrite</td>
<td>NaNO₂</td>
<td>+3</td>
</tr>
<tr>
<td>Nitric acid</td>
<td>HNO₃</td>
<td>+5</td>
</tr>
<tr>
<td>Nitrogen oxide</td>
<td>NO₂</td>
<td>+1</td>
</tr>
<tr>
<td>Nitrous oxide</td>
<td>N₂O</td>
<td>+2</td>
</tr>
<tr>
<td>Hydrazine</td>
<td>N₂H₆</td>
<td>-2</td>
</tr>
</tbody>
</table>

3. During chemical reactions, the oxidation state of atoms can change. This occurs when compounds gain or lose electrons, or when the bonds to an atom change. This is illustrated by the reaction between nitrogen and hydrogen to make ammonia:

   N₂(g) + 3H₂(g) → 2NH₃(g)

   a. Assign oxidation numbers to each of the atoms in this reaction.
      N₁ (in N₂) = 0  H₂ (in H₂) = 0
      H₁ (in H₂) = 1  H₂ (in NH₃) = 1

   When an oxidation number increases, that species has been oxidized.

   b. Which reactant undergoes an increase in its oxidation number?
      H₂

   When an oxidation number decreases, that species has been reduced.

   c. Which reactant undergoes a decrease in its oxidation number?
      N₂

Beyond iGCSE Balancing Redox Reactions

Oxidation/Reduction (Redox) reactions can be balanced using the oxidation state changes, as seen in the previous example. However, there is an easier method, which involves breaking a redox reaction into two half-reactions. This is best shown by working an example.

Hydrobromic acid will react with potassium to form elemental bromine and the manganese(II) ion. The unbalanced, net reaction is shown below.

   Br⁻ + MnO₂ → Br₂ + Mn²⁺

5. Break this into two half-reactions, one involving bromine and the other involving manganese.

   5a. Balance the bromine half-reaction first.

   a. Balance the bromine atoms of the reaction:
      Br⁻ → Br₂

   b. Now balance charge by adding electrons (e⁻)
      2Br⁻ → Br₂ + 2e⁻

   This half-reaction is producing/consuming electrons. This is an oxidation/reduction half-reaction. Confirm this by assigning oxidation numbers to the bromine species.

   5b. Next, balance the manganese half-reaction.

   a. Balance the manganese atoms of the half-reaction:
      MnO₂ → Mn²⁺

   b. Next, balance oxygen by adding water molecules (H₂O)
      MnO₂ → Mn²⁺ + 4H₂O

10.4 ESSENTIAL EXAM QUESTIONS Paper 3/4 48marks

Q# 1/ iGCSE Chemistry/2015/s/Paper 31/

3 (a) The reactions between metals and acids are redox reactions.

\[ \text{Zn} + 2\text{H}^+ \rightarrow \text{Zn}^{2+} + \text{H}_2 \]

(i) Which change in the above reaction is oxidation, Zn to Zn\(^{2+}\) or 2H\(^+\) to H\(_2\)? Give a reason for your choice.

.............................................................................................................................................................................. [2]

(ii) Which reactant in the above reaction is the oxidising agent? Give a reason for your choice.

.............................................................................................................................................................................. [2]

Q# 2/ iGCSE Chemistry/2012/s/Paper 31/

4 Vanadium is a transition element. It has more than one oxidation state. The element and its compounds are often used as catalysts.
(d) The oxidation states of vanadium in its compounds are V(+5), V(+4), V(+3) and V(+2). The vanadium(III) ion can behave as a reductant or an oxidant.

(i) Indicate on the following equation which reactant is the oxidant.

$$2V^{3+} + Zn \rightarrow 2V^{2+} + Zn^{2+}$$  \hspace{1cm} [1]

(ii) Which change in the following equation is oxidation? Explain your choice.

$$V^{3+} + Fe^{3+} \rightarrow V^{4+} + Fe^{2+}$$

Q# 3/ iGCSE Chemistry/2011/w/Paper 31/ Q5

(b) Iron has two oxidation states +2 and +3. There are two possible equations for the redox reaction between iron and bromine.

$$Fe + Br_2 \rightarrow Fe^{2+} + 2Br^-$$

$$2Fe + 3Br_2 \rightarrow 2Fe^{3+} + 6Br^-$$

(i) Indicate, on the first equation, the change which is oxidation. Give a reason for your choice.

........................................................................................................................................................................ [2]

(ii) Which substance in the first equation is the reductant (reducing agent)?

........................................................................................................................................................................ [1]

Q# 4/ iGCSE Chemistry/2010/w/Paper 31/Q3

This equation is needed for the question that follows:

(iii) $$Br_2 + 2e^- \rightarrow 2Br^-$$

(iv) Is the change in (iii) oxidation or reduction? Give a reason for your choice.

........................................................................................................................................................................ [1]

(v) Complete the following description of the reaction in the right hand beaker.

Fe$$^{2+}$$ changes into ..........................  \hspace{1cm} [1]
Q# 5/ iGCSE Chemistry/2010/w/Paper 31/

6  The table below shows the elements in the second period of the Periodic Table and some of their oxidation states in their most common compounds.

<table>
<thead>
<tr>
<th>element</th>
<th>Li</th>
<th>Be</th>
<th>B</th>
<th>C</th>
<th>N</th>
<th>O</th>
<th>F</th>
<th>Ne</th>
</tr>
</thead>
<tbody>
<tr>
<td>number of outer electrons</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>oxidation state</td>
<td>+1</td>
<td>+2</td>
<td>+3</td>
<td>+4</td>
<td>-3</td>
<td>-2</td>
<td>-1</td>
<td>0</td>
</tr>
</tbody>
</table>

(a) (i) What does it mean when the only oxidation state of an element is zero?

........................................................................................................................................... [1]

(ii) Explain why some elements have positive oxidation states but others have negative ones.

........................................................................................................................................... [2]

Q# 6/ iGCSE Chemistry/2009/w/Paper 3/ Q4

(b) Ozone is an oxidant. It can oxidise an iodide to iodine.

\[
2I^- + O_3 + 2H^+ \rightarrow I_2 + O_2 + H_2O
\]

(ii) Explain in terms of electron transfer why the change from iodide ions to iodine molecules is oxidation.

........................................................................................................................................... [1]

(iii) Explain, using your answer to b(ii), why ozone is the oxidant in this reaction.

........................................................................................................................................... [1]

Q# 7/ iGCSE Chemistry/2007/w/Paper 3/ Q2 (b)

(iii) The reaction between magnesium and bromine is redox. Complete the sentences.

Magnesium is the ............................................................................................................ agent because it has

................................................................................................................................. electrons.

Bromine has been ........................................................................................................ because it has ........................................................................................................ electrons. [4]
Q# 8/ iGCSE Chemistry/2005/s/Paper 3/ Q2

2 The following apparatus was used to measure the rate of the reaction between zinc and iodine.

![Diagram of the apparatus](image)

The mass of the zinc plate was measured every minute until the reaction was complete.

(a) Write an ionic equation for the redox reaction that occurred between zinc atoms and iodine molecules.

...............................................................................................................................................................................................[2]

Q# 9/ iGCSE Chemistry/2004/s/Paper 31/

(c) Silicon is made by the carbon reduction of the macromolecular compound, silicon(IV) oxide.

(i) Balance the equation for the reduction of silicon(IV) oxide.

\[ \text{SiO}_2 + \underline{\text{C}} \rightarrow \text{Si} + \underline{\text{CO}} \]  \[1\]

(ii) Explain why the silicon(IV) oxide is said to be reduced.

...............................................................................................................................................................................................[1]

Q# 10/ iGCSE Chemistry/2003/w/Paper 3/ Q2

(c) A solution of an impure zinc ore contained zinc, lead and silver(I) ions. The addition of zinc dust will displace both lead and silver.

(i) The ionic equation for the displacement of lead is as follows.

\[
\text{Zn(s)} + \text{Pb}^{2+}(\text{aq}) \rightarrow \text{Zn}^{2+}(\text{aq}) + \text{Pb(s)}
\]

Which change is reduction? Explain your answer.

...............................................................................................................................................................................................[2]
(ii) Write an ionic equation for the reaction between zinc atoms and silver(I) ions.

.................................................................................................[2]

Q# 11/ iGCSE Chemistry/2002/w/Paper 3/

3 The elements in Period 3 and some of their common oxidation states are shown below.

<table>
<thead>
<tr>
<th>Element</th>
<th>Na</th>
<th>Mg</th>
<th>Al</th>
<th>Si</th>
<th>P</th>
<th>S</th>
<th>Cl</th>
<th>Ar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxidation State</td>
<td>+1</td>
<td>+2</td>
<td>+3</td>
<td>+4</td>
<td>−3</td>
<td>−2</td>
<td>−1</td>
<td>0</td>
</tr>
</tbody>
</table>

(a) (i) Why do the oxidation states increase from sodium to silicon?

.................................................................................................[1]

(ii) After Group(IV) the oxidation states are negative and decrease across the period. Explain why.

.................................................................................................[2]

Q# 12/ iGCSE Chemistry/2002/s/Paper 3/ Q4

(b) Bromine is obtained from the bromide ions in sea water. Sea water is concentrated by evaporation. Chlorine gas is bubbled through the solution. Chlorine oxidises the bromide ion to bromine.

(i) Complete the following equation.

\[ \text{Cl}_2 + \ldots..\text{Br}^- \rightarrow \ldots\ldots\ldots\ldots. + \ldots\ldots\ldots\ldots. \] [2]

(ii) Explain using the idea of electron transfer why the bromide ion is oxidised by chlorine.

The bromide ion is oxidised because ...........................................................................................................

.................................................................................................................................[2]

Chlorine is the oxidising agent because .................................................................................................

............................................................................................................................................................[2]

(iii) Name a reagent that can be oxidised by bromine molecules.

.......................................................................................................................................................... [1]

Q# 13/ iGCSE Chemistry/2001/w/Paper 3/ QiGCSE Chemistry/201 (a)

(iii) The following reaction is used to detect carbon monoxide.

\[ \text{CO} + \text{Pd}^{2+} + \text{H}_2\text{O} \rightarrow \text{CO}_2 + \text{Pd} + 2\text{H}^+ \]

What type of chemical reaction is the change Pd\(^{2+}\) to Pd? Give a reason for your answer.

...........................................................................................................................................................[2]
10.4.1 Mark Scheme iGC Chem 7.4 EQ Paper 3/4

Q# 1/ iGCSE Chemistry/2015/s/Paper 31/

| Q# 1(a) | 2 | Zn to Zn²⁺: because oxidation number has increased for NZ²⁺ |
| Q# 1(a) | 2 | R⁺ to ‘hydrogen’ ion(s): it accepts electrons or takes electrons (from zinc atom(s)); A because it is reduced or because it decreases in oxidation number A it causes zinc to lose electrons |

Q# 2/ iGCSE Chemistry/2012/s/Paper 31/Q4

(d i) V⁵⁺ is oxidant; [1]

(ii) V²⁺ to V⁴⁺: increase in oxidation number / electron loss; [1]

Q# 3/ iGCSE Chemistry/2011/w/Paper 31/ Q5

(b i) Fe to Fe²⁺ because oxidation is electron loss / increase in oxidation number [1]

(ii) Fe [1]

Q# 4/ iGCSE Chemistry/2010/w/Paper 31/

(iv) reduction because electron gain / because oxidation number decreases need both points [1]

(v) Fe³⁺ [1]

Q# 5/ iGCSE Chemistry/2010/w/Paper 31/

6 (a i) does not form compounds / does not accept and does not lose electrons / has full outer shell/has 8e in outer shell / it is a Noble Gas / it is in Group 0/8 [1]

(ii) small number of outer electrons / lose electrons then positive large number of outer electrons / gain electrons then negative [1]

Q# 6/ iGCSE Chemistry/2009/w/Paper 3/ Q4

(iii) I⁻ loses electrons (to form iodine molecules) must be in terms of electron transfer NOT oxidation number [1]

(iii) they (electrons) are accepted by ozone or it is an electron acceptor [1]

Q# 7/ iGCSE Chemistry/2007/w/Paper 3/ Q3 (b)

(iii) reducing or reduction or reductant lost electrons or given or donated electrons or transferred (to bromine) reduced [1]

(iii) gained or accepted electrons [1]

Q# 8/ iGCSE Chemistry/2005/s/Paper 3/

2 (a) Zn + I₂ = Zn²⁺ + 2I⁻ For having either reactants or products correct ONLY [2]

Q# 9/ iGCSE Chemistry/2004/s/Paper 3/

(c i) correctly balanced [1]

(ii) lost oxygen or decrease in oxidation number NOT accepts electrons unless valid explanation [1]
Q# 10/ iGCSE Chemistry/2003/w/Paper 3/ Q3

(c) (i) one involving lead – change 2
cond because electrons are gained
or oxidation number less

(ii) correct equation
Zn + 2Ag⁺ = 2Ag + Zn²⁺
not balanced ONLY [1]

Q# 11/ iGCSE Chemistry/2002/w/Paper 3/

3 (a) (i) number of outer electrons increases
or number of electrons more than complete energy level
or number of electrons to be lost
or accept clear examples
NOT just different groups or valencies

(ii) gain electrons
number of electrons to be gained is less across period [1]
or number of outer electrons increases

Q# 12/ iGCSE Chemistry/2002/s/Paper 3/

4 (a) (i) fluorine [1]

(ii) iodine and astatine [1]

(b) (i) Cl₂ + 2Br⁻ → 2Cl⁻ + Br₂
not balanced ONLY [1]

(ii) because it has lost electron(s) (Must be electron transfer) [1]
Not cause because it took electrons from the bromide
or chlorine gained electrons
or because chlorine was reduced

(iii) iodide or metals or iron(II) etc
not iodine accept iodine ions or alkene

Q# 13/ iGCSE Chemistry/2001/w/Paper 3/ QGCSE Chemistry/201 (a)

(iii) reduction
COND electron gain or decrease in oxidation number [1]
ESSENTIAL EXAM QUESTIONS Paper 2 18marks

Q# 1/ iGCSE Chemistry/2018/w/Paper 23/
16 The equation for the reaction between zinc and copper(II) oxide is shown.

\[ \text{Zn} + \text{CuO} \rightarrow \text{ZnO} + \text{Cu} \]

Which row shows the oxidising agent and the reducing agent?

<table>
<thead>
<tr>
<th></th>
<th>oxidising agent</th>
<th>reducing agent</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>CuO</td>
<td>Cu</td>
</tr>
<tr>
<td>B</td>
<td>CuO</td>
<td>Zn</td>
</tr>
<tr>
<td>C</td>
<td>Zn</td>
<td>CuO</td>
</tr>
<tr>
<td>D</td>
<td>Zn</td>
<td>ZnO</td>
</tr>
</tbody>
</table>

Q# 2/ iGCSE Chemistry/2018/w/Paper 22/
16 The thermite reaction can be used to produce iron from iron(III) oxide.

The equation for the reaction is shown.

\[ 2\text{Al} + \text{Fe}_2\text{O}_3 \rightarrow 2\text{Fe} + \text{Al}_2\text{O}_3 \]

Which statements about this reaction are correct?

1. Aluminium is the oxidising agent.
2. Aluminium is less reactive than iron.
3. Electrons are transferred from aluminium to iron.
4. The iron in the iron(III) oxide is reduced.

A 1 and 3     B 1 and 4     C 2 and 3     D 3 and 4

Q# 3/ iGCSE Chemistry/2018/w/Paper 21/
16 An excess of iron(II) chloride is added to acidified potassium manganate(VII).

Which statements are correct?

1. The purple colour disappears.
2. Iron(II) is reduced to iron(III).
3. Manganate(VII) ions are oxidised to manganese(II) ions.
4. Potassium manganate(VII) is an oxidising agent.

A 1 and 2     B 1 and 4     C 2 and 3     D 3 and 4

Q# 4/ iGCSE Chemistry/2018/s/Paper 23/
16 The equation for a redox reaction is shown.

\[ 2\text{Fe}^{3+} + \text{Zn} \rightarrow 2\text{Fe}^{2+} + \text{Zn}^{2+} \]

Which statements are correct?

1. Fe\(^{3+}\) is reduced to form Fe\(^{2+}\).
2. Zn oxidises the Fe\(^{3+}\) ions.
3. Fe\(^{2+}\) is an oxidising agent.

A 1, 2 and 3     B 1 and 2 only     C 1 and 3 only     D 2 and 3 only

Q# 5/ iGCSE Chemistry/2018/s/Paper 22/
16 Iron(II) chloride solution reacts with chlorine gas.

The equation is shown.

\[2\text{FeCl}_2(aq) + \text{Cl}_2(g) \rightarrow 2\text{FeCl}_3(aq)\]

Which statements about this reaction are correct?

1. Fe\(^{2+}\) ions are reduced to Fe\(^{3+}\) ions.
2. Chlorine acts as a reducing agent.
3. Fe\(^{2+}\) ions each lose an electron.
4. \(\text{Cl}_2\) molecules are reduced to \(\text{Cl}^-\) ions.

A  1 and 2       B  2 and 3       C  2 and 4       D  3 and 4

Q# 6/ iGCSE Chemistry/2018/s/Paper 21/

16 Chlorine displaces iodide ions from potassium iodide.

\[\text{Cl}_2 + 2\text{I}^- \rightarrow \text{I}_2 + 2\text{Cl}^-\]

What is the oxidising agent?

A  chloride ions
B  chlorine
C  iodide ions
D  iodine

Q# 7/ iGCSE Chemistry/2018/m/Paper 22/

18 The reaction between magnesium and carbon dioxide is shown in the equation.

\[2\text{Mg} + \text{CO}_2 \rightarrow 2\text{MgO} + \text{C}\]

Which statement describes what happens in this reaction?

A  Carbon is oxidised.
B  Magnesium is reduced.
C  Neither oxidation nor reduction happens.
D  The carbon in carbon dioxide is reduced.

Q# 8/ iGCSE Chemistry/2017/w/Paper 23/

19 Which changes involve reduction?

1. \(2\text{I}^- \rightarrow \text{I}_2 + 2\text{e}^-\)
2. \(\text{CuO} + \text{H}_2 \rightarrow \text{Cu} + \text{H}_2\text{O}\)
3. \(\text{Al}^{3+} + 3\text{e}^- \rightarrow \text{Al}\)
4. \(\text{Pb}^{2+} + \text{SO}_4^{2-} \rightarrow \text{PbSO}_4\)

A  1 and 2       B  1 and 4       C  2 and 3       D  3 and 4
14 Silver chloride reacts when it is exposed to light.

Which row shows what happens to the silver in this process?

<table>
<thead>
<tr>
<th></th>
<th>half-equation</th>
<th>type of reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Ag → Ag⁺ + e⁻</td>
<td>oxidation</td>
</tr>
<tr>
<td>B</td>
<td>Ag → Ag⁺ + e⁻</td>
<td>reduction</td>
</tr>
<tr>
<td>C</td>
<td>Ag⁺ + e⁻ → Ag</td>
<td>oxidation</td>
</tr>
<tr>
<td>D</td>
<td>Ag⁺ + e⁻ → Ag</td>
<td>reduction</td>
</tr>
</tbody>
</table>

Q# 9/ iGCSE Chemistry/2017/w/Paper 22/  
14 Copper metal donates electrons to silver ions.

Zinc metal donates electrons to copper ions.

What is the strongest reducing agent?

A copper ions  
B copper metal  
C silver ions  
D zinc metal

Q# 10/ iGCSE Chemistry/2017/w/Paper 21/  
14 Copper(II) oxide reacts with hydrogen.

\[ \text{CuO} + \text{H}_2 \rightarrow \text{Cu} + \text{H}_2\text{O} \]

Which row is correct?

<table>
<thead>
<tr>
<th></th>
<th>oxidising agent</th>
<th>reducing agent</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>H₂</td>
<td>CuO</td>
</tr>
<tr>
<td>B</td>
<td>CuO</td>
<td>H₂</td>
</tr>
<tr>
<td>C</td>
<td>H₂O</td>
<td>Cu</td>
</tr>
<tr>
<td>D</td>
<td>Cu</td>
<td>H₂O</td>
</tr>
</tbody>
</table>

Q# 11/ iGCSE Chemistry/2017/s/Paper 21/  
17 An example of a redox reaction is shown.

\[ \text{Zn} + \text{Cu}^{2+} \rightarrow \text{Zn}^{2+} + \text{Cu} \]

Which statement about the reaction is correct?

A Zn is the oxidising agent and it oxidises Cu²⁺.  
B Zn is the oxidising agent and it reduces Cu²⁺.  
C Zn is the reducing agent and it oxidises Cu²⁺.  
D Zn is the reducing agent and it reduces Cu²⁺.
17 Chlorine displaces bromine from a solution of potassium bromide.

\[ \text{Cl}_2 + 2\text{KBr} \rightarrow 2\text{KCl} + \text{Br}_2 \]

What is the oxidising agent in this reaction?

A  bromide ions  
B  bromine  
C  chloride ions  
D  chlorine

Q# 13/ iGCSE Chemistry/2016/w/Paper 23/

17 Which change represents an oxidation reaction?

A  chlorine changes to chlorate(I) ions  
B  chlorine changes to chloride ions  
C  copper(II) ions change to copper  
D  potassium manganate(VII) ions change to potassium manganate(VI) ions

Q# 14/ iGCSE Chemistry/2016/w/Paper 22/

17 Chromium forms the compound chromium(III) sulfate.

What does the (III) represent?

A  the charge on a sulfate ion  
B  the number of chromium ions combined with one sulfate ion  
C  the number of sulfate ions combined with one chromium ion  
D  the oxidation state of chromium

Q# 15/ iGCSE Chemistry/2016/w/Paper 21/

17 Four ionic half-equations are shown.

1  \[ \text{Cu}^{2+}(aq) + 2e^- \rightarrow \text{Cu}(s) \]
2  \[ 2\text{I}^- (aq) \rightarrow \text{I}_2(aq) + 2e^- \]
3  \[ \text{Fe}^{2+}(aq) \rightarrow \text{Fe}^{3+}(aq) + e^- \]
4  \[ \text{Cl}_2(g) + 2e^- \rightarrow 2\text{Cl}^-(aq) \]

Which statement is correct?

A  In equation 1, copper(II) ions are oxidised to copper.  
B  In equation 2, iodide ions are reduced to iodine.  
C  In equation 3, iron(II) ions are oxidised to iron(III) ions.  
D  In equation 4, chlorine is oxidised to chloride ions.
Q# 16/ iGCSE Chemistry/2016/s/Paper 21/
17 Which equation represents a reduction reaction?
   A  Fe^{2+} + e^- \rightarrow Fe^{3+}
   B  Fe^{2+} \rightarrow Fe^{3+} + e^-
   C  Fe^{3+} + e^- \rightarrow Fe^{2+}
   D  Fe^{3+} \rightarrow Fe^{2+} + e^-
Q# 17/ iGCSE Chemistry/2016/m/Paper 22/
16 Zinc is extracted from zinc blende by roasting it in air to form zinc oxide.

The zinc oxide is then heated with carbon to form zinc.

The equations for the reactions are shown.
   1  2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2
   2  ZnO + C \rightarrow Zn + CO

Which statement about reactions 1 and 2 is not correct?
   A  In reaction 1 the oxidation state of sulfur increases and it is oxidised.
   B  In reaction 1 the oxidation state of zinc increases and it is oxidised.
   C  In reaction 2 the carbon acts as a reducing agent and it is oxidised.
   D  In reaction 2 the oxidation state of zinc decreases and it is reduced.

10.5.1 ESSENTIAL EXAM QUESTIONS T7.4 Paper 2 Mark Scheme

Q# 1/ iGCSE Chemistry/2018/w/Paper 23/
16  B
Q# 2/ iGCSE Chemistry/2018/w/Paper 22/
16  D
Q# 3/ iGCSE Chemistry/2018/w/Paper 21/
16  B
Q# 4/ iGCSE Chemistry/2018/s/Paper 23/
16  C
Q# 5/ iGCSE Chemistry/2018/s/Paper 22/
16  D
Q# 6/ iGCSE Chemistry/2018/s/Paper 21/
16  B
Q# 7/ iGCSE Chemistry/2018/m/Paper 22/
18  D
19  C
Q# 8/ iGCSE Chemistry/2017/w/Paper 23/
14  D
Q# 9/ iGCSE Chemistry/2017/w/Paper 22/
14  D
Q# 10/ iGCSE Chemistry/2017/w/Paper 21/
14  B
Q# 11/ iGCSE Chemistry/2017/s/Paper 21/
17  D
Q# 12/ iGCSE Chemistry/2017/m/Paper 22/
17  D
Q# 13/ iGCSE Chemistry/2016/w/Paper 23/
17  A
Q# 14/ iGCSE Chemistry/2016/w/Paper 22/
17  D
Q# 15/ iGCSE Chemistry/2016/w/Paper 21/
17  C
Q# 16/ iGCSE Chemistry/2016/s/Paper 21/
17  C
Q# 17/ iGCSE Chemistry/2016/m/Paper 22/
16  B
## 10.6 FUNDAMENTAL Assessed Activity 1 Keyword Test

<table>
<thead>
<tr>
<th>English</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>oxidation state</td>
<td></td>
</tr>
<tr>
<td>oxidation</td>
<td></td>
</tr>
<tr>
<td>oxidising agent</td>
<td></td>
</tr>
<tr>
<td>redox reaction</td>
<td></td>
</tr>
<tr>
<td>reduction</td>
<td></td>
</tr>
</tbody>
</table>

## 10.7 FUNDAMENTAL Assessed Activity 2 Paper 1 17marks

**Q# 1/**

14 Which change is an oxidation?

A  FeO to Fe₂O₃
B  Fe₂O₃ to FeO
C  H₂O₂ to H₂O
D  H₂O to H₂

**Q# 2/**

14 The element vanadium, V, forms several oxides.

In which change is oxidation taking place?

A  VO₂ → V₂O₃
B  V₂O₅ → VO₂
C  V₂O₃ → VO
D  V₂O₃ → V₂O₅
Q# 3/
18 The red colour in some pottery glazes may be formed as a result of the reactions shown.

\[
\begin{align*}
\text{CuCO}_3 \xrightarrow{\text{heat}} \text{CuO} + \text{CO}_2 \\
\text{CuO} + \text{SnO} \longrightarrow \text{Cu} + \text{SnO}_2
\end{align*}
\]

These equations show that \( \ldots 1 \ldots \) is oxidised and \( \ldots 2 \ldots \) is reduced.

Which substances correctly complete gaps 1 and 2 in the above sentence?

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>CO₂</td>
<td>SnO₂</td>
</tr>
<tr>
<td>B</td>
<td>CuCO₃</td>
<td>CuO</td>
</tr>
<tr>
<td>C</td>
<td>CuO</td>
<td>SnO</td>
</tr>
<tr>
<td>D</td>
<td>SnO</td>
<td>CuO</td>
</tr>
</tbody>
</table>

Q# 4/
18 Iron is extracted from iron oxide using carbon monoxide as shown in the equation.

\[
\text{iron oxide} + \text{carbon monoxide} \rightarrow \text{iron} + \text{carbon dioxide}
\]

What does the equation show?

A  Carbon monoxide is oxidised to carbon dioxide.
B  Carbon monoxide is reduced to carbon dioxide.
C  Iron is oxidised to iron oxide.
D  Iron oxide is oxidised to iron.

Q# 5/
18 The equations represent redox reactions.

In which equation is the underlined substance acting as a reducing agent?

A  \( \text{CaO} + \text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2 \)
B  \( \text{CO}_2 + \text{C} \rightarrow 2\text{CO} \)
C  \( \text{CuO} + \text{H}_2 \rightarrow \text{Cu} + \text{H}_2\text{O} \)
D  \( 3\text{CO} + \text{Fe}_2\text{O}_3 \rightarrow 2\text{Fe} + 3\text{CO}_2 \)

Q# 6/
18 The reactions shown may occur in the air during a thunder storm.

\[
\begin{align*}
\text{N}_2 + \text{O}_2 & \rightarrow 2\text{NO} \\
2\text{NO} + \text{O}_2 & \rightarrow 2\text{NO}_2 \\
\text{NO} + \text{O}_3 & \rightarrow \text{NO}_2 + \text{O}_2
\end{align*}
\]

Which line shows what happens to the reactant molecules in each of these reactions?

<table>
<thead>
<tr>
<th></th>
<th>N₂</th>
<th>NO</th>
<th>O₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>oxidised</td>
<td>oxidised</td>
<td>oxidised</td>
</tr>
<tr>
<td>B</td>
<td>oxidised</td>
<td>oxidised</td>
<td>reduced</td>
</tr>
<tr>
<td>C</td>
<td>reduced</td>
<td>reduced</td>
<td>oxidised</td>
</tr>
<tr>
<td>D</td>
<td>reduced</td>
<td>reduced</td>
<td>reduced</td>
</tr>
</tbody>
</table>
Q# 7/
17 In which of the following reactions is the substance printed in **bold** oxidised?

A   burning the **wax** in a candle
B   dissolving **hydrogen chloride** in water
C   making glucose from **carbon dioxide** and water by photosynthesis
D   reacting **sodium hydroxide** with sulphuric acid

Q# 8/
18 When written as formulae, which compound has the greatest number of oxygen atoms?

A   calcium oxide
B   copper(II) oxide
C   iron(III) oxide
D   potassium oxide

Q# 9/
19 The equation explains the colour change that occurs when aqueous potassium hydroxide is added to aqueous potassium dichromate(VI).

\[ \text{K}_2\text{Cr}_2\text{O}_7 + 2\text{KOH} \rightarrow 2\text{K}_2\text{CrO}_4 + \text{H}_2\text{O} \]

<table>
<thead>
<tr>
<th>oxidation state of the chromium</th>
<th>pH of the mixture</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>decreases</td>
</tr>
<tr>
<td>B</td>
<td>decreases</td>
</tr>
<tr>
<td>C</td>
<td>stays the same</td>
</tr>
<tr>
<td>D</td>
<td>stays the same</td>
</tr>
</tbody>
</table>

Q# 10/
16 Which equation shows an oxidation reaction?

A   C + O\(_2\) \rightarrow CO\(_2\)
B   CaCO\(_3\) \rightarrow CaO + CO\(_2\)
C   2H\(_2\)O\(_2\) \rightarrow 2H\(_2\)O + O\(_2\)
D   N\(_2\)O\(_4\) \rightarrow 2NO\(_2\)
Q# 11/
15 Which process does not involve either oxidation or reduction?
   A burning methane in the air
   B extracting iron from hematite
   C heating copper(II) oxide with carbon
   D reacting sodium carbonate with dilute hydrochloric acid

Q# 12/
29 What is used to test for the presence of water?
   A anhydrous copper(II) sulphate
   B aqueous barium chloride
   C aqueous sodium hydroxide
   D Universal indicator paper

Q# 13/
17 In which reaction does reduction of the underlined substance take place?
   A \( Cu_2O + C \rightarrow 2Cu + CO \)
   B \( 2Cu_2O + O_2 \rightarrow 4CuO \)
   C \( 2Cu + O_2 \rightarrow 2CuO \)
   D \( CuO + CO \rightarrow Cu + CO_2 \)

Q# 14/
16 In an experiment, copper(II) oxide is changed to copper by a gas \( X \).

What happens to the copper(II) oxide and what is \( X \)?

<table>
<thead>
<tr>
<th>copper(II) oxide</th>
<th>gas ( X )</th>
</tr>
</thead>
<tbody>
<tr>
<td>A oxidised</td>
<td>carbon dioxide</td>
</tr>
<tr>
<td>B oxidised</td>
<td>carbon monoxide</td>
</tr>
<tr>
<td>C reduced</td>
<td>carbon dioxide</td>
</tr>
<tr>
<td>D reduced</td>
<td>carbon monoxide</td>
</tr>
</tbody>
</table>

Q# 15/
17 The equation shows what happens when hydrated copper(II) sulphate is heated.
\[
CuSO_4 \cdot 5H_2O(s) \rightleftharpoons CuSO_4(s) + 5H_2O(g)
\]

What can be deduced from the equation?
   A The hydrated copper(II) sulphate is oxidised.
   B The hydrated copper(II) sulphate is reduced.
   C The reaction is reversible.
   D There is no colour change.
15. When hydrogen is passed over a heated metal oxide, the metal and steam are formed.

What happens to the hydrogen and to the metal oxide?

<table>
<thead>
<tr>
<th>hydrogen</th>
<th>metal oxide</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>oxidised</td>
</tr>
<tr>
<td>B</td>
<td>oxidised</td>
</tr>
<tr>
<td>C</td>
<td>reduced</td>
</tr>
<tr>
<td>D</td>
<td>reduced</td>
</tr>
</tbody>
</table>

Q# 17/
18. Zinc reacts with steam to form zinc oxide and hydrogen.

\[ \text{Zn} + \text{H}_2\text{O} \rightarrow \text{ZnO} + \text{H}_2 \]

During the reaction, which substance is oxidised?

A. hydrogen  
B. water  
C. zinc  
D. zinc oxide

10.8 Extension Assessed Activity 3 T7.4 P4 13marks

Q# 1/
(i) The chemical process taking place on the surface of the object is

\[ \text{Cu}^{2+}(aq) + 2e^- \rightarrow \text{Cu}(s) \]

Explain whether this process is oxidation or reduction.

.................................................................

................................................................. [1]

Q# 2/
(d) When a sample of steel is added to dilute hydrochloric acid, an aqueous solution of iron(II) chloride, FeCl₂, is formed.

When a sample of rust is added to dilute hydrochloric acid, an aqueous solution of iron(III) chloride, FeCl₃, is formed.
Solutions of iron(II) chloride and iron(III) chloride were added to solutions of potassium iodide and acidified potassium manganate(VII). The results are shown in the table.

<table>
<thead>
<tr>
<th></th>
<th>iron(II) chloride solution</th>
<th>iron(III) chloride solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>potassium iodide solution</td>
<td>no change</td>
<td>solution turns from colourless to brown</td>
</tr>
<tr>
<td>acidified potassium manganate(VII) solution</td>
<td>solution turns from purple to colourless</td>
<td>no change</td>
</tr>
</tbody>
</table>

(ii) What **types** of substance cause potassium iodide solution to turn from colourless to brown?

........................................................................................................................................... [1]

(iii) What **types** of substance cause acidified potassium manganate(VII) solution to turn from purple to colourless?

........................................................................................................................................... [1]

**Q# 3**

(c) When chlorine gas is bubbled through an aqueous solution of potassium iodide, a redox reaction takes place.

\[ 2I^- + Cl_2 \rightarrow I_2 + 2Cl^- \]

(ii) Identify the reducing agent in this reaction. Explain your answer.

........................................................................................................................................... [2]

**Q# 4**

(c) The electrolysis was repeated using copper electrodes in place of carbon electrodes. The ionic half-equations for the reactions at the two electrodes are shown.

*Anode*  \[ \text{Cu(s)} \rightarrow \text{Cu}^{2+}(aq) + 2e^- \]

*Cathode*  \[ \text{Cu}^{2+}(aq) + 2e^- \rightarrow \text{Cu(s)} \]

(i) Which species is reduced during the electrolysis? Explain your answer.

........................................................................................................................................... [2]
Q# 5/
4 Copper(II) sulfate solution was electrolysed using the apparatus shown.

\[ \text{(b) Oxygen was formed at the anode and copper was formed at the cathode.} \]

(i) The ionic half-equation for the formation of oxygen is shown.
\[ 40H^+ \rightarrow O_2 + 2H_2O + 4e^- \]

Explain why this reaction is oxidation.

............................................................................................................................................... [1]

(ii) Write the ionic half-equation for the formation of copper at the cathode.

............................................................................................................................................... [2]

Q# 6/ 3 (a) When magnesium is added to aqueous copper(II) sulfate a reaction occurs.
The ionic equation for the reaction is shown.
\[ \text{Mg} + \text{Cu}^{2+} \rightarrow \text{Mg}^{2+} + \text{Cu} \]

(i) Give one change you would observe during this reaction.

............................................................................................................................................... [1]

(ii) Explain why this is a redox reaction.

............................................................................................................................................... [1]

(iii) Identify the oxidising agent in this reaction. Give a reason for your answer.

............................................................................................................................................... [2]
Extension Mind Map for Topic 7.4 Redox
10.10 Essential End of Topic 7.4 Review and Reflection

Looking at the goals you could have achieved and the goals you actually achieved try to reflect on your progress.

Try to be as honest and as detailed as possible. Sometimes you may think you have thought about an idea well, but when you talk with someone else, or write it out, it helps you better understand and allows you think more completely and more clearly.

Did you achieve more goals this topic than last topic?

Fill in this table

<table>
<thead>
<tr>
<th>Level</th>
<th>Number of goals achieved at each level</th>
<th>Success rate, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>FUNDAMENTAL</td>
<td>/5</td>
<td></td>
</tr>
<tr>
<td>ESSENTIAL</td>
<td>/10</td>
<td></td>
</tr>
<tr>
<td>EXTENSION</td>
<td>/13</td>
<td></td>
</tr>
<tr>
<td>EXCEPTIONAL</td>
<td>/10</td>
<td></td>
</tr>
</tbody>
</table>

Do you feel you tried harder? If yes, what helped you to do so? If not, why not?

________________________________________________________

What could you do differently next time, in addition to what you are already doing to improve, not only your score in the end of topic tests and other assessed activities, but also in how you learn. How could you become a more effective student to get more learning out of the time you are investing in your studies?

________________________________________________________

________________________________________________________

What did you enjoy most about this topic?

________________________________________________________

What did you find most difficult?

________________________________________________________

What did you find easiest?

________________________________________________________

On a scale of 1 being hardest and 5 being most difficult, circle how challenging you found this topic

1 2 3 4 5

What could be done to make this topic easier to understand?

________________________________________________________

Do you have any questions about this topic?

________________________________________________________
10.11 Exceptional Additional Activities, Further Reading and Exploring Beyond the Syllabus

10.12 Topic 7.4 Exceptional Redox Reactions and the Origins of Life

Redox processes are essential for all life that we have ever discovered and can ever imagine, the redox processes provide the necessary energy to allow the life processes to persist. There are a variety of articles about life discovered underground (it the soil and rocks of the Earth’s crust may in fact be where the majority, by dry mass, of life on Earth exists, not on the land, in the air or in the sea). Increasingly biologists understand life on earth started deep under water, and did not rely on energy from the sun, but instead energy from redox processes where the energy source is volcanic vents. It is even believed that this kind of life may in fact exist on other planets and moons, not only in our solar systems, or even in any solar system: perhaps half of all planets that are made in early solar systems are ejected out of the gravity field of their star or stars, and wander the astronomically empty spaces between solar systems, but if they are young enough, so just a few billion years old, they may have enough inner heat to support this kind of life beneath their icy surface.

All of these articles are available here: [https://www.smashingsciencecn.org/gcse-chem-additional-resources](https://www.smashingsciencecn.org/gcse-chem-additional-resources)

11 Topic 5 Electrochemistry

11.1 End of Topic 6 Goals Checklist

For each topic you ought to try to do as many of the following things to get the most out of your time, the resources available to you and to help you grow as a student. Tick each goal off as you complete it. Growth is difficult and uncomfortable, but you should choose to do these things, and the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win!

<table>
<thead>
<tr>
<th>Aspect</th>
<th>What you should have done</th>
<th>Yes/No</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interacted with your teacher</td>
<td>Ask your teacher 1 question, about anything, once a week</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Try to answer one question asked by your teacher at least once a week</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Ask your teacher one question about something you do not understand in science once a week</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Ask your teacher one question about something to do with science every lesson</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td>Notes and follow up notes</td>
<td>Complete set of class note</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Attempted</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Completed</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Completed to an exemplary standard</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Attempted the Mind Map for this topic</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Completed the Mind Map for this topic</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td>Textbook</td>
<td>Read ahead before the topic has been started</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Highlighted key ideas and translate new words</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Completed the questions at the end of each 2 page spread in your exercise book</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Added to your class notes ideas and important information from the textbook that you learnt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Past Exam Questions</td>
<td>Worked on at least 25% of the exam questions in this workbook</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Attempted more than 25% of the questions and those questions you have completed you have marked in a different colour pen</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Completed and marked all questions here</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Completed, marked and additional key ideas where you have located the most difficult marks added to your notebook</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Used the resources available online to answer additional questions not found in this workbook on the current topic.</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Ask your teacher about an exam question that they cannot answer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assessed Activities</td>
<td>Complete the word list activity using the word list at the front of each topic as little as possible</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities, either in class or as homework</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 70% on average</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 80% on average</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 90% on average</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td>End of Topic Test</td>
<td>Revised sufficiently well to improve upon your score from the previous test (except if you are scoring over 90%, then just write Y for this goal)</td>
<td></td>
<td>ESSENTIAL</td>
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<tr>
<td></td>
<td>Scored 10% higher than your current average</td>
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<td>EXTENSION</td>
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<tr>
<td></td>
<td>Scored 15% or more than your previous end of topic average</td>
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<tr>
<td></td>
<td>Scored over 90%</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Scored over 95%</td>
<td></td>
<td>SMASHING!!!</td>
</tr>
</tbody>
</table>
11.2 Topic 5 Syllabus

5 Electricity and chemistry

5.1 Electricity and chemistry

Core

- Define electrolysis as the breakdown of an ionic compound, molten or in aqueous solution, by the passage of electricity
- Describe the electrode products and the observations made during the electrolysis of:
  - molten lead(II) bromide
  - concentrated hydrochloric acid
  - concentrated aqueous sodium chloride
  - dilute sulfuric acid between inert electrodes (platinum or carbon)
- State the general principle that metals or hydrogen are formed at the negative electrode (cathode), and that non-metals (other than hydrogen) are formed at the positive electrode (anode)
- Predict the products of the electrolysis of a specified binary compound in the molten state
- Describe the electroplating of metals
- Outline the uses of electroplating

Supplement

- Relate the products of electrolysis to the electrolyte and electrodes used, exemplified by the specific examples in the Core together with aqueous copper(II) sulfate using carbon electrodes and using copper electrodes (as used in the refining of copper)
- Describe electrolysis in terms of the ions present and reactions at the electrodes in the examples given
- Predict the products of electrolysis of a specified halide in dilute or concentrated aqueous solution
- Construct ionic half-equations for reactions at the cathode

continued
### 11.3 ESSENTIAL Glossary for Keywords for this topic

<table>
<thead>
<tr>
<th>English</th>
<th>Chinese</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>anion</strong> a negative ion which would be attracted to the anode in electrolysis</td>
<td>阴离子负离子，它在电解中会被吸引到阳极</td>
</tr>
<tr>
<td><strong>anode</strong> the electrode in any type of cell at which oxidation (the loss of electrons) takes place – in electrolysis it is the positive electrode.</td>
<td>在发生氧化（电子损失）的任何类型的电池中，使电极阳极化-在电解中，它为正电极。</td>
</tr>
<tr>
<td><strong>brine</strong> a concentrated solution of sodium chloride in water</td>
<td>盐水在水中的氯化钠浓缩溶液</td>
</tr>
<tr>
<td><strong>cathode</strong> the electrode in any type of cell at which reduction (the gain of electrons) takes place; in electrolysis it is the negative electrode.</td>
<td>使任何类型的发生还原（电子增益）的电池中的电极阴极；在电解中它是负极。</td>
</tr>
<tr>
<td><strong>cation</strong> a positive ion which would be attracted to the cathode in electrolysis. Remember smiling cats: cats are positive!</td>
<td>阳离子在电解中会被吸引到阴极的阳离子，记住微笑的猫：猫是积极的！</td>
</tr>
<tr>
<td><strong>electrochemical cell</strong> a system for converting chemical energy to electrical energy, made by connecting two metals of different reactivity via an electrolyte;</td>
<td>电化学电池一种将化学能转化为电能的系统，通过将两种反应性不同的金属通过电解质连接制成。</td>
</tr>
<tr>
<td><strong>electrode</strong> the point where the electric current enters or leaves a battery or electrolytic cell</td>
<td>电极电流进入或离开电池或电解池的位置</td>
</tr>
<tr>
<td><strong>electrolysis</strong> a process in which a chemical reaction is caused by the passage of an electric current</td>
<td>电解一种通过电流通过引起化学反应的过程</td>
</tr>
<tr>
<td><strong>electrolyte</strong> an ionic compound which will conduct electricity when it is molten or dissolved in water; electrolytes will not conduct electricity when solid</td>
<td>电解质是一种离子化合物，当熔融或溶于水时会导电。固体时电解质不会导电</td>
</tr>
<tr>
<td><strong>electrolytic cell</strong> a cell consisting of an electrolyte and two electrodes (anode and cathode) connected to an external DC power source where positive and negative ions in the electrolyte are separated and discharged</td>
<td>电解池一种由电解质和两个与外部直流电源相连的电极（阳极和阴极）组成的电池，电解质中的正负离子被分离并放电</td>
</tr>
<tr>
<td><strong>electroplating</strong> a process of electrolysis in which a metal object is coated (plated) with a layer of another metal</td>
<td>电镀一种电解过程，其中金属物体被另一种金属层覆盖（电镀）</td>
</tr>
</tbody>
</table>
11.4 ESSENTIAL Active Learning Tasks Electrolysis 1

Match the following words with their meanings

<table>
<thead>
<tr>
<th>Word</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrode</td>
<td>Breaking up a substance by passing electricity through it</td>
</tr>
<tr>
<td>Electrolyte</td>
<td>Adding oxygen to, or removing electrons from, a substance</td>
</tr>
<tr>
<td>Reduction</td>
<td>Positive electrode</td>
</tr>
<tr>
<td>Oxidation</td>
<td>When one element is pushed out of its compound by a more reactive element</td>
</tr>
<tr>
<td>Cathode</td>
<td>Substance that is broken up when electricity is passed through it – usually a liquid</td>
</tr>
<tr>
<td>Anode</td>
<td>The percentage of the reactants that end up in the desired products of a reaction</td>
</tr>
<tr>
<td>Electrolysis</td>
<td>Removing oxygen from, or adding electrons to, a substance</td>
</tr>
<tr>
<td>Displacement</td>
<td>Negative electrode</td>
</tr>
<tr>
<td>Atom economy</td>
<td>A conductor made of a metal or graphite used in electrolysis</td>
</tr>
</tbody>
</table>

**Essential** Now label this diagram showing electrolysis

![Diagram of electrolysis](image)

**Electrode**

Electron Flow Notation

- Electron charge moves from the negative (surplus) side of the battery to the position (deficiency) side.

Conventional Flow Notation

- Electric charge moves from the positive (surplus) side of the battery to the negative (deficiency) side.

**Extension activity**

Assume that the substance being electrolysed is Lead (II) Bromide. Use the information above about Electron Flow Notation to label the electrodes with the ionic half equation that is happening at each side.

**Exceptional activity**

Why is the electron flow notation different from the conventional flow notation?
Compare and contrast what these two processes have in common and how are they different to each other.

Galvanic or Voltaic Cell (also called an Electrochemical Cell)

Electrolytic Cell for Electrolysis
11.6 Extension Classroom Active Learning Task 3

1. What is the oxidation number of chlorine in HClO₃?
   1. −1  2. +1  3. +7  4. +8

2. What is the oxidation number of carbon in C₃H₆?
   1. −6  2. −3  3. +3  4. +6

4. Given the reaction: Mg + CuSO₄ → MgSO₄ + Cu
   Which equation represents the oxidation
   that takes place?
   1. Mg²⁺ + 2e⁻ → Mg
   2. Mg → Mg²⁺ + 2e⁻
   3. Cu²⁺ + 2e⁻ → Cu
   4. Cu → Cu²⁺ + 2e⁻

5. In the following reaction: Fe + Zn²⁺ → Fe²⁺ + Zn
   A. Fe is reduced and Zn²⁺ is the oxidizing agent
   B. Fe is reduced and Zn²⁺ is the reducing agent
   C. Fe is oxidized and Zn²⁺ is the oxidizing agent
   D. Fe is oxidized and Zn²⁺ is the reducing agent

6. In which species does oxygen have an oxidation number of −1?

9. What is the purpose of a salt bridge in an electrochemical cell?
   1. To act as a reducing agent
   2. To act as an oxidizing agent
   3. To provide electrons that flow between the two half cells and complete the electrical circuit
   4. To provide ions that flow between the two half cells and complete the electrical circuit

11. Given the equations A, B, C, and D: which two equations represent redox reactions?
   A. AgNO₃ + NaCl → AgCl + NaNO₃
   B. CH₄ + H₂O → HClO + HCl
   C. CuO + CO → CO₂ + Cu
   D. NaOH + HCl → NaCl + H₂O

12. Given the unbalanced equation: ____NO₃⁻ + 4H⁺ + ____Ag → ____Ag⁺ + ____NO + 2H₂O
   What is the coefficient in front of Ag when the equation is correctly balanced? (Where coefficients are given, these are correct and should not be changed)
   1. 1  2. 2  3. 3  4. 4

Use the diagram of the electrochemical cell below to answer the next four questions:

[Diagram of electrochemical cell with Pb(s) and Cu(s) electrodes, salt bridge, and reactions Pb(s) + Cu²⁺(aq) → Pb²⁺(aq) + Cu(s)]
13. When the switch is closed which electrode will become heavier?
A. Pb
B. Cu
C. Both Pb and Cu will increase in mass
D. Neither Pb nor Cu will increase in mass

14. Which direction will electrons flow?
A. From Pb through the voltmeter to Cu
B. From Cu through the voltmeter to Pb
C. From Pb through the salt bridge to Cu
D. From Cu through the salt bridge to Pb

15. Which metal ion will increase in concentration as the cell runs
1. Cu^{2+} only
2. Pb^{2+} only
3. Both Cu^{2+} and Pb^{2+}
4. Neither Cu^{2+} nor Pb^{2+}

18. In the following reaction, how many total electrons are transferred between chlorine and oxygen?
2 ClO_2 \rightarrow Cl_2 + 2O_2
1. 1
2. 2
3. 8
4. 4

19. In the following reaction what is the reducing agent?
Mg + 2HNO_3 \rightarrow Mg(NO_3)_2 + H_2
1. Mg
2. H^+
3. O^{2-}
4. N^{3-}

Answer the next four questions from the reaction below:

Given the unbalanced reaction:
_____Au^{3+}(aq) + ____I(aq) \rightarrow ____Au(s) + ____I_2(s)

21. Write the reduction half reaction

22. Write the oxidation half reaction

23. Write the balanced reaction

23. How many total electrons are transferred when the reaction is balanced \[\text{____}_\]
The diagram below represents an electrochemical cell for the reaction:

\[ \text{Mg(s)} + \text{Zn(NO}_3\text{)}_2(\text{aq}) \rightarrow \text{Mg(NO}_3\text{)}_2 + \text{Zn(s)} \]

24. Label the cathode
25. Label the anode
26. Write the half reaction which occurs at the cathode

27. Write the half reaction which occurs at the anode

28. Show the direction of movement of Mg\(^{2+}\) ions on the diagram above
29. Show the direction of Zn\(^{2+}\) ions ion the diagram above
30. Label and show the direction of movement of electrons

31. The diagram at right shows a cell for silver plating jewelry, adding a thin coat of silver on top of a cheaper metal such as steel.

A. There are two electrodes in the diagram, the silver electrode and the copper wire that holds the object to be plated. Label correctly in the diagram with anode or cathode.

B. Write the half reaction next to each electrode.

C. In what two ways does this differ from the other type of cell you have studied?
11.6.1 Extension Classroom Active Learning Task 3 Answers

Answers to Electrochemistry: Practice Questions

1. 3 2. 2 4. 2 5. 3 6. 2 9. 4 11. 2 12. 3 13. 2 14. 1 15. 2 18. 3 19. 1

Given the unbalanced reaction: \( \text{_____} \text{Au}^{2+}(aq) + \text{_____} \text{I}^{-}(aq) \rightarrow \text{_____} \text{Au(s)} + \text{_____} \text{I}_2(s) \)

21. Write the reduction half reaction: \( \text{Au}^{3+} + 3 \text{e}^- \rightarrow \text{Au(s)} \) \( \Rightarrow \) \( 2 \text{Au}^{3+} + 6 \text{e}^- \rightarrow 2 \text{Au(s)} \)
22. Write the oxidation half reaction: \( 2 \text{I}^- \rightarrow \text{I}_2(s) + 2 \text{e}^- \) \( \Rightarrow \) \( 6 \text{I}^- \rightarrow 3 \text{I}_2(s) + 6 \text{e}^- \)
23. Write the balanced reaction: \( 2 \text{Au}^{3+} + 6 \text{I}^- \rightarrow 3 \text{I}_2(s) + 2 \text{Au(s)} \)
24. How many total electrons are transferred when the reaction is balanced? 6 electrons
(Not 12 electrons! The 6 electrons lost by 6I\(^-\) are the same ones gained by 2Au\(^{3+}\) – don’t double count them)

The diagram below represents an electrochemical cell for the reaction:

\( \text{Mg(s)} + \text{Zn(NO}_3)_2(aq) \rightarrow \text{Mg(NO}_3)_2 + \text{Zn(s)} \)

32. D. requires power, requires electrical energy, the cathode and anode are all in same cell compartment, does have a salt bridge

\( \text{Ag(s)} \rightarrow \text{Ag}^+(aq) + \text{e}^- \) \( \text{Ag}^+(aq) + \text{e}^- \rightarrow \text{Ag(s)} \)
11.7 ESSENTIAL EXAM QUESTIONS Paper 2 11marks

Q# 1/ iGCSE Chemistry/2016/w/Paper 23/
11 The diagram shows two different metal strips dipped into an electrolyte.

Which pair of metals produces the highest voltage?
A. copper and iron
B. copper and magnesium
C. copper and zinc
D. magnesium and iron

Q# 2/ iGCSE Chemistry/2016/w/Paper 22/
11 A student sets up a number of simple cells by putting strips of two different metals into dilute sulfuric acid.

Which cell produces the highest voltage?
A. copper and magnesium
B. copper and zinc
C. iron and copper
D. magnesium and zinc

Q# 3/ iGCSE Chemistry/2016/w/Paper 21/
C
10 Which apparatus could be used to electroplate an iron nail with copper?

A
B

d = copper sheet
↑ = iron nail
aqueous copper(II) sulfate
11 The diagram shows a simple cell.

Which two metals produce the highest reading on the voltmeter?

<table>
<thead>
<tr>
<th></th>
<th>X</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
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<td>magnesium</td>
<td>copper</td>
</tr>
<tr>
<td>B</td>
<td>magnesium</td>
<td>iron</td>
</tr>
<tr>
<td>C</td>
<td>zinc</td>
<td>copper</td>
</tr>
<tr>
<td>D</td>
<td>zinc</td>
<td>iron</td>
</tr>
</tbody>
</table>

Q# 4/ IGCSE Chemistry/2016/s/Paper 23/

10 The diagram shows a method used to copper-plate a pan.
Which equation represents the reaction at the cathode?

A  \( \text{Cu}^{2+} + 2e^- \rightarrow \text{Cu} \)
B  \( 2\text{H}^+ + 2e^- \rightarrow \text{H}_2 \)
C  \( 4\text{OH}^- \rightarrow \text{O}_2 + 2\text{H}_2\text{O} + 4e^- \)
D  \( 2\text{O}^2- \rightarrow \text{O}_2 + 4e^- \)

12 The diagram shows a simple cell.

![Diagram of a simple cell with metal P and metal Q in dilute sulfuric acid.]

Which pair of metals produces the largest voltage?

<table>
<thead>
<tr>
<th></th>
<th>metal P</th>
<th>metal Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>iron</td>
<td>copper</td>
</tr>
<tr>
<td>B</td>
<td>magnesium</td>
<td>copper</td>
</tr>
<tr>
<td>C</td>
<td>magnesium</td>
<td>zinc</td>
</tr>
<tr>
<td>D</td>
<td>zinc</td>
<td>copper</td>
</tr>
</tbody>
</table>

Q# 5/ iGCSE Chemistry/2016/s/Paper 22/

10 The diagram shows the electrolysis of molten zinc chloride, \( \text{ZnCl}_2 \).

![Diagram of an electrolysis cell with electrodes X and Y in molten zinc chloride.]

Which statement is correct?

A  Oxidation occurs at electrode X and the equation is: \( 2\text{Cl}^- \rightarrow \text{Cl}_2 + 2e^- \).
B  Oxidation occurs at electrode Y and the equation is: \( \text{Zn}^{2+} + 2e^- \rightarrow \text{Zn} \).
C  Reduction occurs at electrode X and the equation is: \( \text{Zn}^{2+} + 2e^- \rightarrow \text{Zn} \).
D  Reduction occurs at electrode Y and the equation is: \( 2\text{Cl}^- \rightarrow \text{Cl}_2 + 2e^- \).
12 The diagram shows a simple cell.

![Diagram of a simple cell]

For which pair of metals would electrons flow from metal X to metal Y?

<table>
<thead>
<tr>
<th></th>
<th>X</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>copper</td>
<td>iron</td>
</tr>
<tr>
<td>B</td>
<td>copper</td>
<td>zinc</td>
</tr>
<tr>
<td>C</td>
<td>iron</td>
<td>zinc</td>
</tr>
<tr>
<td>D</td>
<td>zinc</td>
<td>iron</td>
</tr>
</tbody>
</table>

Q# 6/ IGCSE Chemistry/2016/s/Paper 21/

10 Which reactions could take place at the anode during electrolysis?

1. $4\text{OH}^- (aq) \rightarrow 2\text{H}_2\text{O}(l) + \text{O}_2(g) + 4\text{e}^-$
2. $2\text{Cl}^- (aq) \rightarrow \text{Cl}_2(g) + 2\text{e}^-$
3. $\text{Cu}^{2+} (aq) + 2\text{e}^- \rightarrow \text{Cu}(s)$
4. $2\text{H}^+ (aq) + 2\text{e}^- \rightarrow \text{H}_2(g)$

A  1 and 2   B  1 and 4   C  2 and 4   D  3 and 4

12 The diagram shows a simple cell.

![Diagram of a simple cell with voltmeter, zinc electrode, copper electrode, and electrolyte]
Which statement about the process occurring when the cell is in operation is correct?

A  Cu^{2+} ions are formed in solution.
B  Electrons travel through the solution.
C  The reaction \( \text{Zn} \rightarrow \text{Zn}^{2+} + 2e^- \) occurs.
D  The zinc electrode increases in mass.

Q# 7/ iGCSE Chemistry/2016/m/Paper 22/

10 The electrolysis of concentrated hydrochloric acid is shown.

Which statement describes what happens to the electrons during the electrolysis?

A  They are added to chloride ions.
B  They are added to hydrogen ions.
C  They move through the circuit from positive to negative.
D  They move through the solution from negative to positive.

11.7.1 ESSENTIAL EXAM QUESTIONS Paper 2 T5 11marks MARK SCHEME

<table>
<thead>
<tr>
<th>Question</th>
<th>Mark Scheme</th>
<th>Mark Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q# 1/ iGCSE Chemistry/2016/w/Paper 23/</td>
<td>11 B</td>
<td>10 A</td>
</tr>
<tr>
<td>Q# 2/ iGCSE Chemistry/2016/w/Paper 22/</td>
<td>10 A</td>
<td>12 B</td>
</tr>
<tr>
<td>Q# 3/ iGCSE Chemistry/2016/w/Paper 21/</td>
<td>11 A</td>
<td>12 D</td>
</tr>
<tr>
<td>Q# 4/ iGCSE Chemistry/2016/s/Paper 23/</td>
<td>10 A</td>
<td>10 A, 12 C</td>
</tr>
<tr>
<td>Q# 5/ iGCSE Chemistry/2016/s/Paper 22/</td>
<td>12 D</td>
<td>10 B</td>
</tr>
</tbody>
</table>
11.8 ESSENTIAL EXAM QUESTIONS T5 Paper 3/4 100 marks

Q# 1/ iGCSE Chemistry/2014/w/Paper 31/ Q4

(d) There are two electrochemical methods of rust prevention.

(i) The first method is sacrificial protection.

The second method is to make the steel article the cathode in a circuit for electrolysis.

(ii) Mark on the diagram the direction of the electron flow. [1]

(iii) The steel girder does not rust because it is the cathode. Reduction takes place at the cathode. Give the equation for the reduction of hydrogen ions.

Q# 2/ iGCSE Chemistry/2012/s/Paper 31/

8 Iron and steel rust when exposed to water and oxygen. Rust is hydrated iron(III) oxide.

(a) The following cell can be used to investigate rusting.

(i) What is a cell? [2]
(ii) Which electrode will be oxidised and become smaller? Explain your choice.

.................................................................................................................. [3]

(iii) What measurements would you need make to find the rate of rusting of the electrode you have chosen in (ii)?

.................................................................................................................. [2]

(iv) Suggest an explanation why the addition of salt to the water increases the rate of rusting.

.................................................................................................................. [1]

Q# 3/ iGCSE Chemistry/2011/w/Paper 31/ Q3

(c) The uses of a metal are determined by its properties.

(ii) Explain why overhead electrical power cables are made from aluminium with a steel core.

.................................................................................................................. [3]

Q# 4/ iGCSE Chemistry/2011/s/Paper 31/ Q2 (a)

(ii) Name a device which can change chemical energy into electrical energy.

.................................................................................................................. [2]

Q# 5/ iGCSE Chemistry/2010/w/Paper 31/Q3

This equation is needed for the question that follows:

\[ \text{Br}_2 + 2e^- \rightarrow 2\text{Br}^- \]

(iii) When a solution of bromine is replaced by a solution of chlorine, the voltage increases. When a solution of bromine is replaced by a solution of iodine, the voltage decreases. Suggest an explanation for this difference.

.................................................................................................................. [1]

Q# 6/ iGCSE Chemistry/2010/w/Paper 31/ Q5 (b)
(iii) Describe an industrial method of making chlorine.

Q# 7/ IGCSE Chemistry/2010/w/Paper 31/ Q2c
(iii) Copper oxide is reduced to copper which is then refined by electrolysis. Label the diagram of the apparatus which could be used to refine copper.

Q# 8/ IGCSE Chemistry/2010/w/Paper 31/
3 The diagram shows a cell. This is a device which produces electrical energy. The reaction in a cell is a redox reaction and involves electron transfer.

(i) Complete the sentence.
A cell will change .................................. energy into electrical energy. [1]

(ii) Draw an arrow on the diagram to show the direction of the electron flow. [1]
(iii) In the left hand beaker, the colour changes from brown to colourless. Complete the equation for the reaction.

\[ \text{Br}_2 + \text{Br}_2 \rightarrow \text{Br}_2 \] 

[2]

Q# 9/ iGCSE Chemistry/2009/w/Paper 3/ Q3

(c) Zinc electrodes have been used in cells for many years, one of the first was the Daniel cell in 1831.

\[ \text{copper electrode} \quad \text{zinc electrode} \]

\[ \text{zinc sulfate(aq)} \quad \text{copper(II) sulfate(aq)} \]

\[ \text{porous pot - stops solutions from mixing} \]

(i) Give an explanation for the following in terms of atoms and ions.

observation at zinc electrode – the electrode becomes smaller

explanation

observation at copper electrode – the electrode becomes bigger

explanation

(ii) When a current flows, charged particles move around the circuit.

What type of particle moves through the electrolytes?

[1]

Which particle moves through the wires and the voltmeter?

[1]
2 The results of experiments on electrolysis using inert electrodes are given in the table.

Complete the table; the first line has been completed as an example.

<table>
<thead>
<tr>
<th>electrolyte</th>
<th>change at negative electrode</th>
<th>change at positive electrode</th>
<th>change to electrolyte</th>
</tr>
</thead>
<tbody>
<tr>
<td>molten lead(II) bromide</td>
<td>lead formed</td>
<td>bromine formed</td>
<td>used up</td>
</tr>
<tr>
<td>potassium formed</td>
<td></td>
<td>iodine formed</td>
<td>used up</td>
</tr>
<tr>
<td>dilute aqueous sodium chloride</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>aqueous copper(II) sulfate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hydrogen formed</td>
<td>bromine formed</td>
<td>potassium hydroxide formed</td>
<td></td>
</tr>
</tbody>
</table>

[Total: 8]

Q# 11/ iGCSE Chemistry/2008/w/Paper 31/

5 The electrolysis of concentrated aqueous sodium chloride produces three commercially important chemicals: hydrogen, chlorine and sodium hydroxide.

(a) The ions present are Na⁺(aq), H⁺(aq), Cl⁻(aq) and OH⁻(aq).

(i) Complete the ionic equation for the reaction at the negative electrode (cathode).

............... + ............ → H₂

(ii) Complete the ionic equation for the reaction at the positive electrode (anode).

............... − ............ → Cl₂

(iii) Explain why the solution changes from sodium chloride to sodium hydroxide.

........................................................................................................................................................................................................................................................................................................[1]
3 Copper is purified by electrolysis.

(a) Complete the following.

The positive electrode (anode) is made from .........................................................

The negative electrode (cathode) is made from .........................................................

The electrolyte is aqueous ................................................................. [3]

(b) Write an ionic equation for the reaction at the positive electrode (anode).
...................................................................................................................... [2]

Q# 13/ iGCSE Chemistry/2007/w/Paper 3/ Q4

(c) The remaining zinc oxide reacts with sulphuric acid to give aqueous zinc sulphate. This is electrolysed with inert electrodes (the electrolysis is the same as that of copper(II) sulphate with inert electrodes).

ions present: Zn^{2+}(aq) \ SO_4^{2-}(aq) \ H^+(aq) \ OH^-(aq)

(i) Zinc forms at the negative electrode (cathode). Write the equation for this reaction.
...................................................................................................................... [1]

(ii) Write the equation for the reaction at the positive electrode (anode).
...................................................................................................................... [2]

(iii) The electrolyte changes from aqueous zinc sulphate to
...................................................................................................................... [1]

Q# 14/ iGCSE Chemistry/2007/w/Paper 3/
The alcohols form a homologous series. The first four members are methanol, ethanol, propan-1-ol and butan-1-ol.

(a) One characteristic of a homologous series is that the physical properties vary in a predictable way. The table below gives the heats of combustion of the first three alcohols.

<table>
<thead>
<tr>
<th>Alcohol</th>
<th>Formula</th>
<th>Heat of combustion in kJ/mol</th>
</tr>
</thead>
<tbody>
<tr>
<td>methanol</td>
<td>CH₃OH</td>
<td>-730</td>
</tr>
<tr>
<td>ethanol</td>
<td>CH₃-CH₂-OH</td>
<td>-1370</td>
</tr>
<tr>
<td>propan-1-ol</td>
<td>CH₃-CH₂-CH₂-OH</td>
<td>-2020</td>
</tr>
<tr>
<td>butan-1-ol</td>
<td>CH₃-CH₂-CH₂-CH₂-OH</td>
<td></td>
</tr>
</tbody>
</table>

(i) The minus sign indicates that there is less chemical energy in the products than in the reactants. What form of energy is given out by the reaction?

(ii) Is the reaction exothermic or endothermic?

(iii) Complete the equation for the complete combustion of ethanol.

C₂H₅OH + O₂ → ........................................... + ...........................................
(iv) Determine the heat of combustion of butan-1-ol by plotting the heats of combustion of the first three alcohols against the number of carbon atoms per molecule.

<table>
<thead>
<tr>
<th>Number of Carbon Atoms Per Molecule</th>
<th>Heat of Combustion / kJ/mol</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>700</td>
</tr>
<tr>
<td>2</td>
<td>800</td>
</tr>
<tr>
<td>3</td>
<td>900</td>
</tr>
<tr>
<td>4</td>
<td>1000</td>
</tr>
</tbody>
</table>

The heat of combustion of butan-1-ol = ........................................... kJ/mol  [3]
Q# 15/ iGCSE Chemistry/2006/w/Paper 3/ Q6

(b) Impure copper is extracted from the ore. This copper is refined by electrolysis.

(i) Name:
the material used for the positive electrode (anode),

the material used for the negative electrode (cathode),

a suitable electrolyte. [3]

(ii) Write an ionic equation for the reaction at the negative electrode. [1]

Q# 16/ iGCSE Chemistry/2006/s/Paper 3/ Q6

(c) Cell reactions are both exothermic and redox. They produce electrical energy as well as heat energy.

(i) The diagram shows a simple cell.

![Diagram of a simple cell with electrodes, voltmeter, and reactions](image)

Which substance in this cell is the reductant and which ion is the oxidant?

reductant ........................................................................................................... [2]

oxidant .............................................................................................................

(ii) How could the voltage of this cell be increased?

............................................................................................................................ [1]
(d) Cells can be set up with inert electrodes and the electrolytes as oxidant and reductant.

[Diagram of a cell with a voltmeter, electron flow, carbon electrode (inert), potassium permanganate(VII) (aq), salt bridge (allows ions to move from one beaker to another), carbon electrode (inert), potassium iodide (aq)].

The potassium permanganate(VII) is the oxidant and the potassium iodide is the reductant.

(i) Describe the colour change that would be observed in the left hand beaker.

................................................................................................................................................ [2]

(ii) Write an ionic equation for the reaction in the right hand beaker.

................................................................................................................................................ [2]

Q# 17/ IGCSE Chemistry/2005/w/Paper 3/ Q5

(c) The major ore of strontium is its carbonate, SrCO₃. Strontium is extracted by the electrolysis of its molten chloride.

(ii) The electrolysis of molten strontium chloride produces strontium metal and chlorine. Write ionic equations for the reactions at the electrodes.

negative electrode (cathode) ................................................................................................................ [2]
positive electrode (anode) ................................................................................................................ [2]

(iii) One of the products of the electrolysis of concentrated aqueous strontium chloride is chlorine. Name the other two.

................................................................................................................................................ [2]
Q# 18/ iGCSE Chemistry/2004/s/Paper 3/ Q5

(b) Aqueous copper(II) sulphate solution can be electrolysed using carbon electrodes. The ions present in the solution are as follows.

\[ \text{Cu}^{2+} (aq), \quad \text{SO}_4^{2-} (aq), \quad \text{H}^+ (aq), \quad \text{OH}^- (aq) \]

(i) Write an ionic equation for the reaction at the negative electrode (cathode).

........................................................................................................................................ [1]

(ii) A colourless gas was given off at the positive electrode (anode) and the solution changes from blue to colourless.

Explain these observations.

........................................................................................................................................ [2]

(c) Aqueous copper(II) sulphate can be electrolysed using copper electrodes. The reaction at the negative electrode is the same but the positive electrode becomes smaller and the solution remains blue.

(i) Write a word equation for the reaction at the positive electrode.

........................................................................................................................................ [1]

(ii) Explain why the colour of the solution does not change.

........................................................................................................................................ [2]

(iii) What is the large scale use of this electrolysis?

........................................................................................................................................ [1]

Q# 19/ iGCSE Chemistry/2003/s/Paper 3/

5 The first three elements in Period 6 of the Periodic Table of the Elements are caesium, barium and lanthanum.

(b) All three metals can be obtained by the electrolysis of a molten halide. The electrolysis of the aqueous halides does not produce the metal.

(i) Complete the equation for the reduction of lanthanum ions at the negative electrode (cathode).

\[ \text{La}^{3+} + \text{.......} \rightarrow \text{.......} \]

(ii) Name the three products formed by the electrolysis of aqueous caesium bromide.

........................................................................................................................................ [4]
Q# 20/ iGCSE Chemistry/2003/s/Paper 3/

1 No one knows where iron was first isolated. It appeared in China, the Middle East and in Africa. It was obtained by reducing iron ore with charcoal.

(e) One of the methods used to prevent iron or steel from rusting is to electroplate it with another metal, such as tin. Complete the following.

The anode is made of ..............................................

The cathode is made of ..............................................

The electrolyte is a solution of ......................................

Q# 21/ iGCSE Chemistry/2002/w/Paper 3/ Q4

(b) Copper is refined by the electrolysis of aqueous copper(II) sulphate using copper electrodes. Describe the change that occurs at the electrodes.

(i) cathode (pure copper) ..................................................................................................................................................................................[1]

(ii) anode (impure copper) ..............................................................................................................................................................................[1]

(iii) Write an ionic equation for the reaction at the cathode.

................................................................................................................................................................................................................[1]

(iv) If carbon electrodes are used, a colourless gas is given off at the anode and the electrolyte changes from a blue to a colourless solution.

The colourless gas is ..................................................

The solution changes into ........................................... [2]

(c) Electrolysis and cells both involve chemical reactions and electricity.

What is the essential difference between them?

..................................................................................................................................................................................................................[2]

Q# 22/ iGCSE Chemistry/2002/s/Paper 3/

3 A major food retailer in the UK is going to distribute sandwiches using hydrogen-powered vehicles.

(c) Outline how hydrogen is manufactured from water.

..............................................................................................................................................................................................................[2]
Q# 23/ iGCSE Chemistry/2001/w/Paper 3/Q1 (b)

(ii) The main impurity in the nickel is copper. What technique is used to purify copper after it has been separated from the nickel?  

__________________________________________________________________________________________[1]

Q# 24/ iGCSE Chemistry/2001/w/Paper 3/ Q4

(e) The diagram below represents a simple cell.

(i) Write an ionic equation for the reaction that occurs at the zinc electrode.  

__________________________________________________________________________________________[1]

(ii) How could the voltage of the cell be increased?  

__________________________________________________________________________________________[1]

(f) A different type of cell is drawn below.

(i) The pH of the solution increases. Give the name of the ion formed.  

__________________________________________________________________________________________[1]

(ii) Complete the equation that represents the formation of this ion.

\[
O_2 + \text{ \ldots \ldots . H}_2\text{O} + \text{ \ldots \ldots .} \rightarrow \text{ \ldots \ldots .} \ 
\]

[2]
11.9 ESSENTIAL EXAM QUESTIONS T5 Paper 3/4 Mark Scheme

Q# 1/ iGCSE Chemistry/2014/w/Paper 31/ Q4 (d)

(ii) R to L in wire

(iii) $2H^+ + 2e^- \rightarrow H_2$
species (1) balancing (1)

Q# 2/ iGCSE Chemistry/2012/s/Paper 31/

8 (a) (i) device which changes chemical energy; into electrical energy; [1]
OR produces a voltage / potential difference / electricity; due to difference in reactivity of two metals; [1]
OR produces a voltage / potential difference / electricity; by redox reactions;

(ii) negative / electrode B / right electrode; accept: anode because it is the electrode which supplies electrons to external circuit
loses ions / Iron ions / Fe$^{2+}$ or Fe$^{3+}$; electrons move from this electrode;

(iii) change of mass of electrode / mass of rust formed; time / mention of stop watch / regular intervals;

(iv) to make it a better conductor;

Q# 3/ iGCSE Chemistry/2011/w/Paper 31/ Q3

(ii) aluminium low density / light aluminium is a good conductor strength / prevent sagging / allows greater separation of pylons / core made of steel because it is strong

Q# 4/ iGCSE Chemistry/2011/s/Paper 31/ Q2 (a)

(ii) cell accept battery not generator

Q# 5/ iGCSE Chemistry/2010/w/Paper 31/

(vi) any correct discussion of the reactivity of the halogens e.g. the more reactive the halogen the higher the voltage not better conductor

Q# 6/ iGCSE Chemistry/2010/w/Paper 31/ Q5 (b)

(iii) electrolysis aqueous sodium chloride

Q# 7/ iGCSE Chemistry/2010/w/Paper 31/ Q2

(c) (i) tin(IV) oxide + carbon $\rightarrow$ tin + carbon dioxide not carbon monoxide as a reductant accept carbon monoxide as a product not tin(IV) accept correct symbol equation

(ii) water carbon dioxide
(iii) correct labels for
  (pure) copper cathode
  impure copper anode
  electrolyte copper(II) sulfate / any soluble copper(II) salt / Cu^{2+}
  if labels on electrodes reversed [0]

(iv) wires / pipes / jewellery / nails / roofing / ammunition / coins / cookware / catalyst / sculpture

Q# 8/ IGCSE Chemistry/2010/w/Paper 31/

3  (i) chemical

(ii) from right to left
  not through salt bridge

(iii) \( \text{Br}_2 + 2e^- \rightarrow 2\text{Br}^- \)
  for Br\(^{-}\) as product [1]

Q# 9/ IGCSE Chemistry/2009/w/Paper 3/ Q3

(c) (i) zinc atoms change into ions, (the zinc dissolves)
  copper(II) ions change into atoms, (becomes plated with copper)

(ii) ions
  electrons

Q# 10/ IGCSE Chemistry/2009/s/Paper 31/

2  molten potassium iodide NOT aqueous

hydrogen
oxygen
water used up or solution becomes more concentrated or sodium chloride remains
NOT no change
If products are given as hydrogen, chlorine and sodium hydroxide then 2/3

copper
oxygen (and water)
sulfuric acid accept hydrogen sulfate

aqueous or dilute or concentrated potassium bromide
accept correct formulae

[Total: 8]

Q# 11/ IGCSE Chemistry/2008/w/Paper 31/

5  (a) (i) \( 2\text{H}^+ + 2e^- \rightarrow \text{H}_2 \)

(ii) \( 2\text{Cl}^- - 2e^- \rightarrow \text{Cl}_2 \) or \( 2\text{Cl}^- \rightarrow \text{Cl}_2 + 2e^- \)

(iii) Na\(^+\) and OH\(^-\) are left
OR Cl\(^-\) removed OH\(^-\) left
NB ions by name or formula essential
NOT any reaction of Na or Na\(^+\)
NOT Na\(^+\) and OH\(^-\) combine
Q# 12/ iGCSE Chemistry/2008/s/Paper 31/

3 (a) impure copper
(pure) copper
ACCEPT any (soluble) copper salt or Cu\(^{2+}\)
if both name and formulae given, both have to be correct

(b) Cu - 2e \(\rightarrow\) Cu\(^{2+}\) or Cu \(\rightarrow\) Cu\(^{2+}\) + 2e
for having Cu \(\rightarrow\) Cu\(^{2+}\) [1] ONLY

Q# 13/ iGCSE Chemistry/2007/w/Paper 3/ Q4

(c) (i) Zn\(^{2+}\) + 2e = Zn [1]

(ii) 4OH\(^-\) - 4e = O\(_2\) + 2H\(_2\)O
or 4OH\(^-\) = O\(_2\) + 2H\(_2\)O + 4e
or 2H\(_2\)O = 4H\(^+\) + O\(_2\) + 4e
or 2H\(_2\)O - 4e = 4H\(^+\) + O\(_2\)
oxygen as product [1]

(iii) sulphuric acid
NOTE there are no alternative answers to the above

Q# 14/ iGCSE Chemistry/2007/w/Paper 3/

6 (a) (i) heat (energy) [1]

(ii) exothermic [1]

(iii) C\(_2\)H\(_2\)OH + 3O\(_2\) = 2CO\(_2\) + 3H\(_2\)O
For CO\(_2\) + H\(_2\)O ONLY [1]

(iv) plotting points correctly
straight line
between -2640 and -2700kJ/mol
NOTE minus sign needed [1]

Q# 15/ iGCSE Chemistry/2006/w/Paper 3/ Q6

(b) (i) impure copper/blister copper/boulder copper etc
(pure) copper
iron sulphate or nitrate or chloride or contains Cu\(^{2+}\)aq

(ii) Cu\(^{2+}\) + 2e\(^-\) = Cu [1]

Q# 16/ iGCSE Chemistry/2006/s/Paper 3/ Q6

(c) (i) reductant zinc
oxidant hydrogen (ions)

(ii) magnesium instead of zinc or increase concentration of acid
or copper instead of iron [1]

(iii) sacrificial protection or stop iron/steel rusting
or galvanising [1]

(d) (i) pink or purple
to colourless or decolourised
NOTE red NOT clear [1]

(ii) 2I\(^-\) - 2e = I\(_2\)
unbalanced ONLY [1]
Q# 17/ iGCSE Chemistry/2005/w/Paper 3/ Q5(c)

(ii) \[ \text{Sr}^{2+} + 2e^- = \text{Sr} \] \[ \text{Cl}_2^- - 2e^- = \text{Cl}_2 \]
or \[ 2\text{Cl}^- = \text{Cl}_2 + 2e^- \]

(iii) hydrogen \[ \text{[1]} \] and strontium hydroxide \[ \text{[1]} \]

Q# 18/ iGCSE Chemistry/2004/s/Paper 3/ Q5

(b) (i) \[ \text{Cu}^{2+} + 2e^- = \text{Cu} \]

(ii) gas is oxygen

(copper(II) sulphate) changes to sulphuric acid
or copper ions removed from solution

(i) copper atoms - electrons = copper ions accept correct symbol equation

(ii) concentration of copper ions does not change or amount or number of copper ions does not change

(copper ions are removed and then replaced or copper is transferred from anode to cathode

(iii) refining copper or plating (core) or extraction of boulder copper

Q# 19/ iGCSE Chemistry/2003/s/Paper 3/ Q5

(b) (i) \[ \text{La}^{3+} + 3e^- = \text{La} \]

(ii) hydrogen
bromine NOT Bromide
caesium hydroxide
ignore any comments about electrodes

Q# 20/ iGCSE Chemistry/2003/s/Paper 3/ QiGCSE Chemistry/201

(e) anode tin \text{NOT impure time} \[ \text{[1]} \]
cathode iron or steel \[ \text{[1]} \]
tin salt or tin ions as electrolyte \[ \text{[1]} \]
NOT oxide or hydroxide or carbonate

Q# 21/ iGCSE Chemistry/2002/w/Paper 3/ Q4

(b) (i) copper deposited \text{ or } mass increases \[ \text{[1]} \]

(ii) copper goes into solution \text{ or } mass decreases \[ \text{[1]} \]

(iii) \[ \text{Cu}^{2+} + 2e^- \rightarrow \text{Cu} \]

(iv) oxygen
sulphuric acid accept hydrogen sulphate

(c) (ii) cells produce electricity \text{ or } endothermic \text{ or } change
chemical energy into electrical energy \[ \text{[1]} \]

electrolysis uses it \text{ or } endothermic \text{ or } change
electrical energy into chemical energy \[ \text{[1]} \]
### Q# 22/ iGCSE Chemistry/2002/s/Paper 3/ Q3

(c) (steam) and alkane
heat or catalyst or details of chemistry -- forms carbon monoxide/dioxide and (hydrogen) [1]

OR electrolysis
brine or acidified water
or hydrogen forms at cathode [1]

OR carbon/coke
heat or details of chemistry -- forms carbon monoxide/dioxide and (hydrogen) [1]

### Q# 23/ iGCSE Chemistry/2001/w/Paper 3/Q1 (b)

(ii) electrolysis [1]

### Q# 24/ iGCSE Chemistry/2001/w/Paper 3/ Q4

(e) (i) \( \text{Zn} - 2e \rightarrow \text{Zn}^{2+} \) [1]

(ii) Higher reactivity metal instead of Zn
or lower instead of iron or bigger difference in reactivity or increase concentration of acid [1]

(f) (i) hydroxide [1]

(ii) \( \text{O}_2 + 2\text{H}_2\text{O} + 4e \rightarrow 4\text{OH}^- \) unbalanced only [1]
\( \text{O}_2 + 2\text{H}_2\text{O} + 2\text{Fe} \rightarrow 2\text{Fe(OH)}_2 \) [2]

### 11.10 FUNDAMENTAL Assessed Activity 1 Keyword Test

<table>
<thead>
<tr>
<th>English</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>anion</td>
<td></td>
</tr>
<tr>
<td>anode</td>
<td></td>
</tr>
<tr>
<td>brine</td>
<td></td>
</tr>
<tr>
<td>cathode</td>
<td></td>
</tr>
<tr>
<td>cation</td>
<td></td>
</tr>
<tr>
<td>electrochemical cell</td>
<td></td>
</tr>
<tr>
<td>electrode</td>
<td></td>
</tr>
<tr>
<td>electrolysis</td>
<td></td>
</tr>
<tr>
<td>electrolyte</td>
<td></td>
</tr>
</tbody>
</table>
electrolytic cell

a cell consisting of an electrolyte and two electrodes (anode and cathode) connected to an external DC power source where positive and negative ions in the electrolyte are separated and discharged.

electroplating

11.11 ESSENTIAL Assessed Activity 2 Multiple Choice T5 16marks

Q# 1
10 Electrolysis of copper(II) sulfate can be done using either carbon electrodes or copper electrodes.

Which statement describes what happens at the positive electrode?

A Copper is deposited if the electrode is made from carbon.
B Copper is deposited if the electrode is made from copper.
C Oxygen gas is produced if the electrode is made from carbon.
D Oxygen gas is produced if the electrode is made from copper.

Q# 2/
10 Concentrated aqueous copper(II) chloride is electrolysed using copper electrodes as shown.

What happens to the mass of each electrode during this process?

<table>
<thead>
<tr>
<th></th>
<th>positive electrode</th>
<th>negative electrode</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>decreases</td>
<td>decreases</td>
</tr>
<tr>
<td>B</td>
<td>decreases</td>
<td>increases</td>
</tr>
<tr>
<td>C</td>
<td>increases</td>
<td>decreases</td>
</tr>
<tr>
<td>D</td>
<td>increases</td>
<td>increases</td>
</tr>
</tbody>
</table>
Q# 3/

10 Aqueous copper(II) sulfate is electrolysed using carbon electrodes.

What is the product at each electrode?

<table>
<thead>
<tr>
<th></th>
<th>product at the positive electrode</th>
<th>product at the negative electrode</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>copper</td>
<td>oxygen</td>
</tr>
<tr>
<td>B</td>
<td>hydrogen</td>
<td>oxygen</td>
</tr>
<tr>
<td>C</td>
<td>oxygen</td>
<td>copper</td>
</tr>
<tr>
<td>D</td>
<td>oxygen</td>
<td>hydrogen</td>
</tr>
</tbody>
</table>

11 The diagram shows a circuit used to electrolyse aqueous copper(II) sulfate.

Which arrows indicate the movement of the copper ions in the electrolyte and of the electrons in the external circuit?

<table>
<thead>
<tr>
<th></th>
<th>copper ions</th>
<th>electrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>C</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>D</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

Q# 4/

10 Aqueous copper(II) sulfate is electrolysed using copper electrodes.

Which statement is correct?

A  Oxygen gas is produced at the positive electrode.
B  The blue colour of the solution gradually fades.
C  The concentration of copper ions in the solution stays the same.
D  The mass of the negative electrode decreases.
Q# 5
10 Aqueous copper(II) sulfate is electrolysed using copper electrodes.

Which statement about the electrolysis is **not** correct?

A  An oxidation reaction occurs at the positive electrode.
B  The current is carried through the electrolyte by ions.
C  The negative electrode gains mass.
D  The number of copper(II) ions in the electrolyte decreases.

Q# 6
10 Aqueous copper(II) sulfate is electrolysed using copper electrodes.

Which statement is correct?

A  A reduction reaction occurs at the positive electrode.
B  The blue colour of the solution becomes darker.
C  The concentration of copper ions in the solution decreases.
D  The mass of the negative electrode increases.

11 Dilute sulfuric acid is electrolysed using inert electrodes.

What are the ionic half-equations for the reactions that take place at each electrode?

<table>
<thead>
<tr>
<th>positive electrode</th>
<th>negative electrode</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 2H⁺ + 2e⁻ → H₂</td>
<td>4OH⁻ → 2H₂O + O₂ + 4e⁻</td>
</tr>
<tr>
<td>B 2H⁺ + 2e⁻ → H₂</td>
<td>4OH⁻ + 4H⁺ → 4H₂O</td>
</tr>
<tr>
<td>C 4OH⁻ → 2H₂O + O₂ + 4e⁻</td>
<td>2H⁺ + 2e⁻ → H₂</td>
</tr>
<tr>
<td>D 4OH⁻ + 4H⁺ → 4H₂O</td>
<td></td>
</tr>
</tbody>
</table>

Q# 7
10 Which substance is **not** produced during the electrolysis of concentrated aqueous sodium chloride?

A  chlorine
B  hydrogen
C  sodium
D  sodium hydroxide

11 Aqueous copper(II) sulfate is electrolysed using copper electrodes.

What are the ionic half-equations for the reactions that occur at each electrode?

<table>
<thead>
<tr>
<th>anode</th>
<th>cathode</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Cu → Cu²⁺ + 2e⁻</td>
<td>Cu²⁺ + 2e⁻ → Cu</td>
</tr>
<tr>
<td>B Cu²⁺ + 2e⁻ → Cu</td>
<td>Cu → Cu²⁺ + 2e⁻</td>
</tr>
<tr>
<td>C 4OH⁻ → 2H₂O + O₂ + 4e⁻</td>
<td>Cu²⁺ + 2e⁻ → Cu</td>
</tr>
<tr>
<td>D 4OH⁻ → 2H₂O + O₂ + 4e⁻</td>
<td>2H⁺ + 2e⁻ → H₂</td>
</tr>
</tbody>
</table>
Q# 8/
9 Which statements about the electrolysis of concentrated copper(II) chloride are correct?

1. Electrons are transferred from the cathode to the copper(II) ions.
2. Electrons move round the external circuit from the cathode to the anode.
3. Chloride ions are attracted to the anode.
4. Hydroxide ions transfer electrons to the cathode.

A  1 and 3  B  1 and 4  C  2 and 3  D  2 and 4

10 Which metal combination produces the highest voltage reading in the cells shown?

A

B

C

D

Q# 9/
9 Which statement about electrolysis is correct?

A  Electrons move through the electrolyte from the cathode to the anode.
B  Electrons move towards the cathode in the external circuit.
C  Negative ions move towards the anode in the external circuit.
D  Positive ions move through the electrolyte towards the anode during electrolysis.
Q# 10/
10 The reactivity series for a number of different metals is shown.

| most reactive |  | least reactive |
|---------------|-------------------------|
| magnesium     | zinc                    | iron        |
|               | copper                  | silver      |
|               | platinum                |             |

The diagram shows different metal strips dipped into an electrolyte.

Which pair of metals produces the highest voltage?

A  copper and magnesium  
B  magnesium and platinum  
C  magnesium and zinc  
D  silver and platinum

Q# 11/
10 The diagram shows the electrolysis of aqueous copper(II) sulfate.

Which statement is correct?

A  Copper metal is deposited at the positive electrode.  
B  In the external circuit the electrons move from positive to negative.  
C  In the solution the electrons move from negative to positive.  
D  Oxygen gas is produced at the positive electrode.
11 Four solutions are separately electrolysed.

<table>
<thead>
<tr>
<th>experiment</th>
<th>solution</th>
<th>electrodes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>dilute aqueous sodium chloride</td>
<td>carbon</td>
</tr>
<tr>
<td>2</td>
<td>aqueous copper(II) sulfate</td>
<td>copper</td>
</tr>
<tr>
<td>3</td>
<td>concentrated hydrochloric acid</td>
<td>carbon</td>
</tr>
<tr>
<td>4</td>
<td>dilute sulfuric acid</td>
<td>carbon</td>
</tr>
</tbody>
</table>

In which two experiments is a colourless gas evolved at the anode?

A  1 and 2  B  1 and 4  C  2 and 3  D  3 and 4

11.12 EXTENTION Assessed Activity 3 T5 Longer answer questions 21marks

Q# 1

(b) The ions present in aqueous sodium chloride are Na⁺(aq), Cl⁻(aq), H⁺(aq) and OH⁻(aq).

The electrolysis of concentrated aqueous sodium chloride forms three products. They are hydrogen, chlorine and sodium hydroxide.

(i) Explain how these three products are formed. Give ionic equations for the reactions at the electrodes.

(ii) If the solution of the electrolyte is stirred, chlorine reacts with sodium hydroxide to form sodium chlorate(I), sodium chloride and water. Write an equation for this reaction.

\[ \text{Cl}_2 + \text{NaOH} \rightarrow \text{..........} + \text{..........} + \text{..........} \]
Q# 2/

7 Aluminium is obtained from purified alumina, Al₂O₃, by electrolysis.
   (b) Describe the extraction of aluminium from alumina. Include the electrolyte, the electrodes and the reactions at the electrodes.

(c) Aluminium is resistant to corrosion. It is protected by an oxide layer on its surface. The thickness of this oxide layer can be increased by anodising.
   (ii) Anodising is an electrolytic process. Dilute sulfuric acid is electrolysed with an aluminium object as the anode. The thickness of the oxide layer is increased. Complete the equations for the reactions at the aluminium anode.

   ....OH⁻ → O₂ + 2H₂O + ....e⁻
   ....Al + ....... → .......Al₂O₃

Q# 3/

(b) Chlorine is made by the electrolysis of concentrated aqueous sodium chloride.
Describe this electrolysis. Write ionic equations for the reactions at the electrodes and name the sodium compound formed.
11.13 Extension Mind Map for Topic 5 Electrochemistry
11.14 Essential End of Topic 5 Review and Reflection

Looking at the goals you could have achieved and the goals you actually achieved try to reflect on your progress.

Try to be as honest and as detailed as possible. Sometimes you may think you have thought about an idea well, but when you talk with someone else, or write it out, it helps you better understand and allows you think more completely and more clearly.

Did you achieve more goals this topic than last topic?

Fill in this table

<table>
<thead>
<tr>
<th>Level</th>
<th>Number of goals achieved at each level</th>
<th>Success rate, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>FUNDAMENTAL</td>
<td>/5</td>
<td></td>
</tr>
<tr>
<td>ESSENTIAL</td>
<td>/10</td>
<td></td>
</tr>
<tr>
<td>EXTENSION</td>
<td>/13</td>
<td></td>
</tr>
<tr>
<td>EXCEPTIONAL</td>
<td>/10</td>
<td></td>
</tr>
</tbody>
</table>

Do you feel you tried harder? If yes, what helped you to do so? If not, why not?

__________________________________________________________

What could you do differently next time, in addition to what you are already doing to improve, not only your score in the end of topic tests and other assessed activities, but also in how you learn. How could you become a more effective student to get more learning out of the time you are investing in your studies?

__________________________________________________________

__________________________________________________________

What did you enjoy most about this topic?

__________________________________________________________

What did you find most difficult?

__________________________________________________________

What did you find easiest?

__________________________________________________________

On a scale of 1 being hardest and 5 being most difficult, circle how challenging you found this topic

1 2 3 4 5

What could be done to make this topic easier to understand?

__________________________________________________________

Do you have any questions about this topic?

__________________________________________________________
11.15 Exceptional Additional Activities, Further Reading and Exploring Beyond the Syllabus

Michael Faraday, for a long while he was on the back of the UK 20 pound note (who was recently replaced by the artist J. M. W. Turner, click here to find out more about the artist). Einstein famously said that Faraday was the greatest experimental scientist in history and kept a picture of him in his study (Gleeson-White, Jane (10 November 2003). “Einstein’s Heroes (book review).” The Sydney Morning Herald. Retrieved 24 October 2017.). It’s been suggested that it was Faraday’s work on invisible magnetic fields allowed Einstein to create his ideas on how gravity is able to curve space-time which he explores in his theories on special and general relativity.

Who was Michael Faraday and what did he discover?

To find out more about electricity you can go here: https://www.chemguide.co.uk/inorganic/electrolysismenu.html#top

And read this Wikipedia article which can be found here:
https://www.smashingsciencecn.org/igcse-chem-additional-resources
## 12 Topic 6 Chemical Energetics

### 12.1 End of Topic 6 Goals Checklist

For each topic you ought to try to do as many of the following things to get the most out of your time, the resources available to you and to help you grow as a student. Tick each goal off as you complete it. Growth is difficult and uncomfortable, but you should choose to do these things, and the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win!

<table>
<thead>
<tr>
<th>Aspect</th>
<th>What you should have done</th>
<th>Yes/No</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interacted with your teacher</td>
<td>Ask your teacher 1 question, about anything, once a week</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Try to answer one question asked by your teacher at least once a week</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Ask your teacher one question about something you do not understand in science once a week</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Ask your teacher one question about something to do with science every lesson</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td>Notes and follow up notes</td>
<td>Complete set of class note</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Attempted</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Completed</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Completed to an exemplary standard</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Attempted the Mind Map for this topic</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Completed the Mind Map for this topic</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td>Textbook</td>
<td>Read ahead before the topic has been started</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Highlighted key ideas and translate new words</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Completed the questions at the end of each 2 page spread in your exercise book</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Added to your class notes ideas and important information from the textbook that you learnt</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td>Past Exam Questions</td>
<td>Worked on at least 25% of the exam questions in this workbook</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Attempted more than 25% of the questions and those questions you have completed you have marked in a different colour pen</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Completed and marked all questions here</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Completed, marked and additional key ideas where you have located the most difficult marks added to your notebook</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Used the resources available online to answer additional questions not found in this workbook on the current topic.</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Ask your teacher about an exam question that they cannot answer</td>
<td></td>
<td>EXCEPTIONALLY SMASHING!!!</td>
</tr>
<tr>
<td>Assessed Activities</td>
<td>Complete the word list activity using the word list at the front of each topic as little as possible</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities, either in class or as homework</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 70% on average</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 80% on average</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 90% on average</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td>End of Topic Test</td>
<td>Revised sufficiently well to improve upon your score from the previous test (except if you are scoring over 90%, then just write Y for this goal)</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Scored 10% higher than your current average</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Scored 15% or more than your previous end of topic average</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Scored over 90%</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Scored over 95%</td>
<td></td>
<td>SMASHING!!!</td>
</tr>
<tr>
<td>Aspect</td>
<td>What you should have done</td>
<td>Yes/No</td>
<td>Level</td>
</tr>
<tr>
<td>--------</td>
<td>--------------------------</td>
<td>--------</td>
<td>-------</td>
</tr>
<tr>
<td>Reading</td>
<td>Spend more than 1 hour a week reading a book you enjoy (in any language) about anything.</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Spend more than 3 hours a week reading a book you enjoy (in any language) about anything.</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Spend more than 5 hours a week reading a book you enjoy (in any language) about anything.</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Spend at least one hour a week reading a book you enjoy in English about anything.</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Spend more than 3 hours a week reading a book you enjoy in English about anything.</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td>Reflection</td>
<td>You completed this goal setting table</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>You have looked at the goals you have achieved and the ones you have not and added them up and entered them into the table in the Review and Reflection section</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>You have given an answer for every question in the Review and Reflection section at the end of this topic</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>You have given good and thoughtful answers for every question in the Review and Reflection section at the end of this topic</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
</tbody>
</table>

12.2  Topic 6 Syllabus

6  Chemical energetics

6.1  Energetics of a reaction

Core
- Describe the meaning of exothermic and endothermic reactions
- Interpret energy level diagrams showing exothermic and endothermic reactions

Supplement
- Describe bond breaking as an endothermic process and bond forming as an exothermic process
- Draw and label energy level diagrams for exothermic and endothermic reactions using data provided
- Calculate the energy of a reaction using bond energies

6.2  Energy transfer

Core
- Describe the release of heat energy by burning fuels
- State the use of hydrogen as a fuel
- Describe radioactive isotopes, such as $^{235}\text{U}$, as a source of energy

Supplement
- Describe the use of hydrogen as a fuel reacting with oxygen to generate electricity in a fuel cell. (Details of the construction and operation of a fuel cell are not required.)
### 12.3 ESSENTIAL Glossary for Keywords for Topic 6

<table>
<thead>
<tr>
<th>Topic #</th>
<th>English</th>
<th>Chinese</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>activation energy (EA) the energy required to start a chemical reaction – for a reaction to take place the colliding particles must possess at least this amount of energy</td>
<td>活化能（EA），用于启动化学反应所需的能量 - 为了发生反应，碰撞的粒子必须至少具有此能量</td>
</tr>
<tr>
<td>6</td>
<td>bond energy the energy required to break a particular type of covalent bond</td>
<td>键能打破特定类型的共价键所需的能量</td>
</tr>
<tr>
<td>6</td>
<td>burning is a combustion reaction which produces a flame</td>
<td>燃烧是产生火焰的燃烧反应</td>
</tr>
<tr>
<td>6</td>
<td>catalyst a substance which increases the rate of a chemical reaction but itself remains unchanged at the end of the reaction</td>
<td>催化剂一种增加化学反应速率但在反应结束时本身保持不变的物质</td>
</tr>
<tr>
<td>6</td>
<td>collision theory a theory which states that a chemical reaction takes place when particles for the reactants collide with sufficient energy to initiate the reaction</td>
<td>碰撞理论一种理论 - 该理论指出，当反应物的颗粒与足够的能量碰撞以引发反应时，就会发生化学反应</td>
</tr>
<tr>
<td>6</td>
<td>combustion a chemical reaction in which a substance reacts with oxygen – the reaction is exothermic;</td>
<td>燃烧一种化学反应 - 其中一种物质与氧气反应 - 该反应是放热的；</td>
</tr>
<tr>
<td>6</td>
<td>endothermic change a process or chemical reaction which takes in heat from the surroundings; ΔH has a positive value</td>
<td>吸热改变从周围吸收热量的过程或化学反应; ΔH为正值</td>
</tr>
<tr>
<td>6</td>
<td>exothermic change a process or chemical reaction in which heat energy is produced and released to the surroundings; ΔH has a negative value</td>
<td>放热的变化过程或化学反应 - 在其中产生热能并释放到周围; ΔH为负值</td>
</tr>
<tr>
<td>6</td>
<td>fuel a substance that can be used as a source of energy, usually by burning (combustion)</td>
<td>燃料通常可以通过燃烧（燃烧）用作能源的物质</td>
</tr>
<tr>
<td>6</td>
<td>fuel cell a device for continuously converting chemical energy into electrical energy using a combustion reaction; a hydrogen fuel cell uses the reaction between hydrogen and oxygen</td>
<td>燃料电池：一种通过燃烧反应将化学能连续转换为电能的装置 - 氢燃料电池利用氢和氧之间的反应</td>
</tr>
<tr>
<td>6</td>
<td>fuel cells are electrolytic cells capable of providing a continuous supply of electricity without recharging</td>
<td>燃料电池是能够连续供电而无需充电的电解电池</td>
</tr>
<tr>
<td>6</td>
<td>heat of combustion the heat change which takes place when one mole of a substance is completely burnt in oxygen</td>
<td>燃烧热 - 当一摩尔物质在氧气中完全燃烧时发生的热变化</td>
</tr>
<tr>
<td>6</td>
<td>heat of reaction the heat change during the course of a reaction; can be either exothermic or endothermic</td>
<td>反应热 - 反应过程中的热变化 - 可以是放热的或吸热的</td>
</tr>
<tr>
<td>6</td>
<td>kinetic (particle) theory a theory which accounts for the bulk properties of the different states of matter in terms of the movement of particles (atoms or molecules) – the theory explains what happens during changes in physical state</td>
<td>动力学（粒子）理论 - 根据粒子（原子或分子）的运动解释物质不同状态的总体性质的理论 - 该理论解释了物理状态变化时发生的情况</td>
</tr>
</tbody>
</table>

### 12.4 ESSENTIAL Classroom Active Learning Tasks 1 Drawing AND Interpreting Graphs for Paper 6

**Q# 4/ iGCSE Chemistry/2017/w/Paper 63/Q2**
A student investigated what happened to the temperature when two different solids, \( W \) and \( X \), dissolved in water.

Two experiments were carried out.

**Experiment 1**

- Using a measuring cylinder, 30 cm\(^2\) of distilled water were poured into a polystyrene cup. The initial temperature of the water was measured at time = 0 seconds.
- Solid \( W \) was added to the water, a timer was started and the solution was stirred with a thermometer.
- The temperature of the solution was measured every 10 seconds for 90 seconds.

(a) Use the thermometer diagrams to record the temperatures in the table.

<table>
<thead>
<tr>
<th>time/s</th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>15</td>
<td>20</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>10</td>
<td>15</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>5</td>
<td>10</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>10</td>
<td>15</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>temperature of the solution / °C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Experiment 2**

- The polystyrene cup was emptied and rinsed with water.
- Experiment 1 was repeated using solid \( X \).
- The temperature of the solution was measured every 10 seconds for 90 seconds.

(b) Use the thermometer diagrams to record the temperatures in the table.

<table>
<thead>
<tr>
<th>time/s</th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>35</td>
<td>35</td>
<td>35</td>
<td>40</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>35</td>
<td>35</td>
<td>35</td>
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<tr>
<td></td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>temperature of the solution / °C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
(c) Plot the results for Experiments 1 and 2 on the grid. Draw two smooth line graphs. Clearly label your lines.

\[ \begin{array}{|c|c|c|c|c|c|c|c|c|c|c|} \hline
\text{time/s} & 0 & 20 & 40 & 60 & 80 & 100 \\
\hline
\text{temperature of the solution/}^\circ\text{C} & 0 & 10 & 20 & 30 & 40 & \ \\
\hline\end{array} \]

(d) (i) From your graph, deduce the temperature of the solution in Experiment 1 after 15 seconds. Show clearly on the grid how you worked out your answer.

\[ \text{..........................}^\circ\text{C} \quad [2] \]

(ii) From your graph, deduce the time taken for the temperature of the solution in Experiment 2 to change by 6 \(^\circ\text{C}\) from the initial temperature. Show clearly on the grid how you worked out your answer.

\[ \text{..........................} \text{s} \quad [2] \]
(e) Use the results to identify the type of energy change that occurs when solid X dissolves in water.

........................................................................................................................................... [1]

(f) Predict the temperature of the solution in Experiment 2 after 1 hour. Explain your answer.

........................................................................................................................................... [1]

(g) State two sources of error in these experiments. Give one improvement to reduce each of these sources of error.

source of error 1 ......................................................................................................................

improvement 1 ......................................................................................................................

source of error 2 ......................................................................................................................

improvement 2 ...................................................................................................................... [4]

(h) When carrying out the experiments, what would be a disadvantage of taking the temperature readings only every 30 seconds?

........................................................................................................................................... [1]
12.5 ESSNETIAL Classroom Active Learning Tasks 2 Endothermic or Exothermic?

Circe or highlight if these processes are either exothermic or endothermic. The first has already been done for you.

Q#1/ Exothermic or Endothermic?

Q#2/ Boiling water

Q#3/ Evaporation

Q#4/ Exothermic or Endothermic?

Q#5/ Surroundings

Q#6/ Exothermic or Endothermic?

Q#7/ Exothermic or Endothermic?

Q#8/ Exothermic or Endothermic?
Q# 9/ Exothermic or Endothermic

Q# 10/ Exothermic or Endothermic?

Q# 11/ Exothermic or Endothermic?

Q# 12/ Exothermic or Endothermic?

Q# 13/ Exothermic or Endothermic?

Q# 14/ Exothermic or Endothermic?

Q# 15/ Exothermic or Endothermic?

Q# 16/ Exothermic or Endothermic?

Q# 17/ CaCO\_3(s) \rightarrow \text{Heat} \rightarrow CaO(s) + CO\_2(g)

Exothermic or Endothermic?

Q# 18/ Acid + Alkali \rightarrow \text{Salt} + \text{Water}

Exothermic or Endothermic?

Q# 19/ Br\_2(l) \rightarrow Br\_2(s)

Exothermic or Endothermic?

Q# 20/ Sulfuric acid \rightarrow \text{Sodium sulfate} + \text{Sodium hydroxide} + \text{Water}

Exothermic or Endothermic?

Q# 21/ N\_2(g) \rightarrow 2N(g)

Exothermic or Endothermic?

Q# 22/ Hg(l) \rightarrow Hg(g)

Exothermic or Endothermic?

Q# 23/ I\_2(s) \rightarrow I\_2(g)

Exothermic or Endothermic?

Q# 24/ Photosynthesis

Exothermic or Endothermic?
**Extension Activity**: Name the reaction that is being shown, if it could be more than one reaction, name a reaction it could be and try to include the chemical formula

<table>
<thead>
<tr>
<th>Q#</th>
<th>Endo/Exo?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q#1</td>
<td>Exo</td>
</tr>
<tr>
<td>Q#2</td>
<td>Endo</td>
</tr>
<tr>
<td>Q#3</td>
<td>Endo</td>
</tr>
<tr>
<td>Q#4</td>
<td>Endo</td>
</tr>
<tr>
<td>Q#5</td>
<td>Exo</td>
</tr>
<tr>
<td>Q#6</td>
<td>Exo</td>
</tr>
<tr>
<td>Q#7</td>
<td>Endo</td>
</tr>
<tr>
<td>Q#8</td>
<td>Exo</td>
</tr>
<tr>
<td>Q#9</td>
<td>Endo</td>
</tr>
<tr>
<td>Q#10</td>
<td>Exo</td>
</tr>
<tr>
<td>Q#11</td>
<td>Endo</td>
</tr>
<tr>
<td>Q#12</td>
<td>Exo</td>
</tr>
<tr>
<td>Q#13</td>
<td>Exo</td>
</tr>
<tr>
<td>Q#14</td>
<td>Exo</td>
</tr>
<tr>
<td>Q#15</td>
<td>Endo</td>
</tr>
<tr>
<td>Q#16</td>
<td>Exo</td>
</tr>
<tr>
<td>Q#17</td>
<td>Exo</td>
</tr>
<tr>
<td>Q#18</td>
<td>Endo</td>
</tr>
<tr>
<td>Q#19</td>
<td>Endo</td>
</tr>
<tr>
<td>Q#20</td>
<td>Exo</td>
</tr>
<tr>
<td>Q#21</td>
<td>Exo</td>
</tr>
<tr>
<td>Q#22</td>
<td>Endo</td>
</tr>
<tr>
<td>Q#23</td>
<td>Endo</td>
</tr>
<tr>
<td>Q#24</td>
<td>Exo</td>
</tr>
<tr>
<td>Q#25</td>
<td>Exo</td>
</tr>
</tbody>
</table>

**12.6 ESSENTIAL EXAM QUESTIONS Topic 6 Paper 2 31marks Mark Scheme**

**Q# 1/ IGCSE Chemistry/2018/m/Paper 22/**

12. 10 g of ammonium nitrate is added to water at 25°C and the mixture stirred.

The ammonium nitrate dissolves and, after one minute, the temperature of the solution is 10°C.

Which word describes this change?

A  endothermic  
B  exothermic  
C  neutralisation  
D  reduction

13. Hydrogen reacts with chlorine according to the following equation.

\[ \text{H}_2(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow 2\text{HCl}(\text{g}) \]

The reaction is exothermic.

Which statement about this reaction is correct?

A  Energy absorbed for bond breaking is greater than the energy released in bond making.  
B  Energy absorbed for bond breaking is less than the energy released in bond making.  
C  Energy released in bond breaking is greater than the energy absorbed in bond making.  
D  Energy released in bond breaking is less than the energy absorbed in bond making.

14. Hydrogen-oxygen fuel cells can be used to power cars. Platinum is used as a catalyst.

The amount of energy produced per gram is shown for three fuels.

<table>
<thead>
<tr>
<th>fuel</th>
<th>energy produced per g of fuel /kJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>hydrogen</td>
<td>143</td>
</tr>
<tr>
<td>methane</td>
<td>55</td>
</tr>
<tr>
<td>petrol</td>
<td>44</td>
</tr>
</tbody>
</table>
Which statement is correct and is an advantage of a hydrogen-oxygen fuel cell?

A. Hydrogen is difficult to store.
B. Hydrogen produces less energy per gram than methane or petrol.
C. Platinum is rare and expensive.
D. The only product is water.

Q# 2/ IGCSE Chemistry/2017/w/Paper 23/

11 Some bond energies are shown in the table.

<table>
<thead>
<tr>
<th>bond</th>
<th>bond energy in kJ/mol</th>
</tr>
</thead>
<tbody>
<tr>
<td>H–H</td>
<td>+436</td>
</tr>
<tr>
<td>O=O</td>
<td>+496</td>
</tr>
<tr>
<td>H–O</td>
<td>+460</td>
</tr>
</tbody>
</table>

Hydrogen reacts with oxygen. The reaction is exothermic.

\[2\text{H}_2(g) + \text{O}_2(g) \rightarrow 2\text{H}_2\text{O}(g)\]

What is the energy change for the reaction?

A. \(-3208\) kJ/mol
B. \(-808\) kJ/mol
C. \(-472\) kJ/mol
D. \(-448\) kJ/mol

Q# 3/ IGCSE Chemistry/2017/w/Paper 22/

11 The equation for the combustion of methane is shown.

\[\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}\]

The energy change for the combustion of methane is \(-890\) kJ/mol.

The bond energies are shown in the table.

<table>
<thead>
<tr>
<th>bond</th>
<th>bond energy in kJ/mol</th>
</tr>
</thead>
<tbody>
<tr>
<td>C–H</td>
<td>+410</td>
</tr>
<tr>
<td>O=O</td>
<td>+496</td>
</tr>
<tr>
<td>H–O</td>
<td>+460</td>
</tr>
</tbody>
</table>

What is the bond energy of the C=O bond?

A. +49 kJ/mol  B. +841 kJ/mol  C. +1301 kJ/mol  D. +1335 kJ/mol
11 The compound hydrazine is used as a rocket fuel. It has the structural formula shown.

\[
\begin{array}{c}
\text{N} \\
\text{H} \\
\text{H} \\
\text{N} \\
\text{H} \\
\end{array}
\]

One of the reactions of hydrazine is shown. This reaction is exothermic.

\[
\text{N}_2\text{H}_4 \rightarrow \text{N}_2 + 2\text{H}_2
\]

The bond energies are shown in the table.

<table>
<thead>
<tr>
<th>Bond</th>
<th>Bond Energy in kJ/mol</th>
</tr>
</thead>
<tbody>
<tr>
<td>H–H</td>
<td>+436</td>
</tr>
<tr>
<td>N–H</td>
<td>+390</td>
</tr>
<tr>
<td>N–N</td>
<td>+160</td>
</tr>
<tr>
<td>N≡N</td>
<td>+945</td>
</tr>
</tbody>
</table>

What is the energy change for this reaction?

A. $-339 \text{ kJ/mol}$  
B. $-97 \text{ kJ/mol}$  
C. $+97 \text{ kJ/mol}$  
D. $+339 \text{ kJ/mol}$

12 Which statement describes an exothermic reaction?

A. The energy absorbed for bond breaking is greater than the energy released by bond formation.

B. The energy absorbed for bond breaking is less than the energy released by bond formation.

C. The energy released by bond breaking is greater than the energy absorbed for bond formation.

D. The energy released by bond breaking is less than the energy absorbed for bond formation.

Q# 5/ IGCSE Chemistry/2017/s/Paper 23/

11 Heat energy is produced when hydrocarbons burn in air.

Which equations represent this statement?

1. $\text{C}_2\text{H}_5\text{OH} + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 3\text{H}_2\text{O}$
2. $\text{C}_2\text{H}_4 + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 2\text{H}_2\text{O}$
3. $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$

A. 1, 2 and 3  
B. 1 and 2 only  
C. 1 and 3 only  
D. 2 and 3 only
13 Hydrogen and chlorine react to form hydrogen chloride. The reaction is exothermic.

\[ \text{H}_2(g) + \text{Cl}_2(g) \rightarrow 2\text{HCl}(g) \]

The overall energy change for this reaction is \(-184\text{ kJ/mol}\).

The table gives some of the bond energies involved.

<table>
<thead>
<tr>
<th>bond</th>
<th>bond energy in kJ/mol</th>
</tr>
</thead>
<tbody>
<tr>
<td>H–Cl</td>
<td>+430</td>
</tr>
<tr>
<td>H–H</td>
<td>+436</td>
</tr>
</tbody>
</table>

What is the energy of the Cl–Cl bond?

A \(-240\text{ kJ/mol}\)
B \(-190\text{ kJ/mol}\)
C \(+190\text{ kJ/mol}\)
D \(+240\text{ kJ/mol}\)

Q# 6/ IGCSE Chemistry/2017/s/Paper 22/

11 Which statement about fuels is correct?

A Heat energy can only be produced by burning fuels.
B Hydrogen is used as a fuel although it is difficult to store.
C Methane is a good fuel because it produces only water when burned.
D Uranium is burned in air to produce energy.

13 The equation for the reaction between hydrogen and chlorine is shown.

\[ \text{H}_2(g) + \text{Cl}_2(g) \rightarrow 2\text{HCl}(g) \]

The reaction is exothermic.

The bond energies are shown in the table.

<table>
<thead>
<tr>
<th>bond</th>
<th>bond energy in kJ/mol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cl–Cl</td>
<td>+240</td>
</tr>
<tr>
<td>H–Cl</td>
<td>+430</td>
</tr>
<tr>
<td>H–H</td>
<td>+436</td>
</tr>
</tbody>
</table>
What is the energy change for the reaction?

A  $-1536 \text{kJ/mol}$
B  $-184 \text{kJ/mol}$
C  $+184 \text{kJ/mol}$
D  $+246 \text{kJ/mol}$

**Q# 7/ IGCSE Chemistry/2017/s/Paper 21/**

11 Some properties of four fuels are shown in the table.

Which fuel is a gas at room temperature and makes two products when it burns in a plentiful supply of air?

<table>
<thead>
<tr>
<th></th>
<th>fuel</th>
<th>formula</th>
<th>melting point /°C</th>
<th>boiling point /°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>hydrogen</td>
<td>H₂</td>
<td>-259</td>
<td>-253</td>
</tr>
<tr>
<td>B</td>
<td>methane</td>
<td>CH₄</td>
<td>-182</td>
<td>-164</td>
</tr>
<tr>
<td>C</td>
<td>octane</td>
<td>C₈H₁₈</td>
<td>-57</td>
<td>126</td>
</tr>
<tr>
<td>D</td>
<td>wax</td>
<td>C₃H₆₄</td>
<td>60</td>
<td>400</td>
</tr>
</tbody>
</table>

12 Which statements about exothermic and endothermic reactions are correct?

1. During an exothermic reaction, heat is given out.
2. The temperature of an endothermic reaction goes up because heat is taken in.
3. Burning methane in the air is an exothermic reaction.

A  1, 2 and 3    B  1 and 2 only    C  1 and 3 only    D  2 and 3 only

13 Chlorine reacts with ethane to produce chloroethane and hydrogen chloride.

\[
\text{H} \quad \text{H} \quad \text{C} \quad \text{H} + \text{Cl} \quad \text{Cl} \rightarrow \text{H} \quad \text{H} \quad \text{C} \quad \text{C} \quad \text{Cl} + \text{H} \quad \text{Cl} \\
\text{H} \quad \text{H} \\
\text{H} \quad \text{H}
\]

The reaction is exothermic.

The bond energies are shown in the table.

<table>
<thead>
<tr>
<th>bond</th>
<th>bond energy in kJ/mol</th>
</tr>
</thead>
<tbody>
<tr>
<td>C–Cl</td>
<td>+340</td>
</tr>
<tr>
<td>C–C</td>
<td>+350</td>
</tr>
<tr>
<td>C–H</td>
<td>+410</td>
</tr>
<tr>
<td>Cl–Cl</td>
<td>+240</td>
</tr>
<tr>
<td>H–Cl</td>
<td>+430</td>
</tr>
</tbody>
</table>
What is the energy change for the reaction?

A  $-1420 \text{ kJ/mol}$
B  $-120 \text{ kJ/mol}$
C  $+120 \text{ kJ/mol}$
D  $+1420 \text{ kJ/mol}$

Q#8/ IGCSE Chemistry/2017/m/Paper 22/

12 Ammonia is made by reacting nitrogen with hydrogen in the presence of an iron catalyst. The reaction is exothermic.

The equation for the reaction is shown.

$$\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$$

The bond energies are shown in the table.

<table>
<thead>
<tr>
<th>bond</th>
<th>bond energy in kJ/mol</th>
</tr>
</thead>
<tbody>
<tr>
<td>H–H</td>
<td>436</td>
</tr>
<tr>
<td>N–H</td>
<td>390</td>
</tr>
<tr>
<td>N≡N</td>
<td>945</td>
</tr>
</tbody>
</table>

What is the energy given out during this reaction?

A  $-4593 \text{ kJ/mol}$  B  $-1083 \text{ kJ/mol}$  C  $-959 \text{ kJ/mol}$  D  $-87 \text{ kJ/mol}$

13 The energy level diagram for the reaction between P and Q to form R and S is shown.

Which row describes the energy changes involved and the type of reaction?

<table>
<thead>
<tr>
<th></th>
<th>energy changes involved</th>
<th>type of reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>more energy is given out when the bonds in the products are formed than is needed to break the bonds in the reactants</td>
<td>endothermic</td>
</tr>
<tr>
<td>B</td>
<td>more energy is given out when the bonds in the products are formed than is needed to break the bonds in the reactants</td>
<td>exothermic</td>
</tr>
<tr>
<td>C</td>
<td>more energy is needed to break the bonds in the reactants than is given out when the bonds in the products are formed</td>
<td>endothermic</td>
</tr>
<tr>
<td>D</td>
<td>more energy is needed to break the bonds in the reactants than is given out when the bonds in the products are formed</td>
<td>exothermic</td>
</tr>
</tbody>
</table>
Q# 9/ IGCSE Chemistry/2016/w/Paper 23/
12 10g of ammonium nitrate are added to water at 25°C and the mixture stirred. The ammonium nitrate dissolves and, after one minute, the temperature of the solution is 10°C.

Which word describes this change?
A endothermic
B exothermic
C neutralisation
D reduction

Q# 10/ IGCSE Chemistry/2016/w/Paper 22/
12 The energy level diagram for a reaction is shown.

Which row is correct?

<table>
<thead>
<tr>
<th></th>
<th>sign of $\Delta H$</th>
<th>overall energy change</th>
<th>sign of $E_a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$-$</td>
<td>exothermic</td>
<td>$-$</td>
</tr>
<tr>
<td>B</td>
<td>$+$</td>
<td>endothermic</td>
<td>$+$</td>
</tr>
<tr>
<td>C</td>
<td>$+$</td>
<td>endothermic</td>
<td>$-$</td>
</tr>
<tr>
<td>D</td>
<td>$+$</td>
<td>exothermic</td>
<td>$+$</td>
</tr>
</tbody>
</table>

Q# 10/ IGCSE Chemistry/2016/w/Paper 22/
12 Which experiment is the most exothermic?

<table>
<thead>
<tr>
<th></th>
<th>initial temperature / °C</th>
<th>final temperature / °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>B</td>
<td>20</td>
<td>32</td>
</tr>
<tr>
<td>C</td>
<td>25</td>
<td>12</td>
</tr>
<tr>
<td>D</td>
<td>25</td>
<td>34</td>
</tr>
</tbody>
</table>
13 The energy level diagram for a reaction is shown.

Which row is correct?

<table>
<thead>
<tr>
<th></th>
<th>sign of $\Delta H$</th>
<th>overall energy change</th>
<th>sign of $E_a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>–</td>
<td>exothermic</td>
<td>–</td>
</tr>
<tr>
<td>B</td>
<td>+</td>
<td>endothermic</td>
<td>+</td>
</tr>
<tr>
<td>C</td>
<td>+</td>
<td>endothermic</td>
<td>–</td>
</tr>
<tr>
<td>D</td>
<td>–</td>
<td>exothermic</td>
<td>+</td>
</tr>
</tbody>
</table>

Q# 11/ iGCSE Chemistry/2016/w/Paper 21/

12 When anhydrous copper(II) sulfate is added to water a solution is formed and heat is given out.

Which row shows the temperature change and the type of reaction taking place?

<table>
<thead>
<tr>
<th></th>
<th>temperature change</th>
<th>type of reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>decrease</td>
<td>endothermic</td>
</tr>
<tr>
<td>B</td>
<td>decrease</td>
<td>exothermic</td>
</tr>
<tr>
<td>C</td>
<td>increase</td>
<td>endothermic</td>
</tr>
<tr>
<td>D</td>
<td>increase</td>
<td>exothermic</td>
</tr>
</tbody>
</table>
13 Hydrazine, $\text{N}_2\text{H}_4$, decomposes as shown.

\[
\begin{array}{c}
\text{N} \quad \text{N} \\
\text{H} \quad \text{H} \\
\end{array} \quad \rightarrow \quad \begin{array}{c}
\text{N} \equiv \text{N} \\
\text{H} \quad \text{H}
\end{array} + 2 \text{H} \equiv \text{H}
\]

The energy change for this reaction is $-95\,\text{kJ/mol}$.

The table shows some bond energies involved.

<table>
<thead>
<tr>
<th>bond</th>
<th>bond energy in kJ/mol</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{N} \equiv \text{N}$</td>
<td>945</td>
</tr>
<tr>
<td>$\text{N} \equiv \text{H}$</td>
<td>391</td>
</tr>
<tr>
<td>$\text{H} \equiv \text{H}$</td>
<td>436</td>
</tr>
</tbody>
</table>

What is the bond energy of the $\text{N} \equiv \text{N}$ bond?

A 158$\,\text{kJ/mol}$  B 315$\,\text{kJ/mol}$  C 348$\,\text{kJ/mol}$  D 895$\,\text{kJ/mol}$

13 The energy level diagram for the combustion of methane is shown.

\[
\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g})
\]

Which row gives the equation and energy change for this reaction?

<table>
<thead>
<tr>
<th></th>
<th>equation</th>
<th>energy change in kJ/mol</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g})$</td>
<td>$+891$</td>
</tr>
<tr>
<td>B</td>
<td>$\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g})$</td>
<td>$-891$</td>
</tr>
<tr>
<td>C</td>
<td>$\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l})$</td>
<td>$+891$</td>
</tr>
<tr>
<td>D</td>
<td>$\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l})$</td>
<td>$-891$</td>
</tr>
</tbody>
</table>
Q# 14/ iGCSE Chemistry/2016/s/Paper 21/
11. The diagram shows some properties that substances may have.
   
   To which labelled part of the diagram does $^{235}$U belong?

   ![Diagram]

   A. compound
   B. used as an energy source
   C. radioactive

Q# 15/ iGCSE Chemistry/2016/m/Paper 22/
12. Which substance could **not** be used as a fuel to heat water in a boiler?

   A. ethanol
   B. hydrogen
   C. methane
   D. oxygen

   
   The equation for the reaction is:

   $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$

   The table shows the bond energies involved.

<table>
<thead>
<tr>
<th>bond</th>
<th>bond energy in kJ/mol</th>
</tr>
</thead>
<tbody>
<tr>
<td>H–H</td>
<td>436</td>
</tr>
<tr>
<td>O=O</td>
<td>498</td>
</tr>
<tr>
<td>O–H</td>
<td>464</td>
</tr>
</tbody>
</table>

   What is the energy given out during the reaction?

   A. $-3226$ kJ/mol
   B. $-884$ kJ/mol
   C. $-486$ kJ/mol
   D. $-442$ kJ/mol
13. Which row describes an endothermic reaction?

<table>
<thead>
<tr>
<th></th>
<th>energy needed to break bonds /kJ</th>
<th>energy released by forming bonds /kJ</th>
<th>temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>400</td>
<td>200</td>
<td>decreases</td>
</tr>
<tr>
<td>B</td>
<td>400</td>
<td>800</td>
<td>decreases</td>
</tr>
<tr>
<td>C</td>
<td>600</td>
<td>200</td>
<td>increases</td>
</tr>
<tr>
<td>D</td>
<td>600</td>
<td>800</td>
<td>increases</td>
</tr>
</tbody>
</table>

12.6.1 ESSENTIAL EXAM QUESTIONS Topic 6 Paper 2 31 marks Mark Scheme

Q# 1/ iGCSE Chemistry/2018/m/Paper 22/

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>A</td>
</tr>
<tr>
<td>13</td>
<td>B</td>
</tr>
<tr>
<td>14</td>
<td>D</td>
</tr>
</tbody>
</table>

Q# 2/ iGCSE Chemistry/2017/w/Paper 23/

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>11</td>
<td>C</td>
</tr>
</tbody>
</table>

Q# 3/ iGCSE Chemistry/2017/w/Paper 22/

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>11</td>
<td>B</td>
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<tr>
<td>12</td>
<td>B</td>
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</table>

Q# 4/ iGCSE Chemistry/2017/w/Paper 21/

<p>| | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>11</td>
<td>B</td>
</tr>
<tr>
<td>12</td>
<td>B</td>
</tr>
</tbody>
</table>

Q# 5/ iGCSE Chemistry/2017/s/Paper 23/

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>D</td>
</tr>
<tr>
<td>13</td>
<td>D</td>
</tr>
</tbody>
</table>

Q# 6/ iGCSE Chemistry/2017/s/Paper 22/

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>B</td>
</tr>
<tr>
<td>12</td>
<td>C</td>
</tr>
<tr>
<td>13</td>
<td>B</td>
</tr>
</tbody>
</table>

Q# 7/ iGCSE Chemistry/2017/s/Paper 21/

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>B</td>
</tr>
<tr>
<td>12</td>
<td>C</td>
</tr>
<tr>
<td>13</td>
<td>B</td>
</tr>
</tbody>
</table>

Q# 8/ iGCSE Chemistry/2017/m/Paper 22/

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>D</td>
</tr>
<tr>
<td>13</td>
<td>B</td>
</tr>
</tbody>
</table>

Q# 9/ iGCSE Chemistry/2016/w/Paper 23/

<p>| | |</p>
<table>
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</thead>
<tbody>
<tr>
<td>12</td>
<td>A</td>
</tr>
<tr>
<td>13</td>
<td>B</td>
</tr>
</tbody>
</table>

Q# 10/ iGCSE Chemistry/2016/w/Paper 22/

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>B</td>
</tr>
<tr>
<td>13</td>
<td>D</td>
</tr>
</tbody>
</table>

Q# 11/ iGCSE Chemistry/2016/w/Paper 21/

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>D</td>
</tr>
</tbody>
</table>

Q# 12/ iGCSE Chemistry/2016/s/Paper 23/

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>A</td>
</tr>
</tbody>
</table>

Q# 13/ iGCSE Chemistry/2016/s/Paper 22/

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>B</td>
</tr>
</tbody>
</table>

Q# 14/ iGCSE Chemistry/2016/s/Paper 21/

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>D</td>
</tr>
<tr>
<td>13</td>
<td>C</td>
</tr>
</tbody>
</table>

Q# 15/ iGCSE Chemistry/2016/m/Paper 22/

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>D</td>
</tr>
<tr>
<td>13</td>
<td>A</td>
</tr>
</tbody>
</table>
ESSENTIAL EXAM QUESTIONS T6 Paper 3/4 29marks

Q# 1/ IGCSE Chemistry/2013/w/Paper 31/ Q7

(b) Bond forming is exothermic, bond breaking is endothermic. Explain the difference between an exothermic reaction and an endothermic reaction.

................................................................................................................................................................................................. [2]

(c) Use the bond energies to show that the following reaction is exothermic.
Bond energy is the amount of energy (kJ/mol) which must be supplied to break one mole of the bond.

\[
\text{H} - \text{C} - \text{H} + \text{Cl} - \text{Cl} \rightarrow \text{H} - \text{C} - \text{Cl} + \text{H} - \text{Cl}
\]

Bond energies in kJ/mol

<table>
<thead>
<tr>
<th>Bond</th>
<th>Energy (kJ/mol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cl-Cl</td>
<td>+242</td>
</tr>
<tr>
<td>C-Cl</td>
<td>+338</td>
</tr>
<tr>
<td>C-H</td>
<td>+412</td>
</tr>
<tr>
<td>H-Cl</td>
<td>+431</td>
</tr>
</tbody>
</table>

bonds broken energy in kJ/mol

.................................................................................................................................................................................................

.................................................................................................................................................................................................

total energy = ........................................

bonds formed energy in kJ/mol

.................................................................................................................................................................................................

.................................................................................................................................................................................................

total energy = ........................................
Q# 2/ IGCSE Chemistry/2011/s/Paper 31/ Q5

(d) 20.0 cm³ of aqueous sodium hydroxide, 2.00 mol/dm³, was placed in a beaker. The temperature of the alkali was measured and 1.0 cm³ portions of hydroiodic acid were added. After each addition, the temperature of the mixture was measured. Typical results are shown on the graph.

\[
\text{temperature} \quad \begin{array}{c|c}
18.0 \text{cm}^3 & \text{volume of acid added} \\
\end{array}
\]

\[
\text{NaOH(aq) + HI(aq) \rightarrow NaI(aq) + H}_2\text{O(l)}
\]

(i) Explain why the temperature increases rapidly at first then stops increasing.

(ii) Suggest why the temperature drops after the addition of 18.0 cm³ of acid.

Q# 3/ IGCSE Chemistry/2009/s/Paper 31/

7 Hydrogen reacts with the halogens to form hydrogen halides.

(a) Bond energy is the amount of energy, in kJ, that must be supplied (endothermic) to break one mole of a bond.

<table>
<thead>
<tr>
<th>bond</th>
<th>bond energy in kJ/mol</th>
</tr>
</thead>
<tbody>
<tr>
<td>H−H</td>
<td>+436</td>
</tr>
<tr>
<td>C−C</td>
<td>+242</td>
</tr>
<tr>
<td>H−C</td>
<td>+431</td>
</tr>
</tbody>
</table>

Use the above data to show that the following reaction is exothermic.

\[
\text{H−H} + \text{Cl−Cl} \rightarrow 2\text{H−Cl}
\]
6 (a) Exothermic reactions produce heat energy.

An important fuel is methane, natural gas. The equation for its combustion is as follows.

$$\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$$

(i) In chemical reactions bonds are broken and new bonds are formed. Using this reaction give an example of

a bond that is broken. .................................................................................................................. [2]

a bond that is formed. .................................................................................................................. [2]

(ii) Explain, using the idea of bonds forming and breaking, why this reaction is exothermic, that is it produces heat energy.

.................................................................................................................................................. [2]

(b) Some radioactive isotopes are used as nuclear fuels.

(i) Give the symbol and the nucleon number of an isotope that is used as a nuclear fuel.

.................................................................................................................................................. [2]

Q# 5/ IGCSE Chemistry/2005/w/Paper 3/ Q7

7 In 1909, Haber discovered that nitrogen and hydrogen would react to form ammonia. The yield of ammonia was 8%.

$$\text{N}_2 (g) + 3\text{H}_2 (g) \xrightarrow{\text{catalyst platinum}} 2\text{NH}_3 (g)$$ the forward reaction is exothermic
catalyst platinum
temperature 600 °C
pressure 200 atm

(c) (i) Complete the following table that describes the bond breaking and forming in the reaction between nitrogen and hydrogen to form ammonia.

<table>
<thead>
<tr>
<th>bonds</th>
<th>energy change /kJ</th>
<th>exothermic or endothermic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 mole of N ≡ N broken</td>
<td>+945</td>
<td>..............................................</td>
</tr>
</tbody>
</table>
(ii) Explain, using the above data, why the forward reaction is exothermic.

.......................................................................................................................... [2]

Q# 6/ iGCSE Chemistry/2004/s/Paper 3/
1 It was reported from America that a turbine engine, the size of a button, might replace batteries. The engine would be built from silicon which has suitable properties for this purpose.

(a) (i) Why are batteries a convenient source of energy?

.......................................................................................................................... [1]

(ii) The engine will run on a small pack of jet fuel. What other chemical is needed to burn this fuel?

.......................................................................................................................... [1]

Q# 7/ iGCSE Chemistry/2003/s/Paper 3/Q5
(f) The reactions of these metals with oxygen are exothermic.

\[ 2\text{Ba}(s) + \text{O}_2(g) \rightarrow 2\text{BaO}(s) \]

(i) Give an example of bond forming in this reaction.

..........................................................................................................................

(ii) Explain using the idea of bond breaking and forming why this reaction is exothermic.

..........................................................................................................................[3]

12.7.1 ESSENTIAL EXAM QUESTIONS Paper 2 29marks Mark Scheme

Q# 1/ iGCSE Chemistry/2013/w/Paper 31/ Q7
(b) exothermic reaction gives out energy endothermic reaction absorbs takes in energy

.......................................................................................................................... [1]

(c) bonds broken energy
   C-H     +412
   Cl-Cl    +242
   total energy +654

   bonds formed energy
   C-Cl     -338
   H-Cl     -431
   total energy -769
   energy change -115
   negative sign indicates exothermic

.......................................................................................................................... [1]

Q# 2/ iGCSE Chemistry/2011/s/Paper 31/ Q5
(d) (i) the reaction is exothermic / reaction produces heat/energy
all the sodium hydroxide used up/neutralised / reaction has stopped

(ii) adding colder acid / no more heat produced
if not given in (d)(i) any comments such as “reaction has stopped” can gain mark

Q# 3/ IGCSE Chemistry/2009/s/Paper 31/

7 (a) (total endothermic change = 436 + 242 = +)678 kJ
(total exothermic change = 2 x 431 = –)862 kJ
accept correct sign/supplied/absorbed for endo etc.
accept correct sign/evolved/produced for exo etc.
change for reaction = –184 kJ
not necessary to calculate –184, just show that exo change > than endo ecf allowed provided negative
–184 kJ scores all 3 marks

Q# 4/ IGCSE Chemistry/2006/s/Paper 3/

6 (a) (i) Any bond that is broken C-H or O=O
Bond that is formed C=O or O-H
Do not insist on double bonds

(ii) More energy is released forming bonds
than is used breaking bonds
For just - more energy released than used [1]
For - energy is released forming bonds and it is used
breaking bonds [1]

(b) (i) U
235

Q# 5/ IGCSE Chemistry/2005/w/Paper 3/ Q7

c(i) H—H
endothermic
exothermic

(ii) More heat given out than taken in [1]
–2328 + 945 + 1308 = –75(kJ) [1]

OR More heat given out bond forming than taken in bond breaking [2]
Must mention bond breaking and forming [2]

Q# 6/ IGCSE Chemistry/2004/s/Paper 3/

1. (a) (i) portable [1]

(ii) oxygen or air [1]

Q# 7/ IGCSE Chemistry/2003/s/Paper 3/Q5

(f) (i) barium - oxygen or ionic
(ii) bond forming energy released/exothermic
bond breaking energy taken in/endothermic
more energy released [1]
12.8 ESSENTIAL EXAM QUESTIONS Topic 6 Paper 6 75marks

Most of the exam questions on this topic will be found in Paper 6 and relate to drawing graphs using them to get data from the trend line and explaining what they are showing.

Q# 2/ iGCSE Chemistry/2018/S/Paper 63/Q2

2 A student investigated how the temperature changed when aqueous sodium hydroxide reacted with solutions of two different acids, acid R and acid S.

Two experiments were done.

Experiment 1

- A measuring cylinder was used to pour 50 cm³ of aqueous sodium hydroxide into a polystyrene cup. The temperature of the solution was measured.
- A burette was filled up to the 0.0 cm³ mark with acid R.
- 5.0 cm³ of acid R was added to the aqueous sodium hydroxide in the polystyrene cup and the solution stirred.
- The highest temperature of the solution was measured.
- A further 5.0 cm³ of acid R was added to the polystyrene cup and the solution was stirred.
- The highest temperature of the solution was measured.
- Further 5.0 cm³ portions of acid R were added to the polystyrene cup until a total volume of 40.0 cm³ of acid R had been added. The highest temperature of the solution was measured after each addition.

(a) Use the thermometer diagrams to record the results in the table.

<table>
<thead>
<tr>
<th>volume of acid R added/cm³</th>
<th>thermometer diagram</th>
<th>highest temperature of the solution/°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td><img src="image" alt="Thermometer1" /></td>
<td>30</td>
</tr>
<tr>
<td>10.0</td>
<td><img src="image" alt="Thermometer2" /></td>
<td>30</td>
</tr>
<tr>
<td>15.0</td>
<td><img src="image" alt="Thermometer3" /></td>
<td>30</td>
</tr>
<tr>
<td>20.0</td>
<td><img src="image" alt="Thermometer4" /></td>
<td>30</td>
</tr>
</tbody>
</table>
(b) Plot the results for Experiment 1 on the grid and draw two intersecting straight line graphs.
Experiment 2

- The burette was rinsed with distilled water and then with acid S.
- Experiment 1 was repeated but using acid S instead of acid R.

(c) Use the thermometer diagrams to record the results in the table.

<table>
<thead>
<tr>
<th>volume of acid S added / cm³</th>
<th>thermometer diagram</th>
<th>highest temperature of the solution / °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td><img src="image" alt="Thermometer Diagram" /></td>
<td>20</td>
</tr>
<tr>
<td>5.0</td>
<td><img src="image" alt="Thermometer Diagram" /></td>
<td>25</td>
</tr>
<tr>
<td>10.0</td>
<td><img src="image" alt="Thermometer Diagram" /></td>
<td>30</td>
</tr>
<tr>
<td>15.0</td>
<td><img src="image" alt="Thermometer Diagram" /></td>
<td>35</td>
</tr>
<tr>
<td>20.0</td>
<td><img src="image" alt="Thermometer Diagram" /></td>
<td>40</td>
</tr>
<tr>
<td>25.0</td>
<td><img src="image" alt="Thermometer Diagram" /></td>
<td>30</td>
</tr>
<tr>
<td>30.0</td>
<td><img src="image" alt="Thermometer Diagram" /></td>
<td>25</td>
</tr>
<tr>
<td>35.0</td>
<td><img src="image" alt="Thermometer Diagram" /></td>
<td>20</td>
</tr>
<tr>
<td>40.0</td>
<td><img src="image" alt="Thermometer Diagram" /></td>
<td>30</td>
</tr>
</tbody>
</table>
(d) Plot the results for Experiment 2 on the grid and draw **two** intersecting straight line graphs.

![Graph](image)

(e)  

(i) **Use your graph** to estimate the volume of acid S which must be added to neutralise 50 cm³ of aqueous sodium hydroxide.  

Show clearly **on the grid** how you worked out your answer.

........................................... cm³  [2]

(ii) Suggest how the volume in (e)(i) would differ if the experiment were repeated using 25 cm³ instead of 50 cm³ of aqueous sodium hydroxide.  

Explain your answer.

........................................................................................................................................

........................................................................................................................................  [2]

(f) **What type of energy change occurs when acid S reacts with aqueous sodium hydroxide?**

........................................................................................................................................  [1]
(g) (i) In Experiment 2, why was the burette rinsed with distilled water?

[1]

(ii) Why was the burette then rinsed with acid S?

[1]

(h) Describe one source of error in Experiment 2. Suggest an improvement to reduce this source of error.

source of error

improvement

[2]

Q# 3/ IGCSE Chemistry/2018/s/Paper 62/Q2

2 A student investigated the temperature changes when two different solids, solid C and solid D, dissolved in water.

Two experiments were done.

Experiment 1

- Using a measuring cylinder, 40 cm$^3$ of distilled water was poured into a polystyrene cup. The initial temperature of the distilled water was measured.
- 3 g of solid C was added to the polystyrene cup and the mixture was stirred with a thermometer. The temperature of the solution was measured after 1 minute.
- The procedure was repeated using 4 g of solid C.
- The procedure was repeated using 6 g of solid C.

(a) Use the thermometer diagrams to record the results in the table.

Calculate and record the temperature change in each case, including whether the temperature increased (+) or decreased (−).

<table>
<thead>
<tr>
<th>mass of solid C/g</th>
<th>thermometer diagram</th>
<th>initial temperature of the distilled water/°C</th>
<th>thermometer diagram</th>
<th>temperature of the solution after 1 min/°C</th>
<th>temperature change/°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td><img src="30" alt="Thermometer Diagram" /></td>
<td><img src="25" alt="Thermometer Diagram" /></td>
<td><img src="20" alt="Thermometer Diagram" /></td>
<td><img src="20" alt="Thermometer Diagram" /></td>
<td><img src="15" alt="Thermometer Diagram" /></td>
</tr>
<tr>
<td>4</td>
<td><img src="30" alt="Thermometer Diagram" /></td>
<td><img src="25" alt="Thermometer Diagram" /></td>
<td><img src="20" alt="Thermometer Diagram" /></td>
<td><img src="20" alt="Thermometer Diagram" /></td>
<td><img src="15" alt="Thermometer Diagram" /></td>
</tr>
</tbody>
</table>
Experiment 2

- Experiment 1 was repeated but using 3 g, 4 g, 6 g and 8 g of solid D.

(b) Use the thermometer diagrams to record the results in the table.

Calculate and record the temperature change in each case, including whether the temperature increased (+) or decreased (−).

<table>
<thead>
<tr>
<th>mass of solid D/g</th>
<th>thermometer diagram</th>
<th>initial temperature of the distilled water/°C</th>
<th>thermometer diagram</th>
<th>temperature of the solution after 1 min/°C</th>
<th>temperature change/°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td><img src="image" alt="Thermometer Diagram 30-20-15-10" /></td>
<td><img src="image" alt="Initial Temperature Diagram" /></td>
<td><img src="image" alt="Thermometer Diagram 30-20-15-10" /></td>
<td><img src="image" alt="Temperature Change Diagram" /></td>
<td><img src="image" alt="Temperature Change Diagram" /></td>
</tr>
<tr>
<td>4</td>
<td><img src="image" alt="Thermometer Diagram 30-20-15-10" /></td>
<td><img src="image" alt="Initial Temperature Diagram" /></td>
<td><img src="image" alt="Thermometer Diagram 30-20-15-10" /></td>
<td><img src="image" alt="Temperature Change Diagram" /></td>
<td><img src="image" alt="Temperature Change Diagram" /></td>
</tr>
<tr>
<td>6</td>
<td><img src="image" alt="Thermometer Diagram 30-20-15-10" /></td>
<td><img src="image" alt="Initial Temperature Diagram" /></td>
<td><img src="image" alt="Thermometer Diagram 30-20-15-10" /></td>
<td><img src="image" alt="Temperature Change Diagram" /></td>
<td><img src="image" alt="Temperature Change Diagram" /></td>
</tr>
<tr>
<td>8</td>
<td><img src="image" alt="Thermometer Diagram 30-20-15-10" /></td>
<td><img src="image" alt="Initial Temperature Diagram" /></td>
<td><img src="image" alt="Thermometer Diagram 40-35-30" /></td>
<td><img src="image" alt="Temperature Change Diagram" /></td>
<td><img src="image" alt="Temperature Change Diagram" /></td>
</tr>
</tbody>
</table>
(c) Plot the results for Experiments 1 and 2 on the grid. The (0,0) point has been plotted for you. Draw two straight lines of best fit. Clearly label your graphs.

(d) Use your graph to estimate the temperature change after 1 minute if 8 g of solid C were added to 40 cm³ of distilled water.

Show clearly on the grid how you worked out your answer.

............... °C [2]

(e) What type of energy change occurs when solid D dissolves in water?

................................................................................................................................. [1]

(f) Suggest the temperature of the solution containing 8 g of solid D, if the solution were left for 2 hours.

Explain your answer.

.................................................................................................................................

................................................................................................................................. [2]
(g) How would the temperature changes measured after 1 minute differ if the experiments were repeated using 80 cm$^3$ instead of 40 cm$^3$ of distilled water in each case?

................................................................................................................................................... [2]

(h) Suggest one change you could make to the experiments to obtain more accurate results. Explain how this change would make the results more accurate.

change ..............................................................................................................................................

explanation ..................................................................................................................................... [2]

(i) Suggest how the reliability of the results could be checked.

...................................................................................................................................................... [2]

[Total: 19]

12.8.1 ESSENTIAL EXAM QUESTIONS Topic 6 Paper 6 75marks Mark Scheme

2(a) all temperature boxes completed correctly;
     21, 23, 26, 27, 29, 31, 30, 29, 29.

2(b) all points plotted correctly (C) half a small square
     best-fit intersecting straight-line graphs

2(c) temperature boxes completed correctly:
     21, 26, 31, 32, 31, 30, 29, 28, 27

2(d) all points plotted correctly
     best-fit intersecting straight-line graphs

2(e)(i) value from graph where lines cross: 12 cm$^3$
     shown clearly at intersection

2(e)(ii) half volume of acid
     less / half as many moles of sodium hydroxide present

2(f) exothermic / heat given out

2(g)(i) to remove traces of acid / clean / remove impurities

2(g)(ii) to remove traces of water

2(h) sources of error
     using a measuring cylinder or heat losses
     improvement
     use a pipette / use a burette / lag / insulation / lid
### Q# 3/ IGCSE Chemistry/2018/s/Paper 62/Q2

<table>
<thead>
<tr>
<th>Q(a)</th>
<th>initial temperatures all 21 AND final temperatures 16, 17, 15</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>temperature changes -3, -4, -5</td>
<td>1</td>
</tr>
<tr>
<td>Q(b)</td>
<td>initial temperatures 22, 22, 21, 22 AND final temperatures 26, 27, 28, 33</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>temperature changes +4, +5, +6, +11</td>
<td>1</td>
</tr>
<tr>
<td>Q(c)</td>
<td>all points plotted correctly (half a small square)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>best fit straight line graphs</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>labels D (upper) and C (lower) or (exact) 2 and 1</td>
<td>1</td>
</tr>
<tr>
<td>Q(d)</td>
<td>value from graph, –8°C</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>extrapolation</td>
<td>1</td>
</tr>
<tr>
<td>Q(e)</td>
<td>exothermic</td>
<td>1</td>
</tr>
<tr>
<td>Q(f)</td>
<td>room temperature / 21 °C / 22°C</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>heat lost to surroundings</td>
<td>1</td>
</tr>
<tr>
<td>Q(g)</td>
<td>half as much</td>
<td>2</td>
</tr>
<tr>
<td>Q(h)</td>
<td>change in apparatus or method e.g. use a pipe/ burette or use insulation / lid</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>explanation e.g. as more accurate / precise than a measuring cylinder / reduce heat losses</td>
<td>1</td>
</tr>
<tr>
<td>Q(i)</td>
<td>repeat experiments</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>compare/average</td>
<td>1</td>
</tr>
</tbody>
</table>

### Q# 4/ IGCSE Chemistry/2017/w/Paper 63/2018/s/Paper 62/Q2

<table>
<thead>
<tr>
<th>Q(a)</th>
<th>temperature boxes completed: 23, 10, 14, 13, 12, 11, 11, 11, 11, 11</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>all readings correct = [2]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8 or 9 readings correct = [1]</td>
<td></td>
</tr>
<tr>
<td>Q(b)</td>
<td>temperature boxes completed correctly: 22, 20, 20, 21, 22, 22, 21, 21</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>all readings correct = [2]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8 or 9 readings correct = [1]</td>
<td></td>
</tr>
<tr>
<td>Q(o)</td>
<td>all points plotted</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>two smooth line graphs (one line graph correct = [1])</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>both graphs appropriately labelled</td>
<td>1</td>
</tr>
<tr>
<td>Q(c)(i)</td>
<td>value from graph</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>shown clearly</td>
<td>1</td>
</tr>
<tr>
<td>Q(c)(ii)</td>
<td>value from graph</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>shown clearly</td>
<td>1</td>
</tr>
<tr>
<td>Q(e)</td>
<td>exothermic</td>
<td>1</td>
</tr>
<tr>
<td>Q(f)</td>
<td>room temperature / 22 °C</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>reaction has finished / all the solid has dissolved</td>
<td></td>
</tr>
<tr>
<td>Q(g)</td>
<td>source of error</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>improvement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>heat losses</td>
<td>use a lid / lag the apparatus</td>
</tr>
<tr>
<td></td>
<td>use of a measuring cylinder</td>
<td>use a pipette/burette</td>
</tr>
<tr>
<td></td>
<td>wet cup in the second experiment</td>
<td>use new/another cup OR dry the cup</td>
</tr>
<tr>
<td></td>
<td>the solid absorbs water from the air</td>
<td>store in a sealed container / airtight container / desiccator</td>
</tr>
<tr>
<td></td>
<td>only done once</td>
<td>repeat and average</td>
</tr>
<tr>
<td></td>
<td>different masses of solids used / masses of solids not measured</td>
<td>use same mass of solid / weigh the solids</td>
</tr>
<tr>
<td>Q(h)</td>
<td>fewer data / less detail / fewer readings / graph not as good / not</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>enough readings whilst the solid is reacting</td>
<td></td>
</tr>
<tr>
<td>Topic #</td>
<td>English</td>
<td>Meaning</td>
</tr>
<tr>
<td>-------</td>
<td>-------------------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>998</td>
<td>exothermic change</td>
<td></td>
</tr>
<tr>
<td>842</td>
<td>activation energy (EA)</td>
<td></td>
</tr>
<tr>
<td>776</td>
<td>burning</td>
<td></td>
</tr>
<tr>
<td>700</td>
<td>combustion</td>
<td></td>
</tr>
<tr>
<td>664</td>
<td>fuel cells</td>
<td></td>
</tr>
<tr>
<td>642</td>
<td>kinetic (particle) theory</td>
<td></td>
</tr>
<tr>
<td>621</td>
<td>fuel cell</td>
<td></td>
</tr>
<tr>
<td>592</td>
<td>collision theory</td>
<td></td>
</tr>
<tr>
<td>530</td>
<td>endothermic change</td>
<td></td>
</tr>
<tr>
<td>434</td>
<td>fuel</td>
<td></td>
</tr>
<tr>
<td>307</td>
<td>bond energy</td>
<td></td>
</tr>
<tr>
<td>183</td>
<td>catalyst</td>
<td></td>
</tr>
<tr>
<td>724</td>
<td>heat of combustion</td>
<td></td>
</tr>
<tr>
<td>133</td>
<td>heat of reaction</td>
<td></td>
</tr>
</tbody>
</table>
Q# 1/  
12. Ethene burns in oxygen to form carbon dioxide and water vapour.

\[
\begin{array}{c}
\text{H} & \text{C} & \text{H} \\
\text{H} & \text{C} & \text{H} \\
\end{array}
\quad + \quad \begin{array}{c}
3 \text{O} = \text{O} \\
\text{H} & \text{O} & \text{H} \\
\text{H} & \text{O} & \text{H} \\
\end{array}
\rightarrow \quad \begin{array}{c}
2 \text{O} = \text{C} = \text{O} \\
2 \text{H} = \text{O} = \text{H} \\
\end{array}
\]

The bond energies are shown in the table.

<table>
<thead>
<tr>
<th>bond</th>
<th>bond energy in kJ/mol</th>
</tr>
</thead>
<tbody>
<tr>
<td>C=C</td>
<td>+610</td>
</tr>
<tr>
<td>C–H</td>
<td>+410</td>
</tr>
<tr>
<td>O=O</td>
<td>+497</td>
</tr>
<tr>
<td>C=O</td>
<td>+805</td>
</tr>
<tr>
<td>O–H</td>
<td>+460</td>
</tr>
</tbody>
</table>

What is the energy change for the reaction?

A \(-2959 \text{ kJ/mol}\)  
B \(-2313 \text{ kJ/mol}\)  
C \(-1319 \text{ kJ/mol}\)  
D \(-399 \text{ kJ/mol}\)

Q# 2/  

\[
2\text{H}_2\text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{g}) + \text{O}_2(\text{g})
\]

The bond energies are shown in the table. The reaction is exothermic.

<table>
<thead>
<tr>
<th>bond</th>
<th>bond energy in kJ/mol</th>
</tr>
</thead>
<tbody>
<tr>
<td>O–H</td>
<td>+460</td>
</tr>
<tr>
<td>O–O</td>
<td>+150</td>
</tr>
<tr>
<td>O=O</td>
<td>+496</td>
</tr>
</tbody>
</table>

What is the energy change for the reaction?

A \(-346 \text{ kJ/mol}\)  
B \(-196 \text{ kJ/mol}\)  
C \(+196 \text{ kJ/mol}\)  
D \(+346 \text{ kJ/mol}\)
Q# 3/
12 Methane burns in an excess of oxygen. The equation is shown.

\[
\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g})
\]

The bond energies are shown in the table.

<table>
<thead>
<tr>
<th>bond</th>
<th>bond energy in kJ/mol</th>
</tr>
</thead>
<tbody>
<tr>
<td>C–H</td>
<td>+410</td>
</tr>
<tr>
<td>C=O</td>
<td>+805</td>
</tr>
<tr>
<td>O–H</td>
<td>+460</td>
</tr>
<tr>
<td>O=O</td>
<td>+496</td>
</tr>
</tbody>
</table>

What is the energy change for the reaction?
A  +318 kJ/mol
B  -102 kJ/mol
C  -359 kJ/mol
D  -818 kJ/mol

13 The equation for the formation of ammonia is shown.

\[
\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3
\]

The energy level diagram for the reaction is shown.

What is the energy change for the reaction?
A  -592 kJ/mol
B  -92 kJ/mol
C  +92 kJ/mol
D  +592 kJ/mol
Q# 4/

17 Part of the Periodic Table is shown.

Which element forms an oxide that reacts with dilute acid to form a salt and water?

```
    I   II  
    III  IV  V  VI  VII VIII
    C    
    A    B
    D
```

18 Aqueous sodium hydroxide is added to solid Q in a test-tube.

A gas is produced which turns damp red litmus blue.

What is Q?

A  aluminium
B  ammonia
C  ammonium chloride
D  sodium nitrate

19 Potassium hydroxide is a base.

Which statement describes a reaction of potassium hydroxide?

A  Chlorine is formed when it is heated with ammonium chloride.
B  It turns Universal Indicator green.
C  It reacts with an acid to produce a salt and water.
D  It turns methyl orange red.

20 Some general rules for the solubility of salts in water are listed.

- Carbonates are insoluble (except ammonium carbonate, potassium carbonate and sodium carbonate).
- Chlorides are soluble (except lead(II) chloride and silver chloride).
- Nitrates are soluble.
- Sulfates are soluble (except barium sulfate, calcium sulfate and lead(II) sulfate).

Which substances produce an insoluble salt when aqueous solutions of them are mixed?

A  barium chloride and magnesium nitrate
B  calcium chloride and ammonium nitrate
C  silver nitrate and zinc chloride
D  sodium carbonate and potassium sulfate
Q# 5/

12 Information about two reactions is given.

- The neutralisation reaction between citric acid and sodium hydrogen carbonate is endothermic.
- The displacement reaction between magnesium and carbon dioxide is exothermic.

Which statements about the two reactions are correct?

1. The energy of the products formed in the neutralisation reaction is greater than the energy of the reactants.
2. The energy of magnesium and carbon dioxide is greater than the energy of magnesium oxide and carbon.
3. In an exothermic reaction, the energy required to break the bonds is greater than the energy released when the new bonds are formed.

A 1, 2 and 3  B 1 and 2 only  C 1 and 3 only  D 2 and 3 only

13 Ethene reacts with hydrogen. The equation is shown:

\[ \text{CH}_2=\text{CH}_2 + \text{H}_2 \rightarrow \text{C}_2\text{H}_6 \]

The bond energies are shown in the table. The reaction is exothermic.

<table>
<thead>
<tr>
<th>bond</th>
<th>bond energy in kJ/mol</th>
</tr>
</thead>
<tbody>
<tr>
<td>C–C</td>
<td>+350</td>
</tr>
<tr>
<td>C=C</td>
<td>+610</td>
</tr>
<tr>
<td>C–H</td>
<td>+410</td>
</tr>
<tr>
<td>H–H</td>
<td>+436</td>
</tr>
</tbody>
</table>

What is the energy change for the reaction?

A -560 kJ/mol  B -124 kJ/mol  C +486 kJ/mol  D +5496 kJ/mol

Q# 6/

12 Which diagram is a correctly labelled energy level diagram for an endothermic reaction?

A

```
progress of reaction
```

B

```
progress of reaction
```
13 The equation for the complete combustion of methane is shown.

\[ \text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g}) \]

The bond energies are shown in the table.

<table>
<thead>
<tr>
<th>bond</th>
<th>bond energy in kJ/mol</th>
</tr>
</thead>
<tbody>
<tr>
<td>C–H</td>
<td>+410</td>
</tr>
<tr>
<td>C=O</td>
<td>+805</td>
</tr>
<tr>
<td>O–H</td>
<td>+460</td>
</tr>
<tr>
<td>O=O</td>
<td>+496</td>
</tr>
</tbody>
</table>

What is the energy change for the reaction?

A. \(-818\) kJ/mol  B. \(-359\) kJ/mol  C. \(-323\) kJ/mol  D. \(+102\) kJ/mol

Q# 7/

12 Plant cells use energy from sunlight for photosynthesis.

Which row describes and explains the energy change that occurs?

<table>
<thead>
<tr>
<th></th>
<th>type of energy change</th>
<th>explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>endothermic</td>
<td>less energy is released making bonds than is absorbed to break bonds</td>
</tr>
<tr>
<td>B</td>
<td>endothermic</td>
<td>more energy is released making bonds than is absorbed to break bonds</td>
</tr>
<tr>
<td>C</td>
<td>exothermic</td>
<td>less energy is released making bonds than is absorbed to break bonds</td>
</tr>
<tr>
<td>D</td>
<td>exothermic</td>
<td>more energy is released making bonds than is absorbed to break bonds</td>
</tr>
</tbody>
</table>
13 Hydrogen bromide decomposes to form hydrogen and bromine. The equation is shown.

\[ 2\text{HBr}(g) \rightarrow \text{H}_2(g) + \text{Br}_2(g) \]

The bond energies are shown in the table. The reaction is endothermic.

<table>
<thead>
<tr>
<th>bond</th>
<th>bond energy in kJ/mol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Br–Br</td>
<td>+193</td>
</tr>
<tr>
<td>H–Br</td>
<td>+366</td>
</tr>
<tr>
<td>H–H</td>
<td>+436</td>
</tr>
</tbody>
</table>

What is the energy change for the reaction?

A  +263 kJ/mol  B  +103 kJ/mol  C  −103 kJ/mol  D  −263 kJ/mol

12.11 Essential Assessed Activity 3 Topic 6 Paper 6 19 marks

Q# 1/

2 A student investigated the temperature changes when two different metals, zinc and magnesium, reacted with aqueous copper(II) sulfate.

Three experiments were done.

Experiment 1

- A measuring cylinder was used to pour 25 cm³ aqueous copper(II) sulfate into a polystyrene cup.
- The initial temperature of the solution was measured and the timer was started.
- The temperature of the solution was measured at 30 seconds and at 60 seconds.
- At 60 seconds, 5g of zinc powder was added to the aqueous copper(II) sulfate. The mixture was stirred with a thermometer.
- The temperature of the mixture was measured every 30 seconds for 210 seconds. The mixture was stirred continuously.
(a) Use the thermometer diagrams to record the temperatures in the table.

<table>
<thead>
<tr>
<th>time /s</th>
<th>0</th>
<th>30</th>
<th>60</th>
<th>90</th>
<th>120</th>
<th>150</th>
<th>180</th>
<th>210</th>
</tr>
</thead>
<tbody>
<tr>
<td>temperature of mixture /°C</td>
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</tbody>
</table>

Experiment 2

- Experiment 1 was repeated using 5 g of magnesium powder instead of zinc powder.

(b) Use the thermometer diagrams to record the temperatures in the table.

<table>
<thead>
<tr>
<th>time /s</th>
<th>0</th>
<th>30</th>
<th>60</th>
<th>90</th>
<th>120</th>
<th>150</th>
<th>180</th>
<th>210</th>
</tr>
</thead>
<tbody>
<tr>
<td>temperature of mixture /°C</td>
<td></td>
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</tbody>
</table>

Experiment 3

- Experiment 1 was repeated using 5 g of zinc granules instead of zinc powder.

(c) Use the thermometer diagrams to record the temperatures in the table.

<table>
<thead>
<tr>
<th>time /s</th>
<th>0</th>
<th>30</th>
<th>60</th>
<th>90</th>
<th>120</th>
<th>150</th>
<th>180</th>
<th>210</th>
</tr>
</thead>
<tbody>
<tr>
<td>temperature of mixture /°C</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
(d) Plot the results for Experiments 1–3 on the grid and draw three smooth line graphs. Clearly label your lines.

(e) From your graph, deduce the temperature of the mixture in Experiment 2 after 75 seconds. Show clearly on the grid how you worked out your answer.
(f) (i) From the results, which Experiment was the most exothermic? Explain your answer.

........................................................................................................................................................... [2]

(ii) Compare the rates of reaction in Experiments 1 and 3. Explain why the rates of reaction are different.

........................................................................................................................................................... [2]

(g) Predict the temperature of the mixture in Experiment 2 after 2 hours. Explain your answer.

........................................................................................................................................................... [2]

(h) When doing the experiments, what would be the advantage of taking the temperature readings every 15 seconds?

........................................................................................................................................................... [2]

(i) Explain why a copper can should not be used in place of the polystyrene cup in these experiments.

........................................................................................................................................................... [2]

[Total: 19]
11. One important property of a rocket fuel mixture is the large volume of gaseous products formed which provide thrust. Hydrazine, N₂H₄, is often used as a rocket fuel. The combustion of hydrazine is represented by the equation below.

\[
\text{N}_2\text{H}_4(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{N}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g}) \quad \Delta H_c^{\ominus} = -585 \text{ kJ mol}^{-1}
\]

(a) Hydrazine reacts with fluorine to produce nitrogen and hydrogen fluoride only, all in the gaseous state. State an equation for the reaction.

(b) Use the average bond enthalpies given in Table 10 of the Data Booklet to determine the enthalpy change for the reaction in part (a) above.

(d) Based on your answers to parts (a) and (c), suggest whether a mixture of hydrazine and fluorine is a better rocket fuel than a mixture of hydrazine and oxygen.
13. Which equation best represents the bond enthalpy of HCl?
   A. HCl(g) → H\(^+(g)\) + Cl\(^-(g)\)
   B. HCl(g) → H(g) + Cl(g)
   C. HCl(g) → \(\frac{1}{2}\) H\(_2\)(g) + \(\frac{1}{2}\) Cl\(_2\)(g)
   D. 2HCl(g) → H\(_2\)(g) + Cl\(_2\)(g)
   (Total 1 mark)

14. Which process represents the C–Cl bond enthalpy in tetrachloromethane?
   A. CCl\(_4\)(g) → C(g) + 4Cl(g)
   B. CCl\(_4\)(g) → CCl\(_3\)(g) + Cl(g)
   C. CCl\(_4\)(l) → C(g) + 4Cl(g)
   D. CCl\(_4\)(l) → C(s) + 2Cl\(_2\)(g)
   (Total 1 mark)

15. Hydrazine is a valuable rocket fuel.
   The equation for the reaction between hydrazine and oxygen is given below.
   \[ \text{N}_2\text{H}_4(g) + \text{O}_2(g) \rightarrow \text{N}_2(g) + 2\text{H}_2\text{O}(g) \]
   Use the bond enthalpy values from Table 10 to determine the enthalpy change for this reaction.
   ..........................................................................................................................
   ..........................................................................................................................
   ..........................................................................................................................
   ..........................................................................................................................
   (Total 3 marks)

16. When some solid barium hydroxide and solid ammonium thiosulfate were reacted together, the temperature of the surroundings was observed to decrease from 15 °C to –4 °C. What can be deduced from this observation?
   A. The reaction is exothermic and \(\Delta H\) is negative.
   B. The reaction is exothermic and \(\Delta H\) is positive.
   C. The reaction is endothermic and \(\Delta H\) is negative.
   D. The reaction is endothermic and \(\Delta H\) is positive.
12.13  ESSENTIAL End of Topic 6 Review and Reflection

Looking at the goals you could have achieved and the goals you actually achieved try to reflect on your progress.

Try to be as honest and as detailed as possible. Sometimes you may think you have thought about an idea well, but when you talk with someone else, or write it out, it helps you better understand and allows you think more completely and more clearly.

Did you achieve more goals this topic than last topic?

Fill in this table

<table>
<thead>
<tr>
<th>Level</th>
<th>Number of goals achieved at each level</th>
<th>Success rate, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>FUNDAMENTAL</td>
<td>/5</td>
<td></td>
</tr>
<tr>
<td>ESSENTIAL</td>
<td>/10</td>
<td></td>
</tr>
<tr>
<td>EXTENSION</td>
<td>/13</td>
<td></td>
</tr>
<tr>
<td>EXCEPTIONAL</td>
<td>/10</td>
<td></td>
</tr>
</tbody>
</table>

Do you feel you tried harder? If yes, what helped you to do so? If not, why not?

________________________________________________________________________

________________________________________________________________________

What could you do differently next time, in addition to what you are already doing to improve, not only your score in the end of topic tests and other assessed activities, but also in how you learn. How could you become a more effective student to get more learning out of the time you are investing in your studies?

________________________________________________________________________

________________________________________________________________________

What did you enjoy most about this topic?

________________________________________________________________________

What did you find most difficult?

________________________________________________________________________

What did you find easiest?

________________________________________________________________________

On a scale of 1 being hardest and 5 being most difficult, circle how challenging you found this topic

1  2  3  4  5

What could be done to make this topic easier to understand?

________________________________________________________________________

Do you have any questions about this topic?

________________________________________________________________________

________________________________________________________________________
Most reactions that happen on Earth give out heat energy, but not all of them. The first law of thermodynamics suggests that energy can neither be created nor destroyed. But it is not the only law, nor is it the most important law. Pick one law and create a short presentation about it.

You could investigate Entropy. What is it, and what isn’t it?

EXCEPTIONALLY SMASHING Ideas: Why has Entropy created problems for the existence of Black Holes? Have these problems been solved? If so how?
12.16 EXCEPTIONAL EXAM QUESTIONS T6 From IB SL 31marks

These questions are taken from an AS Level style syllabus called IB Standard Level. In theory a top level an iGCSE student has covered everything needed answer these questions, but most A* level students probably wouldn’t be able to answer them all.

1. Which statement about bonding is correct?
   A. Bond breaking is endothermic and requires energy.
   B. Bond breaking is endothermic and releases energy.
   C. Bond making is exothermic and requires energy.
   D. Bond making is endothermic and releases energy.

   (Total 1 mark)

2. Propane can be formed by the hydrogenation of propene.

   \[ \text{CH}_3\text{CH}=\text{CH}_2(g) + \text{H}_2(g) \rightarrow \text{CH}_3\text{CH}_2\text{CH}_3(g) \]

   (ii) Enthalpy changes can be determined using average bond enthalpies. Define the term average bond enthalpy.

   ..................................................................................................................................................
   ..................................................................................................................................................
   ..................................................................................................................................................

   (2)

   (iii) Determine a value for the hydrogenation of propene using information from Table 10 above.

   ..................................................................................................................................................
   ..................................................................................................................................................

   (2)

   (iv) Explain why the enthalpy of hydrogenation of propene is an exothermic process.

3. Which types of reaction are always exothermic?
   I. Neutralization
   II. Decomposition
   III. Combustion
   A. I and II only
   B. I and III only
   C. II and III only
   D. I, II and III
   (Total 1 mark)

4. Which equation represents the bond enthalpy for the H–Br bond in hydrogen bromide?
   A. HBr(g) → H(g) + Br(g)
   B. HBr(g) → H(g) + Br(l)
   C. HBr(g) → H(g) + \( \frac{1}{2} \) Br\(_2\)(l)
   D. HBr(g) → H(g) + \( \frac{1}{2} \) Br\(_2\)(g)
   (Total 1 mark)

5. Which is correct about energy changes during bond breaking and bond formation?
<table>
<thead>
<tr>
<th>Bond breaking</th>
<th>Bond formation</th>
</tr>
</thead>
<tbody>
<tr>
<td>exothermic and ( \Delta H ) positive</td>
<td>endothermic and ( \Delta H ) negative</td>
</tr>
<tr>
<td>exothermic and ( \Delta H ) negative</td>
<td>endothermic and ( \Delta H ) positive</td>
</tr>
<tr>
<td>endothermic and ( \Delta H ) positive</td>
<td>exothermic and ( \Delta H ) negative</td>
</tr>
<tr>
<td>endothermic and ( \Delta H ) negative</td>
<td>exothermic and ( \Delta H ) positive</td>
</tr>
</tbody>
</table>
   (Total 1 mark)

6. Which processes are exothermic?
   I. Ice melting
   II. Neutralization
   III. Combustion
   A. I and II only
   B. I and III only
   C. II and III only
   D. I, II and III
   (Total 1 mark)

7. Which is true for a chemical reaction in which the products have a higher enthalpy than the reactants?
<table>
<thead>
<tr>
<th>Reaction</th>
<th>( \Delta H )</th>
</tr>
</thead>
<tbody>
<tr>
<td>endothermic</td>
<td>positive</td>
</tr>
<tr>
<td>endothermic</td>
<td>negative</td>
</tr>
<tr>
<td>exothermic</td>
<td>positive</td>
</tr>
<tr>
<td>exothermic</td>
<td>negative</td>
</tr>
</tbody>
</table>
   (Total 1 mark)

8. Which statement is correct given the enthalpy level diagram below?

   A. The reaction is endothermic and the products are more thermodynamically stable than the reactants.
B. The reaction is exothermic and the products are more thermodynamically stable than the reactants.
C. The reaction is endothermic and the reactants are more thermodynamically stable than the products.
D. The reaction is exothermic and the reactants are more thermodynamically stable than the products.

9. (b) Use the information from Table 10 above to calculate the enthalpy change for the complete combustion of but-1-ene, according to the following equation.

\[ \text{C}_4\text{H}_8(g) + 6\text{O}_2(g) \rightarrow 4\text{CO}_2(g) + 4\text{H}_2\text{O}(g) \]

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12.16.1 EXCEPTIONAL EXAM QUESTIONS T6 From IB SL 31marks Mark Scheme

1. A

2. (ii) the enthalpy change when (one mole of) the gaseous bond is broken (or formed) / X–Y(g) → X(g) + Y(g) / X(g) + Y(g) → X–Y(g); averaged for the same bond in a number of similar compounds / OWTTE; 2

(iii) energy in: C=C + H–H and energy out: C–C + 2C–H:
Accept energy in C–C + 6C–H + C=C + H–H and energy out 2C–C + 8C–H.
If old Data Booklet values then allow: ΔH = 1048 – 1172 = –124 (kJ mol⁻¹)
(iv) due to the relative strength of the C–C and 2C–H bonds compared to the C=C and H–H bonds / bonds in products stronger than bonds in reactants; 1

3. B

4. A

5. C

6. C

7. A

8. B

9. (b) Bonds broken
(612) + (2×348) + (8×412) + (6×496)/7580 (kJ mol⁻¹);
Bonds made
(8×743) + (8×463) / 9648 (kJ mol⁻¹);
ΔH = –2068 (kJ mol⁻¹);
Award [3] for the correct answer.
Allow full ECF.
Allow kJ but no other incorrect units.
Even if the first two marks are lost, the candidate can score [1] for a clear correct subtraction for ΔH. 3

10. (a) energy required = C=C + H–H/612 + 436 and
energy released = C–C + 2(C–H)/347 + 2(413) /
energy required = C=C + H–H + 4(C–H)/612 + 436 + 4(413) and
energy released = C–C + 6(C–H)/347 + 6(413);
ΔH = (1048 – 1173)/(2700 – 2825) = –125 kJ mol⁻¹ 2
(d) (i) –125 kJ mol⁻¹; 1
### 13.1 End of Topic 7.1 & 7.2 Goals Checklist

For each topic you ought to try to do as many of the following things to get the most out of your time, the resources available to you and to help you grow as a student. Tick each goal off as you complete it. Growth is difficult and uncomfortable, but you should choose to do these things, and the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win!

<table>
<thead>
<tr>
<th>Aspect</th>
<th>What you should have done</th>
<th>Yes/No</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interacted with your teacher</td>
<td>Ask your teacher 1 question, about anything, once a week</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Try to answer one question asked by your teacher at least once a week</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Ask your teacher one question about something you do not understand in science once a week</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Ask your teacher one question about something to do with science every lesson</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td>Notes and follow up notes</td>
<td>Complete set of class note</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Attempted</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Completed</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Completed to an exemplary standard</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Attempted the Mind Map for this topic</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Completed the Mind Map for this topic</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td>Textbook</td>
<td>Read ahead before the topic has been started</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Highlighted key ideas and translate new words</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Completed the questions at the end of each 2 page spread in your exercise book</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Added to your class notes ideas and important information from the textbook that you learnt</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td>Past Exam Questions</td>
<td>Worked on at least 25% of the exam questions in this workbook</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Attempted more than 25% of the questions and those questions you have completed you have marked in a different colour pen</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Completed and marked all questions here</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Completed, marked and additional key ideas where you have located the most difficult marks added to your notebook</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Used the resources available online to answer additional questions not found in this workbook on the current topic.</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Ask your teacher about an exam question that they cannot answer</td>
<td></td>
<td>EXCEPTIONALLY SMASHING!!!</td>
</tr>
<tr>
<td>Assessed Activities</td>
<td>Complete the word list activity using the word list at the front of each topic as little as possible</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities, either in class or as homework</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 70% on average</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 80% on average</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 90% on average</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td>End of Topic Test</td>
<td>Revised sufficiently well to improve upon your score from the previous test (except if you are scoring over 90%, then just write Y for this goal)</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Scored 10% higher than your current average</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Scored 15% or more than your previous end of topic average</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Scored over 90%</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Scored over 95%</td>
<td></td>
<td>SMASHING!!!</td>
</tr>
<tr>
<td>Aspect</td>
<td>What you should have done</td>
<td>Yes/No</td>
<td>Level</td>
</tr>
<tr>
<td>--------</td>
<td>--------------------------</td>
<td>--------</td>
<td>-------</td>
</tr>
<tr>
<td>Reading</td>
<td>Spend more than 1 hour a week reading a book you enjoy (in any language) about anything.</td>
<td>ESSENTIAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spend more than 3 hours a week reading a book you enjoy (in any language) about anything.</td>
<td>EXTENSION</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spend more than 5 hours a week reading a book you enjoy (in any language) about anything.</td>
<td>EXCEPTIONAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spend at least one hour a week reading a book you enjoy in English about anything.</td>
<td>EXTENSION</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spend more than 3 hours a week reading a book you enjoy in English about anything.</td>
<td>EXCEPTIONAL</td>
<td></td>
</tr>
<tr>
<td>Reflection</td>
<td>You completed this goal setting table</td>
<td>FUNDAMENTAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>You have looked at the goals you have achieved and the ones you have not and added them up and entered them into the table in the Review and Reflection section</td>
<td>ESSENTIAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>You have given an answer for every question in the Review and Reflection section at the end of this topic</td>
<td>EXTENSION</td>
<td></td>
</tr>
<tr>
<td></td>
<td>You have Given good and thoughtful answers for every question in the Review and Reflection section at the end of this topic</td>
<td>EXCEPTIONAL</td>
<td></td>
</tr>
</tbody>
</table>

13.2 Topic 7.1 and 7.2 Syllabus

7 Chemical reactions

7.1 Physical and chemical changes

Core
- Identify physical and chemical changes, and understand the differences between them

7.2 Rate (speed) of reaction

Core
- Describe and explain the effect of concentration, particle size, catalysts (including enzymes) and temperature on the rate of reactions
- Describe the application of the above factors to the danger of explosive combustion with fine powders (e.g. flour mills) and gases (e.g. methane in mines)
- Demonstrate knowledge and understanding of a practical method for investigating the rate of a reaction involving gas evolution
- Interpret data obtained from experiments concerned with rate of reaction

Note: Candidates should be encouraged to use the term rate rather than speed.

Supplement
- Devise and evaluate a suitable method for investigating the effect of a given variable on the rate of a reaction
- Describe and explain the effects of temperature and concentration in terms of collisions between reacting particles. (An increase in temperature causes an increase in collision rate and more of the colliding molecules have sufficient energy (activation energy) to react whereas an increase in concentration only causes an increase in collision rate.)
- Describe and explain the role of light in photochemical reactions and the effect of light on the rate of these reactions. (This should be linked to section 14.4.)
- Describe the use of silver salts in photography as a process of reduction of silver ions to silver, and photosynthesis as the reaction between carbon dioxide and water in the presence of chlorophyll and sunlight (energy) to produce glucose and oxygen
## 13.3 ESSENTIAL Glossary for Keywords for Topic 7.1 & 7.2

<table>
<thead>
<tr>
<th>Topic #</th>
<th>English</th>
<th>Chinese</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>enzymes protein molecules that act as biological catalysts</td>
<td>酶充当生物催化剂的蛋白质分子</td>
</tr>
<tr>
<td>7</td>
<td>photochemical reaction a chemical reaction that occurs when light, usually of a particular wavelength, falls on the reactants</td>
<td>光化学反应是通常在特定波长的光照射到反应物上时发生的化学反应</td>
</tr>
<tr>
<td>7</td>
<td>photosynthesis the chemical process by which plants synthesise glucose from atmospheric carbon dioxide and water: the energy required for the process is captured from sunlight by chlorophyll molecules in the green leaves of the plants</td>
<td>光合作用是植物从大气中的二氧化碳和水合成葡萄糖的化学过程：该过程所需的能量是由植物的绿叶中的叶绿素分子从阳光中捕获的</td>
</tr>
<tr>
<td>7</td>
<td>Denature If an enzyme is placed in an extreme environment, e.g. too acidic or alkali, too hot or is physically damaged by motion I (like shaking) will no longer be able to function. Usually this change is permanent.</td>
<td>变性如果将酶置于极端环境中，例如太酸或太碱，太热或被运动（如摇晃）将不再起作用。通常，此更改是永久性的。</td>
</tr>
<tr>
<td>7</td>
<td>reaction rate a measure of how fast a reaction takes place</td>
<td>反应速率衡量反应发生的速度</td>
</tr>
<tr>
<td>7</td>
<td>speed of reaction a less accurate name for reaction rate</td>
<td>反应速度反应速率的名称不太准确</td>
</tr>
</tbody>
</table>

### 13.4 EXTENSION Keywords

You do not need to understand these words to score a good A, or even a low A* but if you are aiming for a good or high A* then understanding words like these here will be helpful.

### 13.5 ESSENTIAL Classroom Active Learning Tasks Drawing Graphs

Based on the Rate of a Reaction from Paper 6 36marks

**Q# 1/ IGCSE Chemistry/2018/w/Paper 63/Q2**

2 A student investigated the rate of reaction between solution S and solution T at different temperatures. When these chemicals react they form iodine. Sodium thiosulfate solution and starch solution were used to show how fast the reaction proceeded.

Four experiments were done.

**Experiment 1**

- A measuring cylinder was used to add 10 cm$^3$ of solution S and 10 cm$^3$ of sodium thiosulfate solution to a conical flask.
- A test pipette was then used to add 1 cm$^3$ of starch solution to the mixture.
- The temperature of the mixture was measured and recorded in the table.
- The reaction was started by using a measuring cylinder to add 10 cm$^3$ of solution T to the conical flask. A timer was started immediately and the mixture was swirled.
- The time taken for the mixture to turn blue-black was measured.
- The final temperature of the mixture was measured and recorded.
- The conical flask was emptied and rinsed with distilled water.
Experiment 2

- A measuring cylinder was used to add 10 cm³ of solution S and 10 cm³ of sodium thiosulfate solution to the conical flask.
- A teat pipette was then used to add 1 cm³ of starch solution to the mixture.
- The mixture was then heated to about 30 °C.
- The temperature of the mixture was measured and recorded in the table.
- The reaction was started by using a measuring cylinder to add 10 cm³ of solution T to the conical flask. The timer was started immediately and the mixture was swirled.
- The time taken for the mixture to turn blue-black was measured.
- The final temperature of the mixture was measured and recorded.
- The conical flask was emptied and rinsed with distilled water.

Experiment 3

- Experiment 2 was repeated but the mixture of solution S, sodium thiosulfate solution and starch solution in the conical flask was heated to about 40 °C before adding solution T.

Experiment 4

- Experiment 2 was repeated but the mixture of solution S, sodium thiosulfate solution and starch solution in the conical flask was heated to about 50 °C before adding solution T.
(a) Calculate the average temperatures in the table. Use the stop-clock diagrams to record the time taken for each experiment in the table.

<table>
<thead>
<tr>
<th>experiment number</th>
<th>initial temperature /°C</th>
<th>final temperature /°C</th>
<th>average temperature /°C</th>
<th>stop-clock diagram</th>
<th>time taken for the mixture to turn blue-black / s</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>22</td>
<td>22</td>
<td></td>
<td><img src="image" alt="Stop-clock diagram" /></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>31</td>
<td>29</td>
<td></td>
<td><img src="image" alt="Stop-clock diagram" /></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>41</td>
<td>37</td>
<td></td>
<td><img src="image" alt="Stop-clock diagram" /></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>51</td>
<td>45</td>
<td></td>
<td><img src="image" alt="Stop-clock diagram" /></td>
<td></td>
</tr>
</tbody>
</table>

[4]
(b) Plot the results for Experiments 1–4 on the grid. Draw a smooth line graph.

(c) From your graph, deduce the average temperature needed for the mixture to turn blue-black in 60s.

Show clearly on the grid how you worked out your answer.

(d) (i) In which experiment, 1, 2, 3 or 4, was the rate of reaction greatest?

(ii) Explain, in terms of particles, why the rate of reaction was greatest in this experiment.
(e) Pipettes or burettes could be used to measure the volumes of solution S and the sodium thiosulfate solution more accurately.

State and explain one other way to improve the accuracy of the results of these experiments.

way to improve the accuracy ........................................................................................................

explanation .................................................................................................................................. [2]

(f) A student predicted that using a burette to add solution T would improve the accuracy of the results of these experiments.

Suggest why the student's prediction would not improve the accuracy of the results of these experiments.

........................................................................................................................................................ [2]

[Total: 18]

Q#2/ iGCSE Chemistry/2018/w/Paper 61/Q2

2 A student investigated the rate of reaction between dilute nitric acid and lumps of magnesium carbonate. The apparatus shown was used.

![Diagram of apparatus](image.png)

Lumps of magnesium carbonate were added to a conical flask. 40 cm³ of dilute nitric acid was then poured into the conical flask using a measuring cylinder. The magnesium carbonate was in excess.

The conical flask was placed on a balance. Cotton wool was placed in the top of the conical flask.

The mass of the conical flask and its contents was measured and a timer was started. The mass of the conical flask and its contents was measured every minute for 7 minutes.
(a) Use the balance diagrams to record the mass of the conical flask and its contents in the table. Complete the table to work out the total loss of mass of the conical flask and its contents since the start of the experiment.

<table>
<thead>
<tr>
<th>time/minutes</th>
<th>balance diagram</th>
<th>mass of conical flask and its contents/g</th>
<th>total loss of mass/g</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td><img src="image" alt="Balance Diagram" /></td>
<td>-87 g</td>
<td>-86 g</td>
</tr>
<tr>
<td>1</td>
<td><img src="image" alt="Balance Diagram" /></td>
<td>-86 g</td>
<td>-85 g</td>
</tr>
<tr>
<td>2</td>
<td><img src="image" alt="Balance Diagram" /></td>
<td>-85 g</td>
<td>-84 g</td>
</tr>
<tr>
<td>3</td>
<td><img src="image" alt="Balance Diagram" /></td>
<td>-84 g</td>
<td>-83 g</td>
</tr>
<tr>
<td>4</td>
<td><img src="image" alt="Balance Diagram" /></td>
<td>-85 g</td>
<td>-84 g</td>
</tr>
<tr>
<td>5</td>
<td><img src="image" alt="Balance Diagram" /></td>
<td>-84 g</td>
<td>-83 g</td>
</tr>
<tr>
<td>6</td>
<td><img src="image" alt="Balance Diagram" /></td>
<td>-85 g</td>
<td>-84 g</td>
</tr>
<tr>
<td>7</td>
<td><img src="image" alt="Balance Diagram" /></td>
<td>-84 g</td>
<td>-83 g</td>
</tr>
</tbody>
</table>
(b) Plot the results on the grid. Draw a smooth line graph.

(c) The average rate of reaction can be calculated using the equation shown.

\[
\text{average rate of reaction} = \frac{\text{total loss of mass/g}}{\text{time taken/s}}
\]

Calculate the average rate of reaction for the first 30 seconds of the reaction. Deduce the unit.

\[
\text{rate} = \text{...}
\]

\[
\text{unit} = \text{...}
\]

(d) The experiment is repeated using an excess of powdered magnesium carbonate. All other conditions are kept the same.

Sketch on the grid the graph you would expect.
(e) (i) Why does the mass of the conical flask and its contents decrease?

........................................................................................................................................... [1]

(ii) Suggest the purpose of the cotton wool.

........................................................................................................................................... [2]

(iii) Why does the graph level off? Explain your answer.

........................................................................................................................................... [2]

(f) Give one advantage and one disadvantage of using a burette instead of a measuring cylinder to add the dilute nitric acid to the conical flask.

advantage ................................................................................................................................ [2]

disadvantage ............................................................................................................................ [2]

**Makr Scheme For Drawing Graphs Active Learning Excercise**

**Q#1/ iGCSE Chemistry/2018/w/Paper 63/Q2**

<table>
<thead>
<tr>
<th>2(a)</th>
<th>Table of results for experiments 1-4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>average temperature boxes completed correctly</td>
</tr>
<tr>
<td></td>
<td>22, 30, 36, 48</td>
</tr>
<tr>
<td></td>
<td>Time boxes completed correctly</td>
</tr>
<tr>
<td></td>
<td>98, 42, 26, 22</td>
</tr>
<tr>
<td></td>
<td>Times completed in seconds</td>
</tr>
</tbody>
</table>

| 2(b) | All points plotted correctly       |
|      | Smooth line graph (curve)          |

| 2(c) | indication on graph                |
|      | Value from graph                   |
|      | °C                                 |

| 2(d)(i) | Experiment 4                       |
|         |                                    |

| 2(d)(ii) | M1 particles (of solution L) have more / most (kinetic) energy / move faster |
|          | M2 more frequent collisions / particles collide more often |

| 2(e) | M1 Insulation / use a lid          |
|      | M2 To reduce heat losses           |

| 2(f) | M1 Too slow / slower addition of solution |
|      | M2 Measuring time taken / results less accurate |
13.6 Extension Classroom Active Learning Tasks Dealing with Multi-mark Questions

Based on Rate of reaction 43 Marks

Q# 1/ IGCSE Chemistry/2018/w/Paper 43/Q5

5 A student investigates the rate of reaction between lumps of calcium carbonate and dilute hydrochloric acid using the apparatus shown.

\[
\text{CaCO}_3(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow \text{CaCl}_2(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})
\]

The calcium carbonate was in excess.

(a) Which measurements should the student make during the reaction to determine the rate of reaction?

[2]
(b) What happens to the rate of reaction as the reaction proceeds? Explain your answer.

........................................................................................................................................... [3]

(c) The student repeated the experiment at a higher temperature. All other conditions were kept the same. The student found that the rate of reaction increased.

Explain, in terms of collisions, why the rate of reaction increased.

........................................................................................................................................... [4]

Q# 2/ IGCSE Chemistry/2018/w/Paper 42/Q4

(c) The original experiment was repeated at a higher temperature. All other conditions were kept the same.

Describe and explain, in terms of collisions between particles, the effect of using a higher temperature on the time taken for the reaction to finish.

........................................................................................................................................... [5]

Q# 3/ IGCSE Chemistry/2018/s/Paper 43/Q3

(d) Cobalt reacts with dilute hydrochloric acid to make the salt cobalt(II) chloride. Bubbles of hydrogen gas are produced.
(iii) Use collision theory to explain how heating the dilute hydrochloric acid makes the rate of reaction faster.

.................................................................................................................................................. [3]

Q# 4/ IGCSE Chemistry/2017/w/Paper 41/

7 Copper(II) oxide reacts with dilute hydrochloric acid.

\[ \text{CuO(s)} + 2\text{HCl(aq)} \rightarrow \text{CuCl}_2(\text{aq}) + \text{H}_2\text{O(l)} \]

6.00 g of copper(II) oxide were added to 50.0 cm³ of 1.00 mol/dm³ hydrochloric acid. This was an excess of copper(II) oxide.

(a) The rate of the reaction can be increased by increasing the concentration of the hydrochloric acid or by heating it.

(i) In terms of collisions, explain why increasing the concentration of the hydrochloric acid increases the rate of the reaction.

.................................................................................................................................................. [2]

(ii) In terms of collisions, explain why heating the hydrochloric acid increases the rate of the reaction.

.................................................................................................................................................. [2]
(e) The original graph has been drawn again.

On the grid, draw the graph expected if the concentration of dilute hydrochloric acid is changed from 0.1 mol/dm$^3$ to 0.2 mol/dm$^3$. All other conditions are the same as in the original experiment.

Explain, in terms of particles, why your graph is different from the original graph.

\[
\text{volume of gas/cm}^3
\]

\[
\text{time/s}
\]

Q# 6/ IGCSE Chemistry/2016/w/Paper 41/

8 Magnesium carbonate reacts with dilute hydrochloric acid.

\[
\text{MgCO}_3(s) + 2\text{HCl(aq)} \rightarrow \text{MgCl}_2(aq) + \text{H}_2\text{O(l)} + \text{CO}_2(g)
\]

An excess of magnesium carbonate pieces was added to dilute hydrochloric acid. The apparatus in the diagram was used to measure the volume of gas produced. The total volume of gas collected was recorded every 20 seconds.
(a) The results obtained are shown on the graph.

(i) Describe how the rate of this reaction changed during the reaction. Explain why the rate changed in this way.

(ii) The experiment was repeated using the same mass of powdered magnesium carbonate with the same volume and concentration of dilute hydrochloric acid.

Explain how the initial rate of reaction and total volume of gas collected would compare to the first experiment.

initial rate of reaction ..........................................................................................................

.............................................................................................................................

.............................................................................................................................

.............................................................................................................................

.............................................................................................................................

............................................................................................................................. [4]

total volume of gas ..........................................................................................................

.............................................................................................................................

.............................................................................................................................

.............................................................................................................................

............................................................................................................................. [4]
(b) A piece of magnesium ribbon was cleaned. The experiment was repeated using this clean magnesium ribbon instead of magnesium carbonate.

\[ \text{Mg(s)} + 2\text{HCl(aq)} \rightarrow \text{MgCl}_2(\text{aq}) + \text{H}_2(\text{g}) \]

This reaction is exothermic.
The rate of the reaction gradually increased over the first 2 minutes.

Explain why the rate of the reaction increased.

Q# 7/ IGCSE Chemistry/2016/s/Paper 41/

3  When aqueous sodium thiosulfate and dilute hydrochloric acid are mixed, a precipitate of insoluble sulfur is produced. This makes the mixture difficult to see through.

\[ \text{Na}_2\text{S}_2\text{O}_3(\text{aq}) + 2\text{HCl(aq)} \rightarrow \text{S(s)} + 2\text{NaCl(aq)} + \text{H}_2\text{O(l)} + \text{SO}_2(\text{g}) \]

The time taken for the cross to disappear from view is measured.

A student adds the following volumes of aqueous sodium thiosulfate, dilute hydrochloric acid and distilled water to the conical flask.
The time taken for the formation of the precipitate of sulfur to make the cross disappear from view is recorded.

<table>
<thead>
<tr>
<th>experiment number</th>
<th>volume of sodium thiosulfate / cm³</th>
<th>volume of hydrochloric acid / cm³</th>
<th>volume of distilled water / cm³</th>
<th>time taken for cross to disappear from view / s</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>10</td>
<td>40</td>
<td>56</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>10</td>
<td>30</td>
<td>28</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(ii) Use collision theory to explain why increasing the concentration of sodium thiosulfate would change the rate of reaction.

........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
........................................................................................................................................ [2]

(c) The student repeated experiment 1 at a higher temperature.

Use collision theory to explain why the rate of reaction would increase.

........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
........................................................................................................................................ [3]

Mark Scheme Extension Classroom Active Learning Tasks Dealing With Multi-mark Questions Based on Rate of reaction 43 Marks

Q# 1/ IGCSE Chemistry/2018/w/Paper 43/

<table>
<thead>
<tr>
<th>5(a)</th>
<th>5(b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1 volume of gas</td>
<td>M1 rate decreases / reaction gets slower</td>
</tr>
<tr>
<td>M2 time</td>
<td>M2 concentration of acid decreases</td>
</tr>
<tr>
<td></td>
<td>M3 fewer collisions per unit time</td>
</tr>
</tbody>
</table>

2

3
<table>
<thead>
<tr>
<th>Q# 2/ IGCSE Chemistry/2018/w/Paper 42/</th>
</tr>
</thead>
<tbody>
<tr>
<td>4(c) M1 particles have more kinetic energy</td>
</tr>
<tr>
<td>4(c) M2 particles move faster</td>
</tr>
<tr>
<td>4(c) M3 more collisions per unit time</td>
</tr>
<tr>
<td>4(c) M4 more of the particles have energy greater than or equal to activation energy / more of the collisions have energy greater than or equal to activation energy</td>
</tr>
<tr>
<td>OR more of the particles have sufficient energy to react / more of the collisions have sufficient energy to react</td>
</tr>
<tr>
<td>OR A greater percentage or greater proportion or greater fraction of collisions are successful</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Q# 3/ IGCSE Chemistry/2018/s/Paper 43/</th>
</tr>
</thead>
<tbody>
<tr>
<td>3(d)(ii) (particles) have more energy / (particles) move faster</td>
</tr>
<tr>
<td>more collisions per second / greater collision rate</td>
</tr>
<tr>
<td>more of the colliding molecules have sufficient energy (activation energy) to react</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Q# 4/ IGCSE Chemistry/2017/w/Paper 41/</th>
</tr>
</thead>
<tbody>
<tr>
<td>7(a)(i) more particles (of acid) in a given volume / dm$^3$ / cm$^3$</td>
</tr>
<tr>
<td>more collisions per second / unit time OR greater collision rate</td>
</tr>
<tr>
<td>7(a)(ii) particles have more energy / particles move faster / more collisions per second / more collisions per unit time / greater collision rate</td>
</tr>
<tr>
<td>more (of the) particles / collisions have energy greater than the activation energy / more particles have sufficient energy to react / more collisions have sufficient energy to react / a greater percentage of collisions are successful</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Q# 5/ IGCSE Chemistry/2017/s/Paper 41/</th>
</tr>
</thead>
<tbody>
<tr>
<td>5(d) curve starts from (0,0) and has a lower gradient than the original curve</td>
</tr>
<tr>
<td>because lumps have a lower surface area</td>
</tr>
<tr>
<td>5(d) curve starts from (0,0) and has a lower gradient than the original curve</td>
</tr>
<tr>
<td>because lumps have a lower surface area</td>
</tr>
</tbody>
</table>
13.7 ESSENTIAL EXAM QUESTIONS Paper 2 Topic 7.1 & 7.2 12 marks

Q# 1/ IGCSE Chemistry/2018/w/Paper 23/

14 Dilute hydrochloric acid reacts with 1 g of limestone.

Which conditions produce the fastest rate of reaction?

A 2 mol/dm³ hydrochloric acid and a single lump of limestone
B 4 mol/dm³ hydrochloric acid and a single lump of limestone
C 4 mol/dm³ hydrochloric acid and small pieces of limestone
D 4 mol/dm³ hydrochloric acid and powdered limestone

Q# 2/ IGCSE Chemistry/2018/w/Paper 22/

14 The rate of reaction between magnesium ribbon and 2 mol/dm³ hydrochloric acid at 25°C to produce hydrogen gas is measured.

In another experiment, either the concentration of the hydrochloric acid or the temperature is changed. All other conditions are kept the same.

Which conditions increase the rate of reaction?

A 1 mol/dm³ hydrochloric acid at 25°C
B 2 mol/dm³ hydrochloric acid at 10°C
C 2 mol/dm³ hydrochloric acid at 20°C
D 3 mol/dm³ hydrochloric acid at 25°C
Q# 3/ IGCSE Chemistry/2018/w/Paper 21/

14 The effects of a change in conditions on a chemical reaction are listed.

1. The total number of collisions per minute increased.
2. The number of effective collisions per minute increased.
3. The average energy of the particles increased.

Which change in conditions caused all of these effects?

A. addition of a catalyst
B. increasing the concentration of a solution of a reactant
C. increasing the surface area of a solid reactant
D. increasing the temperature

Q# 4/ IGCSE Chemistry/2018/s/Paper 21/

14 Which row describes the effects of increasing both concentration and temperature on the collisions between reacting particles?

<table>
<thead>
<tr>
<th></th>
<th>increasing concentration</th>
<th>increasing temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>more collisions per second only</td>
<td>more collisions per second only</td>
</tr>
<tr>
<td>B</td>
<td>more collisions per second and more</td>
<td>more collisions per second only</td>
</tr>
<tr>
<td></td>
<td>collisions with sufficient energy to react</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>more collisions per second only</td>
<td>more collisions per second and more</td>
</tr>
<tr>
<td></td>
<td>collisions with sufficient energy to react</td>
<td>more collisions per second and more</td>
</tr>
<tr>
<td></td>
<td></td>
<td>collisions with sufficient energy to react</td>
</tr>
<tr>
<td>D</td>
<td>more collisions per second and more</td>
<td>more collisions per second and more</td>
</tr>
<tr>
<td></td>
<td>collisions with sufficient energy to react</td>
<td>more collisions per second and more</td>
</tr>
<tr>
<td></td>
<td></td>
<td>collisions with sufficient energy to react</td>
</tr>
</tbody>
</table>

Q# 5/ IGCSE Chemistry/2018/m/Paper 22/

15 A student adds dilute hydrochloric acid at two different temperatures to two different lumps of limestone. The lumps of limestone have the same mass.

The carbon dioxide gas produced is collected in a gas syringe.

The volume of carbon dioxide collected in 1 minute at each temperature is shown.

<table>
<thead>
<tr>
<th>temperature/°C</th>
<th>volume of carbon dioxide produced in 1 minute/cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>50</td>
<td>40</td>
</tr>
</tbody>
</table>

Which row describes and explains the results obtained at 50 °C compared with 25 °C?

<table>
<thead>
<tr>
<th></th>
<th>reaction rate</th>
<th>energy of collisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>higher</td>
<td>lower</td>
</tr>
<tr>
<td>B</td>
<td>higher</td>
<td>higher</td>
</tr>
<tr>
<td>C</td>
<td>lower</td>
<td>lower</td>
</tr>
<tr>
<td>D</td>
<td>lower</td>
<td>higher</td>
</tr>
</tbody>
</table>
Q# 6/ IGCSE Chemistry/2017/w/Paper 23/

15 Which statement about the effect of concentration and temperature on the rate of a reaction is not correct?

A  If the concentration of a reactant is increased, the rate of reaction increases because more particles have sufficient energy to react.

B  If the concentration of a reactant is increased, the rate of reaction increases because there are more collisions between particles per second.

C  If the temperature is increased, the rate of reaction increases because there are more collisions between particles per second.

D  If the temperature is increased, the rate of reaction increases because more particles have sufficient energy to react.

Q# 7/ IGCSE Chemistry/2017/w/Paper 22/

15 Four statements about the effect of increasing temperature on a reaction are shown.

1  The activation energy becomes lower.

2  The particles move faster.

3  There are more collisions between reacting particles.

4  There are more collisions which have energy greater than the activation energy.

Which statements are correct?

A  1, 2 and 3  B  1, 3 and 4  C  2, 3 and 4  D  2 and 3 only

Q# 8/ IGCSE Chemistry/2017/w/Paper 21/

13 The mass of a beaker and its contents is plotted against time.

Which graph represents what happens when sodium carbonate reacts with an excess of dilute hydrochloric acid in an open beaker?


Q# 9/ IGCSE Chemistry/2017/s/Paper 23/

14 Which changes are physical changes?

1  melting ice to form water

2  burning hydrogen to form water

3  adding sodium to water

4  boiling water to form steam

A  1 and 2  B  1 and 4  C  2 and 3  D  3 and 4
Q# 10/ iGCSE Chemistry/2017/s/Paper 22/

14 A gas is produced when calcium carbonate is heated.

Which type of change is this?

A  chemical  
B  exothermic  
C  physical  
D  separation

Q# 11/ iGCSE Chemistry/2017/s/Paper 21/

14 When sulfur is heated it undergoes a ......1...... change as it melts.

Further heating causes the sulfur to undergo a ......2...... change and form sulfur dioxide.

Which words complete gaps 1 and 2?

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>chemical</td>
<td>chemical</td>
</tr>
<tr>
<td>B</td>
<td>chemical</td>
<td>physical</td>
</tr>
<tr>
<td>C</td>
<td>physical</td>
<td>chemical</td>
</tr>
<tr>
<td>D</td>
<td>physical</td>
<td>physical</td>
</tr>
</tbody>
</table>

15 A student was investigating the reaction between marble chips and dilute hydrochloric acid.

Which changes slow down the rate of reaction?

<table>
<thead>
<tr>
<th></th>
<th>temperature of acid</th>
<th>concentration of acid</th>
<th>surface area of marble chips</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>decrease</td>
<td>decrease</td>
<td>decrease</td>
</tr>
<tr>
<td>B</td>
<td>decrease</td>
<td>decrease</td>
<td>increase</td>
</tr>
<tr>
<td>C</td>
<td>increase</td>
<td>decrease</td>
<td>decrease</td>
</tr>
<tr>
<td>D</td>
<td>increase</td>
<td>increase</td>
<td>increase</td>
</tr>
</tbody>
</table>
Q# 1/ iGCSE Chemistry/2015/w/Paper 31/Q7

7 The rate of a photochemical reaction is affected by light.

(b) A piece of white paper was coated with silver bromide and exposed to the light. Sections of the paper were covered as shown in the diagram.

\[
\begin{array}{c}
\text{paper coated with silver bromide} \\
\text{not covered} \\
\text{covered with thin paper} \\
\text{covered with thick card}
\end{array}
\]

Predict the appearance of the different sections of the paper after exposure to the light and the removal of the card. Explain your predictions.

\[\text{Answer...}[4]\]

(c) Photosynthesis is another example of a photochemical reaction. Green plants can make simple carbohydrates, such as glucose. These can polymerise to make more complex carbohydrates, such as starch.

(i) Write a word equation for photosynthesis.

\[\text{Answer...}[2]\]

(ii) Name the substance which is responsible for the colour in green plants and is essential for photosynthesis.

\[\text{Answer...}[1]\]

Q# 2/ iGCSE Chemistry/2015/s/Paper 31/

3 (a) The reactions between metals and acids are redox reactions.

\[
\text{Zn} + 2\text{H}^+ \rightarrow \text{Zn}^{2+} + \text{H}_2
\]
(b) The rate of reaction between a metal and an acid can be investigated using the apparatus shown below.

A piece of zinc foil was added to 50 cm$^3$ of hydrochloric acid, of concentration 2.0 mol/dm$^3$. The acid was in excess. The hydrogen evolved was collected in the gas syringe and its volume measured every minute. The results were plotted and labelled as graph 1.

The experiment was repeated to show that the reaction between zinc metal and hydrochloric acid is catalysed by copper. A small volume of aqueous copper(II) chloride was added to the acid before the zinc was added. The results of this experiment were plotted on the same grid and labelled as graph 2.

(i) Explain why the reaction mixture in the second experiment contains copper metal. Include an equation in your explanation.

.................................................................................................................................................. [2]

(ii) Explain how graph 2 shows that copper catalyses the reaction.

.................................................................................................................................................. [3]
Q# 3/ IGCSE Chemistry/2014/s/Paper 31/

6 Hydrogen peroxide decomposes to form water and oxygen. This reaction is catalysed by manganese(IV) oxide.

\[ 2\text{H}_2\text{O}_2(\text{aq}) \rightarrow 2\text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g}) \]

The rate of this reaction can be investigated using the following apparatus.

![Diagram of reaction apparatus]

40 cm³ of aqueous hydrogen peroxide was put in the flask and 0.1 g of small lumps of manganese(IV) oxide was added. The volume of oxygen collected was measured every 30 seconds. The results were plotted to give the graph shown below.

![Graph of reaction rate]

(a) (i) How do the rates at times \( t_1 \), \( t_2 \) and \( t_3 \) differ?

.......................................................................................................................................................... [2]

.......................................................................................................................................................... [2]

(ii) Explain the trend in reaction rate that you described in (a)(i).

..........................................................................................................................................................

..........................................................................................................................................................

.......................................................................................................................................................... [2]
(b) The experiment was repeated using 0.1 g of finely powdered manganese(IV) oxide. All the other variables were kept the same.

(i) On the axes opposite, sketch the graph that would be expected. [2]

(ii) Explain the shape of this graph. .................................................................
..................................................................................................................... [2]

(c) Describe how you could show that the catalyst, manganese(IV) oxide, was not used up in the reaction. Manganese(IV) oxide is insoluble in water.
.....................................................................................................................
.....................................................................................................................
.....................................................................................................................
.....................................................................................................................
.....................................................................................................................
..................................................................................................................... [4]

Q# 4/ IGCSE Chemistry/2013/w/Paper 31/
4 20.0 g of small lumps of calcium carbonate and 40 cm³ of hydrochloric acid, concentration 2.0 mol/dm³, were placed in a flask on a top pan balance. The mass of the flask and contents was recorded every minute.

The mass of carbon dioxide given off was plotted against time.

```
cotton wool to prevent drops of acid spray escaping
flask
40 cm³ of hydrochloric acid, 2.0 mol/dm³
20.0 g of small lumps of calcium carbonate
balance
```

mass of carbon dioxide

\[ \text{mass of carbon dioxide} \]

\[ \text{time} \]
\[ \text{CaCO}_3(s) + 2\text{HCl}(aq) \rightarrow \text{CaCl}_2(aq) + \text{H}_2\text{O}(l) + \text{CO}_2(g) \]

In all the experiments mentioned in this question, the calcium carbonate was in excess.

(a) (i) Explain how you could determine the mass of carbon dioxide given off in the first five minutes.

........................................................................................................................................ [1]

(ii) Label the graph where the reaction rate is the fastest, S where it is slowing down and O where the rate is zero. [2]

(iii) Explain how the shape of the graph shows where the rate is fastest, where it is slowing down and where the rate is zero.

........................................................................................................................................ [2]

(b) Sketch on the same graph, the line which would have been obtained if 20.0 g of small lumps of calcium carbonate and 80 cm\(^3\) of hydrochloric acid, concentration 1.0 mol/dm\(^3\), had been used. [2]

(c) Explain in terms of collisions between reacting particles each of the following.

(i) The reaction rate would be slower if 20.0 g of larger lumps of calcium carbonate and 40 cm\(^3\) of hydrochloric acid, concentration 2.0 mol/dm\(^3\), were used.

........................................................................................................................................ [2]

(ii) The reaction rate would be faster if the experiment was carried out at a higher temperature.

........................................................................................................................................ [2]
A small piece of marble, CaCO₃, was added to 5.0 cm³ of hydrochloric acid, concentration 1.0 mol/dm³, at 25°C. The time taken for the reaction to stop was measured. The experiment was repeated using 5.0 cm³ of different solutions of acids. The acid was in excess in all of the experiments.

Typical results are given in the table.

<table>
<thead>
<tr>
<th>experiment</th>
<th>temperature/°C</th>
<th>acid solution</th>
<th>time/min</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25</td>
<td>hydrochloric acid 1.0 mol/dm³</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>25</td>
<td>hydrochloric acid 0.5 mol/dm³</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>25</td>
<td>ethanoic acid 1.0 mol/dm³</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>15</td>
<td>hydrochloric acid 1.0 mol/dm³</td>
<td>8</td>
</tr>
</tbody>
</table>

(a) (i) Explain why it is important that the pieces of marble are the same size and the same shape.

..................................................................................................................................................  [2]

(ii) How would you know when the reaction had stopped?

..............................................................................................................................................  [1]

(c) (i) Explain why the reaction in experiment 1 is faster than the reaction in experiment 2.

..................................................................................................................................................

..................................................................................................................................................  [1]

(iii) Explain in terms of collisions between reacting particles why experiment 4 is slower than experiment 1.

..................................................................................................................................................

..................................................................................................................................................  [3]
Q# 6/ IGCSE Chemistry/2012/w/Paper 31/
5 Carbonyl chloride, COCl₂, is widely used in industry to make polymers, dyes and pharmaceuticals.

(a) Carbonyl chloride was first made in 1812 by exposing a mixture of carbon monoxide and chlorine to bright sunlight. This is a photochemical reaction.

\[ \text{CO}(g) + \text{Cl}_2(g) \rightarrow \text{COCl}_2(g) \]

(i) Explain the phrase photochemical reaction.

(ii) Give another example of a photochemical reaction and explain why it is important either to the environment or in industry.

Q# 7/ IGCSE Chemistry/2012/w/Paper 31/
5 Carbonyl chloride, COCl₂, is widely used in industry to make polymers, dyes and pharmaceuticals.

(iii) Explain why a catalyst is used.

Q# 8/ IGCSE Chemistry/2012/w/Paper 31/
3 The speed (rate) of a chemical reaction depends on a number of factors which include temperature and the presence of a catalyst.

(a) Reaction speed increases as the temperature increases.

(i) Explain why reaction speed increases with temperature.

(ii) Reactions involving enzymes do not follow the above pattern. The following graph shows how the speed of such a reaction varies with temperature.
Suggest an explanation why initially the reaction speed increases then above a certain temperature the speed decreases.

(b) An organic compound decomposes to give off nitrogen.

\[ C_6H_5N_2Cl(aq) \rightarrow C_6H_5Cl(l) + N_2(g) \]

The speed of this reaction can be determined by measuring the volume of nitrogen formed at regular intervals. Typical results are shown in the graph below.

(i) The reaction is catalysed by copper. Sketch the graph for the catalysed reaction on the diagram above.

(ii) How does the speed of this reaction vary with time?

(iii) Why does the speed of reaction vary with time?

5 The rate of the reaction between iron and aqueous bromine can be investigated using the apparatus shown below.
(a) A piece of iron was weighed and placed in the apparatus. It was removed at regular intervals and the clock was paused. The piece of iron was washed, dried, weighed and replaced. The clock was restarted. This was continued until the solution was colourless. The mass of iron was plotted against time. The graph shows the results obtained.

(i) Suggest an explanation for the shape of the graph.

.......................................................................................................................................................................................................................................................... [3]

(ii) Predict the shape of the graph if a similar piece of iron with a much rougher surface had been used. Explain your answer.

.......................................................................................................................................................................................................................................................... [2]

(iii) Describe how you could find out if the rate of this reaction depended on the speed of stirring.

................................................................................................................................................................................................................................................................... [2]

Q# 10/ iGCSE Chemistry/2010/s/Paper 31/ Q4
(b) The only difference in the two experiments was the method used to hold down the magnesium. The results are shown below.
(i) In which experiment did the magnesium react faster?

(ii) Suggest a reason why the experiment chosen in (i) had the faster rate.

(d) Give two factors which would alter the rate of this reaction. For each factor explain why it alters the rate.

factor .................................................................................................................. [4]

explanation ...........................................................................................................

factor ..................................................................................................................

explanation ...........................................................................................................

Q# 11/ iGCSE Chemistry/2008/s/Paper 31/

6 Three of the factors that can influence the rate of a chemical reaction are:

- physical state of the reactants
- light
- the presence of a catalyst

(a) The first recorded dust explosion was in a flour mill in Italy in 1785. Flour contains carbohydrates. Explosions are very fast exothermic reactions.

(i) Use the collision theory to explain why the reaction between the particles of flour and the oxygen in the air is very fast.

(ii) Write a word equation for this exothermic reaction.

The decomposition of silver(1) bromide is the basis of film photography. The equation for this decomposition is:

\[ 2\text{AgBr} \rightarrow 2\text{Ag} + \text{Br}_2 \]

white \hspace{1cm} \text{black}
This reaction is photochemical. A piece of white paper was coated with silver(I) bromide and the following experiment was carried out.

Initially

- not covered
- covered with thin paper
- covered with thick card

Paper coated with silver(I) bromide

Some time later with the card and paper removed

- black
- grey
- white

Exposure to light

(b) Explain the results.

Q# 12/ iGCSE Chemistry/2007/w/Paper 3/

7 (a) A small piece of marble, calcium carbonate, was added to 5 cm³ of hydrochloric acid at 25 °C. The time taken for the reaction to stop was measured.

\[
\text{CaCO}_3(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow \text{CaCl}_2(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})
\]

Similar experiments were performed always using 5 cm³ of hydrochloric acid.

<table>
<thead>
<tr>
<th>experiment</th>
<th>number of pieces of marble</th>
<th>concentration of acid in mol/ dm³</th>
<th>temperature/ °C</th>
<th>time / min</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1.00</td>
<td>25</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>0.50</td>
<td>25</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>1 piece crushed</td>
<td>1.00</td>
<td>25</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>1.00</td>
<td>35</td>
<td>2</td>
</tr>
</tbody>
</table>
Explain each of the following in terms of collisions between reacting particles.

(i) Why is the rate in experiment 2 slower than in experiment 1?

(ii) Why is the rate in experiment 3 faster than in experiment 1?

(iii) Why is the rate in experiment 4 faster than in experiment 1?

(b) An alternative method of measuring the rate of this reaction would be to measure the volume of carbon dioxide produced at regular intervals.

(i) Sketch this graph

```
volume

\[\text{time}\]
```

[2]
7 The rate of a reaction depends on concentration of reactants, temperature and possibly a catalyst or light.

(a) A piece of magnesium ribbon was added to 100 cm$^3$ of 1.0 mol/dm$^3$ hydrochloric acid. The hydrogen evolved was collected in a gas syringe and its volume measured every 30 seconds.

In all the experiments mentioned in this question, the acid was in excess. The results were plotted to give a graph.
(i) The experiment was repeated. Two pieces of magnesium ribbon were added to 100 cm³ of 1.0 mol/dm³ hydrochloric acid. Sketch this graph on the same grid and label it X. [2]

(ii) The experiment was repeated using one piece of magnesium ribbon and 100 cm³ of 1.0 mol/dm³ ethanoic acid. Describe how the shape of this graph would differ from the one given on the grid. [2]

(b) Reaction rate increases when concentration or temperature is increased. Using the idea of reacting particles, explain why:

increasing concentration increases reaction rate. [2]

increasing temperature increases reaction rate. [2]

(c) The rate of a photochemical reaction is affected by light. A reaction, in plants, between carbon dioxide and water is photochemical.

(i) Name the two products of this reaction. [2]

(ii) This reaction will only occur in the presence of light and another chemical. Name this chemical. [1]
2 The following apparatus was used to measure the rate of the reaction between zinc and iodine.

\[
\text{to balance} \\
100 \text{cm}^3 \text{ of aqueous iodine,} \\
0.1 \text{ mol/dm}^3 \text{ at 25 } ^\circ \text{C} \\
\text{mixture stirred by} \\
\text{magnetic stirrer} \\
\text{thin plate of zinc}
\]

The mass of the zinc plate was measured every minute until the reaction was complete.

(c) From the results of this experiment two graphs were plotted.

\begin{align*}
\text{graph 1} & : \quad \text{mass of plate} \\
\text{time} & \\
\text{graph 2} & : \quad \text{loss of mass} \\
\text{time} & 
\end{align*}

(i) Which reagent iodine or zinc was in excess? Give a reason for your choice.

\[\text{...} \] [1]

(ii) Describe how the shape of graph 1 would change if 100 cm\(^3\) of 0.05 mol/dm\(^3\) iodine had been used.

\[\text{...} \] [2]

(iii) On graph 2, sketch the shape if the reaction had been carried out using 100 cm\(^3\) of 0.1 mol/dm\(^3\) iodine at 35 \(^\circ\)C instead of at 25 \(^\circ\)C.

\[\text{...} \] [2]
Q# 15/ iGCSE Chemistry/2004/w/Paper 3/ Q1

(d) The rate of photosynthesis of pond weed can be measured using the following experiment.

![Diagram of photosynthesis experiment](image)

(i) Describe how you could show that the gas collected in this experiment is oxygen.

(ii) What measurements are needed to calculate the rate of this reaction?

(iii) What would be the effect, and why, of moving the apparatus further away from the light?

Q# 16/ iGCSE Chemistry/2004/s/Paper 3/ Q3

(c) The rate of this reaction can be measured using the following apparatus.

![Diagram of reaction setup](image)
The results of this experiment are shown on the graph below.

(i) How does the rate of this reaction vary with time?

(ii) Why does the rate vary?

(iii) The reaction is catalysed by copper powder. Sketch the graph for the catalysed reaction on the same grid.

(iv) Why is copper powder more effective as a catalyst than a single piece of copper?

Q# 17/ GCSE Chemistry/2003/w/Paper 3/

2 Some of the factors that can determine the rate of a reaction are concentration, temperature and light intensity.

(a) A small piece of calcium carbonate was added to an excess of hydrochloric acid. The time taken for the carbonate to react completely was measured.

$$\text{CaCO}_3(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow \text{CaCl}_2(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$$

The experiment was repeated at the same temperature, using pieces of calcium carbonate of the same size but with acid of a different concentration. In all the experiments an excess of acid was used.

<table>
<thead>
<tr>
<th>concentration of acid / mol dm$^{-3}$</th>
<th>4</th>
<th>2</th>
<th>2</th>
<th>........</th>
</tr>
</thead>
<tbody>
<tr>
<td>number of pieces of carbonate</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>time / s</td>
<td>........</td>
<td>80</td>
<td>........</td>
<td>160</td>
</tr>
</tbody>
</table>
(i) Complete the table (assume the rate is proportional to both the acid concentration and the number of pieces of calcium carbonate). [3]

(ii) Explain why the reaction rate would increase if the temperature was increased. [2]

(iii) Explain why the rate of this reaction increases if the piece of carbonate is crushed to a powder. [1]

(iv) Fine powders mixed with air can explode violently. Name an industrial process where there is a risk of this type of explosion. [1]

(b) Sodium chlorate(1) decomposes to form oxygen and sodium chloride. This is an example of a photochemical reaction. The rate of reaction depends on the intensity of the light.

\[ 2\text{NaClO}_3(aq) \rightarrow 2\text{NaCl}(aq) + \text{O}_2(g) \]

(i) Describe how the rate of this reaction could be measured. [2]

(ii) How could you show that this reaction is photochemical? [1]

13.8.1 ESSENTIAL EXAM QUESTIONS Paper 3/4 T7.1 & 7.2 139marks Mark Scheme

Q# 1/ IGCSE Chemistry/2015/w/Paper 31/
Q# 2/ IGCSE Chemistry/2015/s/Paper 31/

3(b)(i) zinc displaces copper or zinc more reactive than copper;
   \[ \text{Zn} + \text{Cu}^2+ \rightarrow \text{Zn}^{2+} + \text{Cu} \]
   OR \[ \text{Zn} + \text{Cu}^{2+} \rightarrow \text{Cu} + \text{Zn}^{2+} \]

2 A copper less reactive than zinc
   - zinc reacts with copper ions or with Cu\(^{2+}\)
   - zinc reacts with copper
   - Cu\(^{2+}\) ions are reduced
   - A multiple of state symbols

3(b)(ii) steeper (line) or higher gradient;
   (means an) increased rate;
   but the same (final) volume;

A less time to complete the reaction/same amount of gas in less time/faster reaction/more gas in the same time period
A same volume of hydrogen produced
A ‘amount’ for volume
A no extra gas is made

Q# 3/ IGCSE Chemistry/2014/s/Paper 31/

6 (a) (i) rate at t_2 less than at t_1 or the rate decreases (1)
   rate at t_1 zero/reaction stopped (1) [2]
   (ii) rate at t_2 less than at t_1 because concentration of hydrogen peroxide is less at t_2 or concentration of hydrogen peroxide is decreasing. (1)
   (rate at t_2 zero/reaction stopped because) hydrogen peroxide is used up (1) [2]

(b) (i) steeper and must come from the origin (1)
final volumes the same (1) [2]
   (ii) Any two from:
   - steeper curve because of a faster rate
   - faster rate because of increased surface area
   - same amount/volume/mass/no of mol of hydrogen peroxide
ecf for M1 for a shallower curve because of slower rate.

(c) filter (and rinse/wash) (1)
   dry manganese(IV) oxide (1)
   weigh/measure mass manganese(IV) oxide after reaction (1)
   the mass should be 0.1g or unchanged. (1) [4]

Q# 4/ IGCSE Chemistry/2013/w/Paper 31/

4 (a) (i) (mass at t =0) – (mass at t = 5)
   NOTE: must have mass at t = 5 not final mass (1)
   (ii) fastest at origin
   slowing down between origin and flat section gradient = 0
   where gradient = 0
   three of above in approximately the correct positions [2]
   (iii) 3 correct comments about gradient = [2]
   2 correct comments about gradient = [1]
   1 correct comment about gradient = [0] [2]

(b) start at origin and smaller gradient
   same final mass just approximate rather than exact [1] [1]
Q# 5/ IGCSE Chemistry/2013/s/Paper 31/

3 (a) (i) pieces have (same) surface area  
same amount / mass / quantity / volume / number of moles of carbonate [1]

(ii) no more bubbles / carbon dioxide or piece disappears / dissolves [1]

(b) experiment 1 Ca^{2+} + CO_2 + H_2O [1]

(c) (i) more concentrated or higher concentration (of acid) (in experiment 1)  
accept: arguments based on collision theory [1]

(iii) lower temperature (particles) have less energy  
moving more slowly [1]

fewer collisions / lower collision rate [1]

or  
lower temperature (particles) have less energy  
Fewer particles collide [1]

with the necessary energy to react [1]

note: less energy fewer successful collisions gains all 3 marks [1]

Q# 6/ IGCSE Chemistry/2012/w/Paper 31/

5 (a) (i) rate of reaction;  
Influenced by light / only happens in light; [1]

or:  
turns light into chemical energy = [2]

accept: light is catalyst = [1]

(ii) reduction of silver halides;  
they are reduced to silver / \( 2AgCl \rightarrow 2Ag + Cl_2 \); [1]

appropriate importance givern; [1]

or:  
photosynthesis;  
correct comment about Chemistry carbon dioxide to carbohydrates / carbon  
dioxide to oxygen;  
anything sensible e.g. its role in the food chain or decrease greenhouse  
effect or oxygen for respiration;  
or:  
chlorination;  
making chloroalkanes;  
appropriate importance given; [1]

Q# 7/ IGCSE Chemistry/2012/w/Paper 31/ Q5

(iii) keeps rate high / increase rate at lower temperatures; [1]
Q# 8/ IGCSE Chemistry/2012/w/Paper 31/ 
3  (a) (i) any three from:
particles have more energy;
move faster;
collide more frequently;
more successful collisions;
accept: atoms or molecules for particles
not: electrons
not: vibrate more

(ii) reaction faster with temperature increase;
enzymes denatured / destroyed;
not: killed

(b) (i) bigger initial gradient;
same final volume of nitrogen;

(ii) decrease / slows down;

(iii) concentration of organic compound decreases;
compound used up = [1]
or: fewer particles;
collision rate decreases;

Q# 9/ IGCSE Chemistry/2011/w/Paper 31/

5  (a) (i) rate of reaction decreases / gradient decreases
because concentration of bromine decreases
reaction stops because all bromine is used up

(ii) initial rate greater / gradient greater
because bigger surface area / more particles of iron exposed
or:
fine mass the same
because mass of bromine is the same so the same mass of iron is used

(iii) increase / decrease / change rate of stirring / not stirred
measure new rate / compare results

Q# 10/ IGCSE Chemistry/2010/s/Paper 31/ Q4

(b) (i) with copper / first experiment

(ii) copper acts as a catalyst

(d) temperature / heat
increase temperature – reaction faster particles have more energy / particles move faster / particles collide more frequently / more particles have enough energy to react
not more excited
accept arguments for a decrease in temperature

powdered greater surface area
greater collision rate / more particles exposed (to acid)
any two
not concentration / light / catalyst / pressure
Q# 11/ iGCSE Chemistry/2008/s/Paper 31/

6 (a) (i) (fine powder) large surface area
high/faster/collision rate/more collisions/fast collisions
(between solid and oxygen in air)

(ii) carbohydrate + oxygen → carbon dioxide + water
ACCEPT flour

(b) rate depends on light
more light more silver or blacker
thicker card less light

Q# 12/ iGCSE Chemistry/2007/w/Paper 3/

7 (a) (i) lower concentration
ACCEPT without reference to experiment 2
but higher concentration must be referred to exp 1
COND fewer collisions or lower rate of collision

(ii) powdered so larger surface area
COND so more collisions or higher rate of collisions

(iii) higher temperature particles move faster
or more particles have enough energy to react or have more energy
or more particles have Ea
COND collide more frequently
or more particles have energy to react
or more collisions result in a reaction

NOTE for conformity faster collisions = rate of collisions

(b) (i) from origin
gradient decreases until = 0
therefore has to be a curve

Q# 13/ iGCSE Chemistry/2006/w/Paper 3/

7 (a) (i) greater initial slope or levels off later
Twice final volume

(ii) smaller slope
same final volume

(b) more particles in same volume/particles closer together
greater collision rate
molecules move faster
greater collision rate

OR molecules have more energy
so more will have sufficient energy to react

(c) (i) glucose
oxygen

(ii) chlorophyll
Q# 14/ iGCSE Chemistry/2005/s/Paper 3/ Q2

(c) (i) zinc and a reason
Do not mark conseq to iodine in excess

(ii) final mass of zinc bigger or the level section higher or less zinc used up
gradient less steep or longer time or falls more slowly

(iii) steeper gradient
same loss of mass of zinc

Q# 15/ iGCSE Chemistry/2004/w/Paper 3/ Q1 GCSE Chemistry/201

(d) (i) glowing splint burst into flame or rekindled
Must have glowing or equivalent idea
OR any similar description that includes the two points glowing and relights.

(ii) measure volume or count bubbles
NOT units

(iii) rate slows down
Because the reaction is photochemical or rate depends on intensity of light
or light less bright or less light falling on plant or light provides energy for
photosynthesis etc.

Q# 16/ iGCSE Chemistry/2004/s/Paper 3/ Q3

(c) (i) decreases or reaction stops or rate becomes zero

(ii) concentration or number of effective collisions
decreases
used up or less chemical or less collisions etc [1] only

(iii) greater initial slope
same final point
as long as new curve touches the original curve near
the top allocate the mark

(iv) greater surface area

Q# 17/ iGCSE Chemistry/2003/w/Paper 3/

2 (a) (i) 40
80 or 40
1

(ii) particles have more energy or moving faster
collide more frequently
or collide with more energy

(iii) greater surface area

(iv) flour mills or coal mines or metal powders
or fireworks or gunpowder

(b) (i) collect and measure volume of oxygen
or mass or count bubbles
time

(ii) measure rate in different light levels and comment
accept if dark no reaction

13.9 ESSENTIAL EXAM QUESTIONS Paper 6 Topic 7.1 and 7.2 151 marks
A student investigated the rate of reaction between solution L, solution M and hydrochloric acid. When these chemicals react they form iodine. Sodium thiosulfate solution and starch solution were used to show how fast the reaction proceeded.

Five experiments were done.

**Experiment 1**
- A measuring cylinder was used to add 10 cm³ of solution L to a conical flask.
- 10 cm³ of dilute hydrochloric acid, 10 cm³ of sodium thiosulfate solution and 1 cm³ of starch solution were then added to the conical flask.
- The reaction was started by using a measuring cylinder to add 10 cm³ of solution M to the conical flask. A timer was started immediately and the mixture was swirled.
- The time taken for the mixture to turn blue-black was measured.
- The conical flask was emptied and rinsed with distilled water.

**Experiment 2**
- A measuring cylinder was used to add 8 cm³ of solution L and 2 cm³ of distilled water to the conical flask.
- 10 cm³ of dilute hydrochloric acid, 10 cm³ of sodium thiosulfate solution and 1 cm³ of starch solution were then added to the conical flask.
- The reaction was started by using a measuring cylinder to add 10 cm³ of solution M to the conical flask. The timer was started immediately and the mixture was swirled.
- The time taken for the mixture to turn blue-black was measured.
- The conical flask was emptied and rinsed with distilled water.

**Experiment 3**
- Experiment 2 was repeated but 6 cm³ of solution L and 4 cm³ of distilled water were added to the conical flask before adding the other reagents.

**Experiment 4**
- Experiment 2 was repeated but 5 cm³ of solution L and 5 cm³ of distilled water were added to the conical flask before adding the other reagents.

**Experiment 5**
- Experiment 2 was repeated but 3 cm³ of solution L and 7 cm³ of distilled water were added to the conical flask before adding the other reagents.
(a) Use the stop-clock diagrams to record the time taken for each experiment in the table.

<table>
<thead>
<tr>
<th>experiment number</th>
<th>volume of solution L/cm³</th>
<th>volume of distilled water cm³</th>
<th>stop-clock diagram</th>
<th>time taken for the mixture to turn blue-black/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>0</td>
<td><img src="image" alt="Stop-Clock Diagram" /></td>
<td><img src="image" alt="Stop-Clock Diagram" /></td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>2</td>
<td><img src="image" alt="Stop-Clock Diagram" /></td>
<td><img src="image" alt="Stop-Clock Diagram" /></td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>4</td>
<td><img src="image" alt="Stop-Clock Diagram" /></td>
<td><img src="image" alt="Stop-Clock Diagram" /></td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>5</td>
<td><img src="image" alt="Stop-Clock Diagram" /></td>
<td><img src="image" alt="Stop-Clock Diagram" /></td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>7</td>
<td><img src="image" alt="Stop-Clock Diagram" /></td>
<td><img src="image" alt="Stop-Clock Diagram" /></td>
</tr>
</tbody>
</table>
(b) Plot the results for Experiments 1–5 on the grid. Draw a smooth line graph.

(c) From your graph, deduce the time taken for the mixture to turn blue-black if Experiment 2 were repeated using 4 cm³ of solution L and 6 cm³ of distilled water.

Show clearly on the grid how you worked out your answer.
(d) (i) In which experiment, 1, 2, 3, 4 or 5, was the rate of reaction greatest?
[1]

(ii) Explain, in terms of particles, why the rate of reaction was greatest in this experiment.

........................................................................................................................................[2]

(e) (i) Suggest an advantage of using a graduated pipette instead of a measuring cylinder to measure solution L.
[1]

(ii) Suggest and explain a disadvantage of using a graduated pipette instead of a measuring cylinder to measure solution M.

........................................................................................................................................[2]

(f) Suggest one way to improve the reliability of the results of these experiments.
[1]

Q# 2 IGCSE Chemistry/2018/s/Paper 61/Q2

2 A student investigated the rate of reaction between dilute hydrochloric acid and aqueous sodium thiosulfate. When these chemicals react they form a precipitate which makes the solution go cloudy. The formation of this precipitate can be used to show how fast the reaction proceeds.

Five experiments were done using the apparatus shown.
Experiment 1

- A large measuring cylinder was used to pour 50 cm$^3$ of aqueous sodium thiosulfate into a 250 cm$^3$ conical flask. The conical flask was placed on a printed sheet of paper.
- 10 cm$^3$ of dilute hydrochloric acid was added to the solution in the conical flask. A timer was started immediately and the mixture was swirled.
- The time taken for the printed words to disappear from view was measured.

Experiment 2

- The large measuring cylinder was used to pour 40 cm$^3$ of aqueous sodium thiosulfate into a conical flask, followed by 10 cm$^3$ of distilled water. The conical flask was placed on the printed sheet of paper.
- 10 cm$^3$ of dilute hydrochloric acid was added to the solution in the conical flask. The timer was started immediately and the mixture was swirled.
- The time taken for the printed words to disappear from view was measured.

Experiment 3

- Experiment 2 was repeated but using 35 cm$^3$ of aqueous sodium thiosulfate and 15 cm$^3$ of distilled water.

Experiment 4

- Experiment 2 was repeated but using 30 cm$^3$ of aqueous sodium thiosulfate and 20 cm$^3$ of distilled water.

Experiment 5

- Experiment 2 was repeated but using 10 cm$^3$ of aqueous sodium thiosulfate and 40 cm$^3$ of distilled water.
(a) Record the volumes of distilled water used in the table. Use the stop-clock diagrams to record the results in the table.

<table>
<thead>
<tr>
<th>experiment</th>
<th>volume of aqueous sodium thiosulfate/cm³</th>
<th>volume of distilled water/cm³</th>
<th>stop-clock diagram</th>
<th>time taken for the printed words to disappear from view/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50</td>
<td></td>
<td><img src="image1" alt="Stop-Clock Diagram" /></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>40</td>
<td></td>
<td><img src="image2" alt="Stop-Clock Diagram" /></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>35</td>
<td></td>
<td><img src="image3" alt="Stop-Clock Diagram" /></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>30</td>
<td></td>
<td><img src="image4" alt="Stop-Clock Diagram" /></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td></td>
<td><img src="image5" alt="Stop-Clock Diagram" /></td>
<td></td>
</tr>
</tbody>
</table>
(b) Plot the results from Experiments 1–5 on the grid. Draw a smooth line graph.

(c) (i) From your graph, deduce the time taken for the printed words to disappear from view if Experiment 2 were repeated using 20 cm³ of aqueous sodium thiosulfate and 30 cm³ of distilled water.

Show clearly on the grid how you worked out your answer.

........................................... s [2]
(ii) The rate of reaction can be calculated using the equation shown.

\[ \text{rate of reaction} = \frac{1}{\text{time taken}} \]

Calculate the rate of reaction using your answer from (c)(i).

.......................................................... [1]

(d) (i) In which experiment, 1, 2, 3, 4 or 5, was the rate of reaction greatest?

.......................................................... [1]

(ii) Explain, in terms of particles, why the rate of reaction was greatest in this experiment.

..........................................................

.......................................................... [2]

(e) Give the name of a more accurate piece of apparatus for measuring volumes than a measuring cylinder.

.......................................................... [1]

(f) Suggest the effect on the results of using a 100 cm\(^2\) conical flask instead of a 250 cm\(^2\) conical flask. Explain your answer.

..........................................................

.......................................................... [2]

(g) Sketch on the grid the graph you would expect if all of the experiments were repeated at a lower temperature. Clearly label your graph.

[Total: 16]
2 A student investigated the rate of reaction between dilute hydrochloric acid and aqueous sodium thiosulfate. When these chemicals react they form a precipitate which makes the solution go cloudy. The formation of this precipitate can be used to show how fast the reaction proceeds.

Five experiments were carried out using the apparatus shown.

Experiment 1

- Using a measuring cylinder, 50 cm³ of aqueous sodium thiosulfate were poured into a conical flask. The initial temperature of the solution was measured. The conical flask was placed on a sheet of paper with words printed on it.
- Using a measuring cylinder, 10 cm³ of dilute hydrochloric acid were added to the solution in the conical flask and a stopclock was started.
- The time taken for the printed words to disappear from view was measured.
- The final temperature of the mixture was measured.

Experiment 2

- Using a measuring cylinder, 50 cm³ of aqueous sodium thiosulfate were poured into a conical flask. The solution was heated to about 30°C and the temperature was measured. The conical flask was placed on a sheet of paper with words printed on it.
- Using a measuring cylinder, 10 cm³ of dilute hydrochloric acid were added to the solution in the conical flask and a stopclock was started.
- The time taken for the printed words to disappear from view was measured.
- The final temperature of the mixture was measured.

Experiment 3

- Experiment 2 was repeated but the 50 cm³ of aqueous sodium thiosulfate were heated to about 40°C before adding the dilute hydrochloric acid.

Experiment 4

- Experiment 2 was repeated but the 50 cm³ of aqueous sodium thiosulfate were heated to about 50°C before adding the dilute hydrochloric acid.

Experiment 5

- Experiment 2 was repeated but the 50 cm³ of aqueous sodium thiosulfate were heated to about 60°C before adding the dilute hydrochloric acid.
(a) Calculate the average temperatures and record them in the table. Use the stopwatch diagrams to record the times in the table.

<table>
<thead>
<tr>
<th>experiment number</th>
<th>initial temperature of the solution/°C</th>
<th>final temperature of the mixture/°C</th>
<th>average temperature/°C</th>
<th>stopwatch diagram</th>
<th>time taken for the printed words to disappear from view/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>19</td>
<td>17</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>32</td>
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<td>4</td>
<td>54</td>
<td>52</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>65</td>
<td>61</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
(b) Plot the results of Experiments 1–5 on the grid. Draw a smooth line graph.

(c) From your graph, deduce the time taken for the printed words to disappear from view when Experiment 2 was repeated at an initial temperature of 73°C. The final temperature of the mixture was 71°C.

Show clearly on the grid how you worked out your answer.

.................................................................................................................................................. [3]

(d) Sketch on the grid the graph you would expect if all of the experiments were repeated using a more dilute solution of aqueous sodium thiosulfate. [1]
(e) (i) In which experiment, 1, 2, 3, 4 or 5, was the rate of reaction greatest? 

(ii) Explain, in terms of particles, why the rate of reaction was greatest in this experiment.

(f) Suggest and explain the effect on the results of using

(i) a burette to measure the volumes,

(ii) a 100 cm³ conical flask instead of a 250 cm³ conical flask.

Q4/ IGCSE Chemistry/2017/s/Paper 63/Q2

2 A student investigated the rate of reaction between magnesium ribbon and two different solutions of dilute sulfuric acid, solution G and solution H. The acid was in excess in both experiments.

Two experiments were carried out.

Experiment 1

- The apparatus was set up as shown in the diagram.

- Using a measuring cylinder, 50 cm³ of solution G were poured into the conical flask. A piece of magnesium ribbon was added to the conical flask and the bung replaced.
- The timer was started immediately and the total volume of gas collected in the measuring cylinder was measured every 20 seconds for 180 seconds (3 minutes).
Experiment 2

- Experiment 1 was repeated using 50 cm³ of solution H instead of solution G.

**(a)** Use the measuring cylinder diagrams to record the volumes of gas collected in Experiment 1.

<table>
<thead>
<tr>
<th>time /s</th>
<th>measuring cylinder diagram</th>
<th>volume of gas /cm³</th>
<th>volume of gas /cm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>![Cylinder Diagram]</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20</td>
<td>![Cylinder Diagram]</td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>40</td>
<td>![Cylinder Diagram]</td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>60</td>
<td>![Cylinder Diagram]</td>
<td></td>
<td>21</td>
</tr>
<tr>
<td>80</td>
<td>![Cylinder Diagram]</td>
<td></td>
<td>27</td>
</tr>
<tr>
<td>100</td>
<td>![Cylinder Diagram]</td>
<td></td>
<td>33</td>
</tr>
<tr>
<td>120</td>
<td>![Cylinder Diagram]</td>
<td></td>
<td>39</td>
</tr>
<tr>
<td>140</td>
<td>![Cylinder Diagram]</td>
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<td>45</td>
</tr>
<tr>
<td>160</td>
<td>![Cylinder Diagram]</td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>180</td>
<td>![Cylinder Diagram]</td>
<td></td>
<td>55</td>
</tr>
</tbody>
</table>
(b) Plot the results for Experiments 1 and 2 on the grid and draw two smooth line graphs. Clearly label your graphs.

(c) Which experiment had the faster rate of reaction? Suggest a reason why the rate was faster in this experiment.
(d) The average rate of this reaction can be calculated using the equation shown.

\[
\text{average rate} = \frac{\text{volume of gas/cm}^3}{\text{time taken/s}}
\]

For Experiment 1, calculate the average rate of reaction for the first 30 seconds of the reaction. Include the units.

rate = ………………………

units = ……………………… [3]

(e) Why, eventually, will no more gas be produced?

………………………………………………………………………………………………………………… [1]

(f) Suggest the effect on the rate of reaction of using the same mass of magnesium powder instead of magnesium ribbon. Explain your answer.

…………………………………………………………………………………………………………………

………………………………………………………………………………………………………………… [2]

(g) Give one advantage and one disadvantage of using a measuring cylinder to measure the volumes of solution G and solution H.

advantage ……………………………………………………………………………………………………

disadvantage ……………………………………………………………………………………………… [2]

(h) Suggest one improvement to these experiments.

………………………………………………………………………………………………………………… [1]
A student investigated the reaction between aqueous potassium manganate(VII), solution A, and two solutions of iron(II) sulfate, solution B and solution C, of different concentrations.

Two experiments were carried out:

**Experiment 1**

- A burette was filled with solution A to the 0.0 cm³ mark.
- A measuring cylinder was used to pour 25 cm³ of solution B into a conical flask.
- Solution A was added to the flask, while the flask was swirled, until the mixture just turned permanently pink. The burette reading was recorded.

(a) Use the burette diagram to record the reading in the table and complete the table.

<table>
<thead>
<tr>
<th>final burette reading/cm³</th>
<th>initial burette reading/cm³</th>
<th>difference/cm³</th>
</tr>
</thead>
</table>

**Experiment 2**

- Experiment 1 was repeated using 25 cm³ of solution C instead of solution B. In Experiment 2 the burette was not filled to the 0.0 cm³ mark.

(b) Use the burette diagrams to record the readings in the table and complete the table.

<table>
<thead>
<tr>
<th>final burette reading/cm³</th>
<th>initial burette reading/cm³</th>
<th>difference/cm³</th>
</tr>
</thead>
</table>
(c) Why is an indicator **not** added to the conical flask?

________________________________________________________________________________________ [1]

(d) (i) Which solution of iron(II) sulfate, solution B or solution C, is the more concentrated? Explain your answer.

________________________________________________________________________________________ [2]

(ii) How many times more concentrated is this solution of iron(II) sulfate?

________________________________________________________________________________________ [1]

(e) (i) If Experiment 2 were repeated using 50 cm³ of solution C, what volume of solution A would be needed? Explain your answer.

________________________________________________________________________________________ [2]

(ii) Suggest a practical problem that using 50 cm³ of solution C in this investigation would cause. Suggest a practical solution to the problem.

problem ........................................................................................................................................

solution .......................................................................................................................................... [2]

(f) Give **one** advantage and **one** disadvantage of using a measuring cylinder instead of a 25 cm³ pipette for solution B.

advantage ........................................................................................................................................

disadvantage .................................................................................................................................. [2]

(g) How would the results be improved by taking repeated measurements?

________________________________________________________________________________________

________________________________________________________________________________________ [1]
Q# 6/ IGCSE Chemistry/2017/s/Paper 61/Q2

2 A student investigated the reaction between aqueous sodium thiosulfate and two different aqueous solutions of potassium iodate labelled solution C and solution D.

Two experiments were carried out.

Experiment 1

- A burette was filled with aqueous sodium thiosulfate. The initial burette reading was recorded.
- Using a measuring cylinder, 20 cm³ of solution C were poured into a conical flask. 10 cm³ of dilute sulfuric acid and 1 g of potassium iodide were added to the flask to form a solution of iodine. The flask was swirled to mix the contents.
- Aqueous sodium thiosulfate was slowly added from the burette to the flask and swirled to mix thoroughly.
- When the contents of the flask turned pale yellow, starch solution was added and the solution turned blue-black.
- More aqueous sodium thiosulfate was then added slowly to the flask until the solution just turned colourless. The final burette reading was recorded.

(a) Use the burette diagrams to record the readings in the table and complete the table.

```
<table>
<thead>
<tr>
<th>final burette reading/cm³</th>
<th>initial burette reading/cm³</th>
<th>difference/cm³</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```

[2]

Experiment 2

- The conical flask was emptied and rinsed with distilled water.
- Experiment 1 was repeated using solution D instead of solution C.

(b) Use the burette diagrams to record the readings in the table and complete the table.

```
<table>
<thead>
<tr>
<th>final burette reading/cm³</th>
<th>initial burette reading/cm³</th>
<th>difference/cm³</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```

[2]
(c) (i) Which solution of potassium iodate, solution C or solution D, is the more concentrated? Explain your answer.

.................................................................................................................................................. [2]

(ii) How many times more concentrated is this solution of potassium iodate?

.................................................................................................................................................. [1]

(d) Predict the volume of aqueous sodium thiosulfate which would be needed to react completely with 30 cm$^3$ of solution D.

.................................................................................................................................................. [2]

(e) (i) State two sources of error in the experiments.

1. ............................................................................................................................................... 

2. ............................................................................................................................................... [2]

(ii) Suggest two improvements to reduce the sources of error in (e)(i).

1. ............................................................................................................................................... 

2. ............................................................................................................................................... [2]

Q# 7/ IGCSE Chemistry/2016/w/Paper 62/Q2

2 A student investigated the rate of reaction between dilute hydrochloric acid and excess magnesium at room temperature. The apparatus was set up as shown in the diagram.

30 cm$^3$ of dilute hydrochloric acid were added to the conical flask containing magnesium ribbon. The timer was then started and the volume of gas collected in the measuring cylinder was measured every 20 seconds for 180 seconds (3 minutes).
(a) Use the measuring cylinder diagrams to record the total volume of gas collected in the table.

<table>
<thead>
<tr>
<th>time/s</th>
<th>measuring cylinder diagram</th>
<th>total volume of gas collected/cm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>![Diagram for 0 s]</td>
<td>30</td>
</tr>
<tr>
<td>20</td>
<td>![Diagram for 20 s]</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>![Diagram for 40 s]</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>![Diagram for 60 s]</td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>![Diagram for 80 s]</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>![Diagram for 100 s]</td>
<td></td>
</tr>
<tr>
<td>120</td>
<td>![Diagram for 120 s]</td>
<td></td>
</tr>
<tr>
<td>140</td>
<td>![Diagram for 140 s]</td>
<td></td>
</tr>
<tr>
<td>160</td>
<td>![Diagram for 160 s]</td>
<td></td>
</tr>
<tr>
<td>180</td>
<td>![Diagram for 180 s]</td>
<td></td>
</tr>
</tbody>
</table>
(b) Plot the results on the grid and draw a smooth line graph.

(c) (i) Which result is anomalous?

(ii) Suggest a possible reason for this anomalous result.

(iii) Use your graph to deduce the total volume of gas that you would have expected to collect instead of this anomalous volume. Show clearly on the grid how you worked out your answer.
(d) Explain why the total volume of gas collected does not increase after 160 seconds.

.................................................................................................................................................. [2]

(e) The average rate of the reaction can be calculated using the equation shown.

\[
\text{average rate of reaction} = \frac{\text{volume of gas collected/cm}^3}{\text{time/s}}
\]

(i) Calculate the volume of gas collected between 20 seconds and 40 seconds.

.................................................................................................................................................. [1]

(ii) Calculate the average rate of reaction between 20 seconds and 40 seconds. Include the unit.

\[
\text{average rate of reaction} = \text{.................................} \quad [2]
\]

(f) Room temperature was 20°C.

Sketch on the grid the graph you would expect if the experiment were repeated at 30°C. [2]

(g) Suggest why the reading on the measuring cylinder was 30 cm³ after the acid had been added and before the timer had been started.

.................................................................................................................................................. [1]

(h) Suggest and explain one improvement to this experiment.

.................................................................................................................................................. [2]
2 A student investigated the rate of reaction between hydrogen peroxide and aqueous potassium iodide. When these chemicals react they form iodine. Sodium thiosulfate solution reacts with iodine and can be used to show how fast the reaction proceeds.

(a) A burette was filled up to the 0.0 cm³ mark with sodium thiosulfate solution.
   Using a large measuring cylinder, 100 cm³ of distilled water were poured into a conical flask.
   Using a small measuring cylinder, 6 cm³ of sulfuric acid, 1 cm³ of starch solution and 4 cm³ of aqueous potassium iodide were added to the flask.
   0.5 cm³ of sodium thiosulfate solution was added from the burette to the mixture in the flask and swirled to mix.
   The reaction was then started by adding 3 cm³ of hydrogen peroxide solution to the mixture, and the timer started.
   The time taken for a blue colour to appear was noted.
   A further 0.5 cm³ of sodium thiosulfate solution was added to the mixture in the conical flask, swirled and the blue colour disappeared. The time when the blue colour reappeared was noted.
   The experiment continued by adding further 0.5 cm³ portions of sodium thiosulfate solution until a total of 3.0 cm³ of sodium thiosulfate solution had been added, noting the times at which the blue colour reappeared.

Use the timer diagrams on page 4 to record the times in seconds in the table.
<table>
<thead>
<tr>
<th>Total volume of sodium thiosulfate solution added / cm³</th>
<th>Timer diagram</th>
<th>Time at which blue colour appeared / s</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td><img src="image" alt="Timer" /></td>
<td></td>
</tr>
<tr>
<td>1.0</td>
<td><img src="image" alt="Timer" /></td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td><img src="image" alt="Timer" /></td>
<td></td>
</tr>
<tr>
<td>2.0</td>
<td><img src="image" alt="Timer" /></td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td><img src="image" alt="Timer" /></td>
<td></td>
</tr>
<tr>
<td>3.0</td>
<td><img src="image" alt="Timer" /></td>
<td></td>
</tr>
</tbody>
</table>
(b) Plot the results you have obtained on the grid and draw a best-fit straight-line graph.

(c) (i) From your graph deduce the time at which the blue colour would appear if a total of 4.0 cm$^3$ of sodium thiosulfate solution were added to the mixture in the conical flask.
Show clearly on the grid how you worked out your answer.

(ii) Sketch on the grid the graph you would expect if the experiment was repeated at a higher temperature.
(d) Suggest the purpose of the starch solution.

............................................................................................................................ [1]

(e) (i) Suggest one advantage of using a pipette to measure the volume of the hydrogen peroxide.

............................................................................................................................ [1]

(ii) Suggest and explain one disadvantage of using a pipette to measure the volume of the hydrogen peroxide.

........................................................................................................................................ [2]

(f) Explain one disadvantage of using a beaker instead of a conical flask.

........................................................................................................................................ [1]

Q# 9/ iGCSE Chemistry/2016/m/Paper 62/Q2

2 A teacher investigated the rate of a reaction between two solutions, J and K, and sulfuric acid at different temperatures.

Four experiments were carried out.

(a) Experiment 1

A large measuring cylinder was used to pour 50 cm$^3$ of distilled water and 40 cm$^3$ of sulfuric acid into a 250 cm$^3$ conical flask.

A small measuring cylinder was used to add 2 cm$^3$ of methyl orange and 5 cm$^3$ of solution J to the mixture in the conical flask. The temperature of the mixture was measured.

The reaction was started by adding 5 cm$^3$ of solution K to the conical flask, immediately starting the timer and swirling the mixture.

The time taken for the mixture to turn pale yellow was measured. The final temperature of the mixture was measured.

Experiment 2

Experiment 1 was repeated but the mixture in the conical flask was heated to about 30°C before adding the solution K. The temperature of the mixture was measured.

5 cm$^3$ of solution K was added to the conical flask. The timer was started and the mixture swirled.

The time taken for the mixture to turn pale yellow was measured. The final temperature of the mixture was measured.

Experiment 3

Experiment 1 was repeated but the mixture in the conical flask was heated to about 40°C before adding the solution K to the flask. The same measurements were taken.
Experiment 4

Experiment 1 was repeated but the mixture in the conical flask was heated to about 50°C before adding the solution K to the flask. The same measurements were taken.

Stop-clock diagrams for these experiments are on page 4.

Use the stop-clock diagrams to record the times in the table.

Work out the average temperatures to complete the table.

<table>
<thead>
<tr>
<th>experiment</th>
<th>stop-clock diagram</th>
<th>time taken for mixture to turn pale yellow /s</th>
<th>initial temperature /°C</th>
<th>final temperature /°C</th>
<th>average temperature /°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><img src="image" alt="Stop Clock 1" /></td>
<td>20</td>
<td>17</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td><img src="image" alt="Stop Clock 2" /></td>
<td>15</td>
<td>28</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td><img src="image" alt="Stop Clock 3" /></td>
<td>30</td>
<td>42</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td><img src="image" alt="Stop Clock 4" /></td>
<td>45</td>
<td>51</td>
<td>49</td>
<td></td>
</tr>
</tbody>
</table>
(b) Plot the results on the grid and draw a smooth line graph.

(c) From your graph deduce the time taken for the mixture to turn pale yellow if Experiment 1 was repeated at an average temperature of 60 °C. Show clearly on the grid how you worked out your answer.
(d) (i) In which experiment was the rate of reaction greatest? [1]

(ii) Explain why the rate of reaction was greatest in this experiment. [2]

(e) (i) Suggest and explain the effect on the results of using a burette to measure the volume of solution J. [2]

(ii) Suggest and explain one other improvement to these experiments. [2]

13.9.1 ESSENTIAL EXAM QUESTIONS Paper 6 Topic 7.1 and 7.2 151 marks Mark Scheme

Q# 1/ iGCSE Chemistry/2018/w/Paper 62/Q2

<table>
<thead>
<tr>
<th>2(a)</th>
<th>Table of results for experiments 1–5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Times completed</td>
</tr>
<tr>
<td></td>
<td>26, 30, 56, 60, 111</td>
</tr>
<tr>
<td></td>
<td>in seconds</td>
</tr>
</tbody>
</table>

| 2(b) | All points plotted correctly       |
|      | Smooth line graph                   |

| 2(c) | Value from graph                    |
|      | indication on graph                 |
|      | unit                                |

| 2(d)(i) | Experiment 1                        |
|         |                                     |
| 2(d)(ii) | More particles (of solution L present per unit volume) |
|         | more frequent collisions / particles collide more often / higher collision rate |

| 2(e)(i) | More accurate                       |
|         |                                     |
| 2(e)(ii) | Too slow / slower addition of solution / takes longer to add |
|         | Measuring time taken less accurate / results less accurate |

| 2(f) | Repeat and average / compare results |
|      |                                     |
### Q# 2/ IGCSE Chemistry/2018/s/Paper 61/Q2

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2(a)</td>
<td>volume boxes completed correctly in seconds&lt;br&gt;0, 10, 15, 20, 40&lt;br&gt;time boxes completed correctly&lt;br&gt;27, 33, 45, 68, 201</td>
</tr>
<tr>
<td>2(b)</td>
<td>all points plotted correctly (¼ half a square)&lt;br&gt;smooth line graph</td>
</tr>
<tr>
<td>2(c)(i)</td>
<td>value from graph&lt;br&gt;with clear indication</td>
</tr>
<tr>
<td>2(c)(ii)</td>
<td>1 value from (c)(i)</td>
</tr>
<tr>
<td>2(d)(i)</td>
<td>experiment 1</td>
</tr>
<tr>
<td>2(d)(ii)</td>
<td>more particles of thioulate (in a given volume)&lt;br&gt;more chance of collision</td>
</tr>
<tr>
<td>2(e)</td>
<td>use a pipette/burette</td>
</tr>
<tr>
<td>2(f)</td>
<td>times would be shorter&lt;br&gt;idea of depth of solution is greater</td>
</tr>
<tr>
<td>2(g)</td>
<td>sketch curve roughly same shape and above original</td>
</tr>
</tbody>
</table>

### Q# 3/ IGCSE Chemistry/2017/w/Paper 61/

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2(a)</td>
<td>average temperature completed for all five experiments: 18, 31, 41, 53, 63&lt;br&gt;times completed for all five experiments: 219, 111, 54, 66, 54&lt;br&gt;all times in seconds</td>
</tr>
<tr>
<td>2(b)</td>
<td>all five points plotted&lt;br&gt;smooth line graph</td>
</tr>
<tr>
<td>2(c)</td>
<td>value from graph for average temperature 72 °C&lt;br&gt;unit (c)&lt;br&gt;shown clearly</td>
</tr>
<tr>
<td>2(d)</td>
<td>line above experimental line</td>
</tr>
<tr>
<td>2(e)(i)</td>
<td>Experiment 5</td>
</tr>
<tr>
<td>2(e)(ii)</td>
<td>particles move faster / particles have more energy&lt;br&gt;more (frequent) collisions / greater chance of collisions</td>
</tr>
<tr>
<td>2(f)(i)</td>
<td>more accurate&lt;br&gt;comparison to measuring cylinder</td>
</tr>
<tr>
<td>2(f)(ii)</td>
<td>time shorter / cross disappears faster&lt;br&gt;depth greater</td>
</tr>
</tbody>
</table>

### Q# 4/ IGCSE Chemistry/2017/s/Paper 63/

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2(a)</td>
<td>all volume boxes completed correctly: 0, 13, 25, 38, 48, 59, 70, 79, 86, 90</td>
</tr>
<tr>
<td>2(b)</td>
<td>origin plotted&lt;br&gt;other points correctly plotted&lt;br&gt;two smooth lines&lt;br&gt;labelled</td>
</tr>
<tr>
<td>2(c)</td>
<td>Experiment 1&lt;br&gt;more concentrated /stronger acid / the acid has a lower pH</td>
</tr>
<tr>
<td>2(d)</td>
<td>volume of gas at 30 s</td>
</tr>
<tr>
<td></td>
<td>correct calculation of rate</td>
</tr>
<tr>
<td></td>
<td>unit: cm³/s OR cm³·s⁻¹</td>
</tr>
<tr>
<td>2(e)</td>
<td>all the magnesium will have reacted</td>
</tr>
<tr>
<td>2(f)</td>
<td>faster reaction/increased rate</td>
</tr>
<tr>
<td></td>
<td>magnesium powder has a higher surface area</td>
</tr>
<tr>
<td>2(g)</td>
<td>advantage: easy to use/quick</td>
</tr>
<tr>
<td></td>
<td>disadvantage: not accurate</td>
</tr>
<tr>
<td>2(h)</td>
<td>use of burette/pipette/gas syringe/weighed amount of magnesium/repeat experiment (and average)/clean the magnesium/remove oxide layer</td>
</tr>
</tbody>
</table>

Q# 5/ IGCSE Chemistry/2017/s/Paper 62/

| 2(a) | initial volume completed correctly: 0.0 |
|      | final volume completed correctly: 13.0 |
|      | difference: 13.0 | 1 |
| 2(b) | final volume, initial volume and difference completed correctly: 41.1, 2.1 and 39.0 |
|      | all readings in (a) and (b) to 1 d.p. | 1 |
| 2(c) | there is a colour change at the end-point already | 1 |
| 2(d)(i) | solution C |
|      | a greater volume of potassium manganate(VII)/solution A was needed | 1 |
| 2(d)(ii) | 3 x as concentrated | 1 |
| 2(e)(i) | double the volume of solution C was used/double the volume of solution A was needed | 1 |
|      | 78 cm³ | 1 |
| 2(e)(ii) | problem: volume of potassium manganate(VII) solution added would be greater than 50 cm³ |
|      | solution: use more than one burette/refill burette | 1 |
| 2(f) | advantage: easy (to use)/quick | 1 |
|      | disadvantage: not accurate | 1 |
| 2(g) | can take average or mean / can spot anomalies /more reliable | 1 |

Q# 6/ IGCSE Chemistry/2017/s/Paper 61/

| 2(a) | initial and final readings completed correctly: 4.1, 38.3 |
|      | difference completed correctly: 34.2 | 1 |
| 2(b) | initial and final readings completed correctly: 3.7, 20.8 |
|      | difference completed correctly: 17.1 | 1 |
| 2(c)(i) | solution C is more concentrated | 1 |
|      | a greater volume of thiosulfate was needed | 1 |
| 2(c)(ii) | 2 x as concentrated | 1 |
Q# 7/ IGCSE Chemistry/2016/w/Paper 62/

| 2(a) | table of results volume boxes completed correctly (30, 44, 67, 62, 79, 85, 86, 86, 90, 90) | 2 |
| 2(b) | all points correctly plotted smooth line graph | 2 |
| 2(c)(i) | point at 60 s/62 cm³/fourth point/measurement 4 | 1 |
| 2(c)(ii) | misread measuring cylinder/read too early | 1 |
| 2(c)(iii) | value from graph (68–70) shown clearly | 1 |
| 2(d) | the Reaction has finished all the acid has reacted/HCl is the limiting factor | 1 |
| 2(e)(ii) | value from graph or table (57–44 = 13 cm³) | 1 |
| 2(e)(ii) | 13/20 + 0.65 cm³/s | 1 |
| 2(f) | steeper curve to same level | 1 |
| 2(g) | air is displaced (when the acid is added) | 1 |
| 2(h) | improvement explanation use a burette/graduated pipette/gas syringe improves accuracy OR use cotton thread to hold a test-tube (containing the acid) in the flask no air is collected OR repeat the experiment take average/more frequent readings | 1 |

Q# 8/ IGCSE Chemistry/2016/s/Paper 62/

| 2(a) | all 6 lines completed correctly (2 marks) (22, 43, 64, 86, 105, 126) 5 lines completed correctly (1 mark); in seconds; | 3 |
| 2(b) | appropriate scale for y-axis/increasing at 20 s per large square; y-axis is a linear scale; all 6 points plotted correctly ± half a small square (2 marks); 5 points plotted correctly ± half a small square (1 mark); best-fit straight-line graph; | 5 |
| 2(c)(i) | value from graph ± half a small square (typically 167–170); units/s; extrapolation; | 3 |
| 2(c)(ii) | sketch line below original line and diverging; | 1 |
| 2(d)(i) | as an indicator; | 1 |
| 2(e)(i) | (more) accurate; | 1 |
| 2(e)(ii) | solution slow to run out of pipette; difficult to know when to start timer/reaction does not start at once/inaccurate time measurement owls; | 2 |
| 2(f) | difficulty in swirling/mixing/shaking; | 1 |
### 13.10  FUNDAMENTAL Assessed Activity 1 Keyword Test

<table>
<thead>
<tr>
<th>Topic #</th>
<th>English</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>enzymes</td>
<td>protein molecules that act as biological catalysts</td>
</tr>
<tr>
<td>7</td>
<td>photochemical reaction</td>
<td>a chemical reaction that occurs when light, usually of a particular wavelength, falls on the reactants</td>
</tr>
<tr>
<td></td>
<td>denature</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>photosynthesis</td>
<td>the chemical process by which plants synthesise glucose from atmospheric carbon dioxide and water: the energy required for the process is captured from sunlight by chlorophyll molecules in the green leaves of the plants</td>
</tr>
<tr>
<td>7</td>
<td>reaction rate</td>
<td>a measure of how fast a reaction takes place</td>
</tr>
<tr>
<td>7</td>
<td>speed of reaction</td>
<td>a less accurate name for reaction rate</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
13.11  ESSENTIAL Assessed Activity 2 Topic 7.1 & 7.2 Paper 2 15marks

Q# 1/
14  Copper(II) carbonate reacts with dilute sulfuric acid.

\[ \text{CuCO}_3(s) + \text{H}_2\text{SO}_4(aq) \rightarrow \text{CuSO}_4(aq) + \text{CO}_2(g) + \text{H}_2\text{O}(l) \]

The rate of the reaction can be changed by varying the conditions.

Which changes always increase the rate of this chemical reaction?

1  increasing the concentration of sulfuric acid  
2  increasing the size of the pieces of copper(II) carbonate  
3  increasing the temperature  
4  increasing the volume of sulfuric acid  

A  1, 3 and 4  B  1 and 3 only  C  2 and 3  D  3 and 4 only

15  Which reaction is not affected by the presence of light?

A  a candle burning  
B  methane reacting with chlorine  
C  photosynthesis  
D  silver bromide decomposing to form silver

Q# 2/
14  An experiment X is carried out between a solid and a solution using the apparatus shown.

![Diagram of apparatus](image)

The volume of gas given off is measured at different times and the results plotted on a graph.

In a second experiment Y, the surface area of the solid is increased but all other factors remain the same.

Which graph shows the results of experiments X and Y?

A  ![Graph A](image)  B  ![Graph B](image)
15 Which change in conditions increases the energy of the particles in a reaction?

A addition of a catalyst  
B increase in concentration  
C increase in surface area  
D increase in temperature

Q#3/

14 Zinc granules are reacted with excess dilute hydrochloric acid.  
The volume of hydrogen given off is measured at different times.  
The results are shown on the graph, labelled experiment 1.  
The results for a second experiment are also shown on the graph, labelled experiment 2.

Which change to the conditions was made in experiment 2?

A The concentration of the hydrochloric acid was decreased.  
B The size of the zinc granules was decreased.  
C The surface area of the zinc granules was increased.  
D The temperature was increased.
15 In an experiment nitric acid is added to excess marble chips and the volume of carbon dioxide formed is measured.

The experiment is repeated using smaller marble chips. All other conditions remain the same.

Which statement about the second experiment is correct?

A The collisions are more frequent and higher energy.
B The collisions are more frequent and the same energy.
C The collisions are the same frequency and the same energy.
D The collisions are the same frequency and higher energy.

Q# 4/
13 The energy level diagram for a reaction is shown.

Which statement is not correct for this energy level diagram?

A It could be the energy level diagram for the reaction when petrol is burnt.
B Less energy is released in bond forming than is needed for bond breaking.
C The activation energy, \( E_a \), has a positive value.
D The energy change, \( \Delta H \), for the reaction is positive.

14 The rate of reaction between magnesium and excess dilute hydrochloric acid was followed by measuring the mass of magnesium present at regular time intervals.

Two experiments were performed.

Both experiments used 0.1g of magnesium ribbon. The acid in experiment 1 was less concentrated than in experiment 2.

Which graph shows the results of the experiments?
15 Which statement explains why coal dust forms an explosive mixture with air?

A  Coal dust catalyses the explosion.  
B  Coal dust has a large surface area.  
C  Crushing coal increases the concentration of the coal.  
D  Crushing coal increases the temperature of the coal.

Q# 5/
15 Which row explains why increasing temperature increases the rate of reaction?

<table>
<thead>
<tr>
<th></th>
<th>particles collide more often</th>
<th>particles collide with more energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>B</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>C</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>D</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

Q# 6/
15 Which row describes how the energy of collision between particles changes when concentration and temperature are increased?

<table>
<thead>
<tr>
<th></th>
<th>concentration</th>
<th>temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>increases</td>
<td>increases</td>
</tr>
<tr>
<td>B</td>
<td>increases</td>
<td>no change</td>
</tr>
<tr>
<td>C</td>
<td>no change</td>
<td>increases</td>
</tr>
<tr>
<td>D</td>
<td>no change</td>
<td>no change</td>
</tr>
</tbody>
</table>
Q# 7/
14 A liquid X reacts with solid Y to form a gas.

Which two diagrams show suitable methods for investigating the rate (speed) of the reaction?

A 1 and 3  B 1 and 4  C 2 and 3  D 2 and 4

Q# 8/
15 Which statements explain why increasing temperature increases the rate of a chemical reaction?

1 Heat makes the molecules move faster and collide more often.
2 Heat makes the molecules collide with more energy so they are more likely to react.
3 Increasing temperature lowers the activation energy for the reaction.

A 1 and 2  B 1 and 3  C 1 only  D 2 only

Q# 8/
15 Which statement about catalysts in chemical reactions is not correct?

A Catalysts are not used up in the reaction.
B Catalysts increase the energy of the reacting particles.
C Catalysts increase the rate of the reaction.
D Catalysts lower the activation energy.
The diagram shows an energy level diagram for a reaction.

The diagram shows that the reaction is endothermic.

Increasing the temperature increases the rate of reaction. A reason for this is that the activation energy decreases.

Which words correctly complete gaps 1 and 2?

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>endothermic</td>
<td>activation energy decreases</td>
</tr>
<tr>
<td>B</td>
<td>endothermic</td>
<td>collision rate increases</td>
</tr>
<tr>
<td>C</td>
<td>exothermic</td>
<td>activation energy decreases</td>
</tr>
<tr>
<td>D</td>
<td>exothermic</td>
<td>collision rate increases</td>
</tr>
</tbody>
</table>

13.12 Extension Assessed Activity 3 Paper 3/4 17marks

Q# 18/

(c) Aqueous hydrogen peroxide decomposes to form water and oxygen.

\[ 2\text{H}_2\text{O}_2(\text{aq}) \rightarrow 2\text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g}) \]

This reaction is catalysed by manganese(IV) oxide.

The following experiments were carried out to investigate the rate of this reaction.

A 0.1 g sample of manganese(IV) oxide was added to 20 cm³ of 0.2 M hydrogen peroxide solution. The volume of oxygen produced was measured every minute. The results of this experiment are shown on the graph.
(i) How does the rate of reaction vary with time? Explain why the rate varies.

...........................................................................................................................................................................[3]

(ii) The following experiment was carried out at the same temperature.

0.1 g of manganese(IV) oxide and 20 cm\(^3\) of 0.4 M hydrogen peroxide

Sketch the curve for this experiment on the same grid. \[2\]

(iii) How would the shape of the graph differ if only half the mass of catalyst had been used in these experiments?

...........................................................................................................................................................................[2]
Q# 19/

(d) The graph shows how the rate of the exothermic reaction between aluminium and hydrochloric acid varies with time.

![Graph showing rate of reaction vs time]

(i) Suggest a reason why the reaction goes slowly at first.

......................................................................................................................................................[1]

(ii) Suggest two reasons for the increase in rate.

..............................................................................................................................................................[2]

Q# 20/

2 Fermentation of sugars is one method of making ethanol. Vines produce glucose by photosynthesis. The glucose collects in the grapes which grow in clusters on the vine.

(b) Explain how the vine produces glucose by photosynthesis.

..............................................................................................................................................................[4]

Q# 21/

(v) Give another example of a reaction that is influenced by light. Describe one important application of this reaction.

reaction ..................................................................................................................................................

application ..............................................................................................................................................[3]
13.13 ESSENTIAL End of Topic Review and Reflection
Looking at the goals you could have achieved and the goals you actually achieved try to reflect on your progress.

Try to be as honest and as detailed as possible. Sometimes you may think you have thought about an idea well, but when you talk with someone else, or write it out, it helps you better understand and allows you think more completely and more clearly.

Did you achieve more goals this topic than last topic?

Fill in this table

<table>
<thead>
<tr>
<th>Level</th>
<th>Number of goals achieved at each level</th>
<th>Success rate, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>FUNDAMENTAL</td>
<td>/5</td>
<td></td>
</tr>
<tr>
<td>ESSENTIAL</td>
<td>/10</td>
<td></td>
</tr>
<tr>
<td>EXTENSION</td>
<td>/13</td>
<td></td>
</tr>
<tr>
<td>EXCEPTIONAL</td>
<td>/10</td>
<td></td>
</tr>
</tbody>
</table>

Do you feel you tried harder? If yes, what helped you to do so? If not, why not?

What could you do differently next time, in addition to what you are already doing to improve, not only your score in the end of topic tests and other assessed activities, but also in how you learn. How could you become a more effective student to get more learning out of the time you are investing in your studies?

What did you enjoy most about this topic?

What did you find most difficult?

What did you find easiest?

On a scale of 1 being hardest and 5 being most difficult, circle how challenging you found this topic

1  2  3  4  5

What could be done to make this topic easier to understand?

Do you have any questions about this topic?
13.14 EXTENSION Mind Map For Topic 7.1 & 7.2
13.15 Exceptional Additional Activities, Further Reading and Exploring Beyond the Syllabus

Possible ideas for a presentation

For extremely unreactive elements check out this information:

- [https://13c35962-6df0-4843-9028-c26407054a5a.filesusr.com/ugd/d26cc6_09d1ac89ec85489bbc6d57fb6a437c9d.docx?dn=iG%20Chem%207.2%20INFO%20Wikipedia%20Noble%20metal%209](https://13c35962-6df0-4843-9028-c26407054a5a.filesusr.com/ugd/d26cc6_09d1ac89ec85489bbc6d57fb6a437c9d.docx?dn=iG%20Chem%207.2%20INFO%20Wikipedia%20Noble%20metal%209)
- [https://13c35962-6df0-4843-9028-c26407054a5a.filesusr.com/ugd/d26cc6_a077fc32486a4f7a80e66250f09392b.docx?dn=iG%20Chem%207.2%20INFO%20Wikipedia%20Helium%20Least%2020](https://13c35962-6df0-4843-9028-c26407054a5a.filesusr.com/ugd/d26cc6_a077fc32486a4f7a80e66250f09392b.docx?dn=iG%20Chem%207.2%20INFO%20Wikipedia%20Helium%20Least%2020)

Some rates are extremely fast, like those involved in the middle of a reaction, these involve things like transition states and intermediates. Try to find out about these very short lived compounds (usually called species) from this website: Chemguide:

[https://www.chemguide.co.uk/physical/basicrates/energyprofiles.html](https://www.chemguide.co.uk/physical/basicrates/energyprofiles.html)

For a much more complicated introduction to a process known as “Flash Photolysis”, be aware though that you might not understand much of this, or anything at all, but it is good to find out where your academic career might take you one day!


13.16 Exceptional Extra Credit Science in Context Topic 7.1 and 7.2

Some rates of reaction are very slow, life uses enzymes to carefully control the rates of certain reactions within a cell. A growing field of investigation is creating artificial enzymes, use the links below to find out more about these catalysts which some people think will revolutionise the way we make all of the materials, from our clothes to our buildings in the decades to come:

Enzymes in general: [https://13c35962-6df0-4843-9028-c26407054a5a.filesusr.com/ugd/d26cc6_e152e10a08314c70b4eaeeef061c9e5d.docx?dn=iG%20Chem%207.2%20INFO%20Wikipedia%20Enzyme%2028Pgs.](https://13c35962-6df0-4843-9028-c26407054a5a.filesusr.com/ugd/d26cc6_e152e10a08314c70b4eaeeef061c9e5d.docx?dn=iG%20Chem%207.2%20INFO%20Wikipedia%20Enzyme%2028Pgs.)

How much faster enzymes speed up a reaction: [https://13c35962-6df0-4843-9028-c26407054a5a.filesusr.com/ugd/d26cc6_1ef6e8f0b7f64dcc8197e710137e2443.pdf?index=true](https://13c35962-6df0-4843-9028-c26407054a5a.filesusr.com/ugd/d26cc6_1ef6e8f0b7f64dcc8197e710137e2443.pdf?index=true)

Artificial enzymes: [https://13c35962-6df0-4843-9028-c26407054a5a.filesusr.com/ugd/d26cc6_b3e22e817cb74bf9b78ab3a53a4037a4.pdf](https://13c35962-6df0-4843-9028-c26407054a5a.filesusr.com/ugd/d26cc6_b3e22e817cb74bf9b78ab3a53a4037a4.pdf)

This website provides free academic articles about the biosciences, check it out!

[https://www.webmedcentral.com/#](https://www.webmedcentral.com/#)
14 Topics 7.3 Reversible Reactions, 11.3 Nitrogen & Fertilisers & 12 Sulfur (Equilibria)

14.1 End of Topic 7.3, 11.3 and 12 Goals Checklist

For each topic you ought to try to do as many of the following things to get the most out of your time, the resources available to you and to help you grow as a student. Tick each goal off as you complete it. Growth is difficult and uncomfortable, but you should choose to do these things, and the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win!

<table>
<thead>
<tr>
<th>Aspect</th>
<th>What you should have done</th>
<th>Yes/No</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interacted with your teacher</td>
<td>Ask your teacher 1 question, about anything, once a week</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Try to answer one question asked by your teacher at least once a week</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Ask your teacher one question about something you do not understand in science once a week</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Ask your teacher one question about something to do with science every lesson</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td>Notes and follow up notes</td>
<td>Complete set of class note</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Attempted</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Completed</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Completed to an exemplary standard</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Attempted the Mind Map for this topic</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Completed the Mind Map for this topic</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td>Textbook</td>
<td>Read ahead before the topic has been started</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Highlighted key ideas and translate new words</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Completed the questions at the end of each 2 page spread in your exercise book</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Added to your class notes ideas and important information from the textbook that you learnt</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td>Past Exam Questions</td>
<td>Worked on at least 25% of the exam questions in this workbook</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Attempted more than 25% of the questions and those questions you have completed you have marked in a different colour pen</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Completed and marked all questions here</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Completed, marked and additional key ideas where you have located the most difficult marks added to your notebook</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Used the resources available online to answer additional questions not found in this workbook on the current topic.</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Ask your teacher about an exam question that they cannot answer</td>
<td></td>
<td>EXCEPTIONALLY SMASHING!!!</td>
</tr>
<tr>
<td>Assessed Activities</td>
<td>Complete the word list activity using the word list at the front of each topic as little as possible</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities, either in class or as homework</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 70% on average</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 80% on average</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 90% on average</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td>End of Topic Test</td>
<td>Revised sufficiently well to improve upon your score from the previous test (except if you are scoring over 90%, then just write Y for this goal)</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Scored 10% higher than your current average</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Scored 15% or more than your previous end of topic average</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Scored over 90%</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Scored over 95%</td>
<td></td>
<td>SMASHING!!!</td>
</tr>
<tr>
<td>Aspect</td>
<td>What you should have done</td>
<td>Yes/No</td>
<td>Level</td>
</tr>
<tr>
<td>--------</td>
<td>---------------------------</td>
<td>--------</td>
<td>-------</td>
</tr>
<tr>
<td>Reading</td>
<td>Spend more than 1 hour a week reading a book you enjoy (in any language) about anything.</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Spend more than 3 hours a week reading a book you enjoy (in any language) about anything.</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Spend more than 5 hours a week reading a book you enjoy (in any language) about anything.</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Spend at least one hour a week reading a book you enjoy in English about anything.</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Spend more than 3 hours a week reading a book you enjoy in English about anything.</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td>Reflection</td>
<td>You completed this goal setting table</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>You have looked at the goals you have achieved and the ones you have not and added them up and entered them into the table in the Review and Reflection section</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>You have given an answer for every question in the Review and Reflection section at the end of this topic</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>You have given good and thoughtful answers for every question in the Review and Reflection section at the end of this topic</td>
<td></td>
<td>EXCEPTIONAL</td>
</tr>
</tbody>
</table>

14.2 Topics 7.3, 11.3 & 12 Equilibria Syllabus

**Topic 7 Chemical Reactions**

### 7.3 Reversible reactions

**Core**
- Understand that some chemical reactions can be reversed by changing the reaction conditions. (Limited to the effects of heat and water on hydrated and anhydrous copper(II) sulfate and cobalt(II) chloride.) (Concept of equilibrium is not required.)

**Supplement**
- Predict the effect of changing the conditions (concentration, temperature and pressure) on other reversible reactions
- Demonstrate knowledge and understanding of the concept of equilibrium

### 7.4 Redox

**Core**
- Define oxidation and reduction in terms of oxygen loss/gain. (Oxidation state limited to its use to name ions, e.g. iron(II), iron(III), copper(II), manganate(VII))

**Supplement**
- Define redox in terms of electron transfer
- Identify redox reactions by changes in oxidation state and by the colour changes involved when using acidified potassium manganate(VII), and potassium iodide. (Recall of equations involving KMnO₄ is not required.)
- Define oxidising agent as a substance which oxidises another substance during a redox reaction. Define reducing agent as a substance which reduces another substance during a redox reaction.
- Identify oxidising agents and reducing agents from simple equations

**Top 11 Air and Water**
### 11.3 Nitrogen and fertilisers

**Core**
- Describe the need for nitrogen-, phosphorus- and potassium-containing fertilisers
- Describe the displacement of ammonia from its salts

**Supplement**
- Describe and explain the essential conditions for the manufacture of ammonia by the Haber process including the sources of the hydrogen and nitrogen, i.e. hydrocarbons or steam and air

### 12 Sulfur

**Core**
- Name some sources of sulfur
- Name the use of sulfur in the manufacture of sulfuric acid
- State the uses of sulfur dioxide as a bleach in the manufacture of wood pulp for paper and as a food preservative (by killing bacteria)

**Supplement**
- Describe the manufacture of sulfuric acid by the Contact process, including essential conditions and reactions
- Describe the properties and uses of dilute and concentrated sulfuric acid

### 14.3 ESSENTIAL Glossary for Keywords for this topic

<table>
<thead>
<tr>
<th>English</th>
<th>英语</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>dynamic (chemical) equilibrium</strong> two chemical reactions, one the reverse of the other, taking place at the same time, where the concentrations of the reactants and products remain constant because the rate at which the forward reaction occurs is the same as that of the back reaction</td>
<td>动态（化学）平衡两个化学反应，一个同时发生，这是同时发生的，反应物和产物的浓度保持恒定，因为发生正向反应的速率与反向发生的速率相同反应</td>
</tr>
<tr>
<td><strong>equilibrium</strong> a less precise name for dynamic equilibrium</td>
<td>平衡动态平衡的较不精确的名称</td>
</tr>
<tr>
<td><strong>reversible reaction</strong> a chemical reaction which can go either forwards or backwards, depending on the conditions</td>
<td>可逆反应，取决于条件，可以向前或向后进行的化学反应</td>
</tr>
<tr>
<td><strong>acid rain</strong> this has been made more acidic than normal by the presence of dissolved pollutants such as sulfur dioxide (SO2) and nitrogen oxides (NOx)</td>
<td>酸雨由于溶解的污染物（例如二氧化硫（SO2）和氨氧化物（NOx））的存在，使酸雨比正常情况下更加酸性</td>
</tr>
<tr>
<td><strong>artificial fertiliser</strong> a substance added to soil to increase the amount of elements such as nitrogen, potassium and phosphorus (NPK fertilisers): this enables crops to grow more healthily and produce higher yields</td>
<td>人工肥料一种添加到土壤中以增加氮、钾和磷等元素含量的物质（NPK肥料）：这可使农作物更健康地生长并产生更高的产量</td>
</tr>
<tr>
<td><strong>carbon cycle</strong> the system by which carbon and its compounds in the air, oceans and rocks are interchanged</td>
<td>碳循环系统，通过该系统可以交换空气、海洋和岩石中的碳及其化合物</td>
</tr>
<tr>
<td><strong>Haber process</strong> the industrial manufacture of ammonia by the reaction of nitrogen with hydrogen in the presence of an iron catalyst</td>
<td>Haber过程在铁催化剂的存在下使氮与氢反应来工业化生产氨</td>
</tr>
<tr>
<td><strong>nitrogen cycle</strong> the system by which nitrogen and its compounds, both in the air and in the soil, are interchanged</td>
<td>氮循环系统，通过该系统可以交换空气和土壤中的氮及其化合物</td>
</tr>
<tr>
<td><strong>Contact process</strong> the industrial manufacture of sulfuric acid using the raw materials sulfur and air</td>
<td>使用原料硫和空气进行接触式工业硫酸生产</td>
</tr>
</tbody>
</table>
Write a number next to each of these statement to indicate the order that is needed to make ammonia in the Haber Process:

1. Steam is reacted with methane to make hydrogen.
2. The gases are passed over an iron catalyst.
3. The gases are heated to 450°C.
4. Hydrogen is mixed with nitrogen, obtained from air.
5. The gases are compressed to 200 atmospheres.
6. Ammonia gas is produced, then cooled to a liquid.
7. Liquid ammonia is pumped off to be sold.
8. Unreacted nitrogen and hydrogen are recycled.

Q6. The flow chart below shows the main stages in the production of ammonium nitrate.

(a) (i) Name the two raw materials shown in the flow chart as A and B.

Raw material A ........................................................

Raw material B ........................................................
(ii) What is the purpose of the iron in the reactor?
............................................................................................................................
............................................................................................................................
............................................................................................................................
............................................................................................................................
............................................................................................................................
............................................................................................................................
............................................................................................................................

(ii) The table shows how temperature and pressure affect the amount of ammonia produced in this reaction.

<table>
<thead>
<tr>
<th>TEMPERATURE (°C)</th>
<th>PRESSURE (ATM)</th>
<th>PERCENTAGE OF NITROGEN AND HYDROGEN CONVERTED TO AMMONIA (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>250</td>
<td>200</td>
<td>75</td>
</tr>
<tr>
<td>250</td>
<td>1000</td>
<td>96</td>
</tr>
<tr>
<td>1000</td>
<td>1</td>
<td>0.01</td>
</tr>
<tr>
<td>1000</td>
<td>1000</td>
<td>1</td>
</tr>
</tbody>
</table>

Explain, as fully as you can, why a temperature of about 450°C and a pressure of about 100 atmospheres are normally used in the industrial process.
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............................................................................................................................
............................................................................................................................
............................................................................................................................
............................................................................................................................
............................................................................................................................

14.5  ESSENTIAL Classroom Active Learning Tasks 2 The Contact Process

*Complete this table*

<table>
<thead>
<tr>
<th>Reagent</th>
<th>Formula</th>
<th>Main Source (and other sources)</th>
<th>Chemical equation (if appropriate)</th>
<th>Reaction conditions, including catalysts, if any</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfur</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulfur Dioxide</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulfur Trioxide</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oleum</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulfuric Acid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In the space below create a flow diagram, like one used to explain the Haber process in the activity before to show how sulfuric acid is made from sulfur. Include as many chemical equations, with state symbols, as you can.
Compare and contrast what these two concentrations of the same acid and show what they have in common and how are they different to each other.

Concentrated Sulfuric Acid
\[ \text{c.} \text{H}_2\text{SO}_4(\text{l}) \]

Dilute Sulfuric Acid
\[ \text{dil.} \text{H}_2\text{SO}_4(\text{aq}) \]
14.7 Extension Classroom Active Learning Tasks 3 Dealing with Multi-mark Questions about Equilibria 84 marks

Q# 1/ IGCSE Chemistry/2018/w/Paper 43/Q5

5 A student investigates the rate of reaction between lumps of calcium carbonate and dilute hydrochloric acid using the apparatus shown.

\[
\text{CaCO}_3(s) + 2\text{HCl}(aq) \rightarrow \text{CaCl}_2(aq) + \text{CO}_2(g) + \text{H}_2\text{O}(l)
\]

The calcium carbonate was in excess.

(a) Which measurements should the student make during the reaction to determine the rate of reaction?

................................................................................................................................................ [2]

(b) What happens to the rate of reaction as the reaction proceeds? Explain your answer.

................................................................................................................................................
................................................................................................................................................
................................................................................................................................................ [3]

(c) The student repeated the experiment at a higher temperature. All other conditions were kept the same. The student found that the rate of reaction increased.

Explain, in terms of collisions, why the rate of reaction increased.

................................................................................................................................................
................................................................................................................................................
................................................................................................................................................
................................................................................................................................................ [4]
(c) The original experiment was repeated at a higher temperature. All other conditions were kept the same.

Describe and explain, in terms of collisions between particles, the effect of using a higher temperature on the time taken for the reaction to finish.

................................................................................................................................................................................
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................................................................................................................................................................................
................................................................................................................................................................................
................................................................................................................................................................................
................................................................................................................................................................................
................................................................................................................................................................................
................................................................................................................................................................................  [5]

(d) A mixture of hydrogen gas and iodine gas is allowed to reach equilibrium.

(i) Increasing the pressure of a gas increases its concentration.

State and explain the effect of increasing the pressure on the rate of the forward reaction.

................................................................................................................................................................................
................................................................................................................................................................................
................................................................................................................................................................................
................................................................................................................................................................................  [2]

(ii) State and explain the effect of increasing the temperature on the rate of the reverse reaction.

................................................................................................................................................................................
................................................................................................................................................................................
................................................................................................................................................................................
................................................................................................................................................................................  [3]

(d) Cobalt reacts with dilute hydrochloric acid to make the salt cobalt(II) chloride. Bubbles of hydrogen gas are produced.
(iii) Use collision theory to explain how heating the dilute hydrochloric acid makes the rate of reaction faster.

(b) The chemical equation shows the equilibrium between dinitrogen tetroxide (N₂O₄, a colourless gas) and nitrogen dioxide (NO₂, a brown gas).

\[
\text{N}_2\text{O}_4(g) \rightleftharpoons 2\text{NO}_2(g)
\]

A mixture of dinitrogen tetroxide and nitrogen dioxide is allowed to reach equilibrium in a closed gas syringe.

(i) In chemistry, what is meant by the term **equilibrium**?

(ii) If the equilibrium mixture is heated at constant pressure, a darker brown colour is seen inside the gas syringe.

What does this information indicate about the decomposition of dinitrogen tetroxide? Explain your answer in terms of the position of the equilibrium.

(iii) Suggest what you would see if the pressure on the equilibrium mixture were increased at constant temperature. Explain your answer in terms of the position of the equilibrium.
5 Some chemical reactions are reversible.

(a) Aqueous potassium chromate(VI), $\text{K}_2\text{CrO}_4$, is a yellow solution.

Aqueous potassium dichromate(VI), $\text{K}_2\text{Cr}_2\text{O}_7$, is an orange solution.

The two compounds interconvert when the pH of the solution changes.

$$2\text{K}_2\text{CrO}_4 + \text{H}_2\text{SO}_4 \rightleftharpoons \text{K}_2\text{Cr}_2\text{O}_7 + \text{K}_2\text{SO}_4 + \text{H}_2\text{O}$$

yellow \hspace{1cm} orange

Solution $\text{Y}$ is a mixture of aqueous potassium chromate(VI) and aqueous potassium dichromate(VI) at equilibrium.

- Explain, in terms of the position of the equilibrium, what you would see if sulfuric acid were added to solution $\text{Y}$.

- Explain, in terms of the position of the equilibrium, what you would see if sodium hydroxide were added to solution $\text{Y}$.

Q# 7/ IGCSE Chemistry/2017/w/Paper 41/Q5

(c) Nitrogen dioxide, $\text{NO}_2$, exists in equilibrium with dinitrogen tetroxide, $\text{N}_2\text{O}_4$.

Nitrogen dioxide is brown and dinitrogen tetroxide is colourless.

$$2\text{NO}_2(g) \rightleftharpoons \text{N}_2\text{O}_4(g)$$

brown \hspace{1cm} colourless

(i) A sample of nitrogen dioxide and dinitrogen tetroxide at equilibrium was placed in a closed gas syringe.

The syringe plunger was pushed in. This increased the pressure in the gas syringe. The temperature was kept constant.
State how the colour of the gas in the syringe changed. Explain your answer in terms of the position of the equilibrium.

(ii) A sealed tube containing nitrogen dioxide and dinitrogen tetroxide at equilibrium was cooled in an ice bath at constant pressure. The contents of the tube became paler.

Suggest an explanation for this observation in terms of the position of the equilibrium.

---

Q# 8/ IGCSE Chemistry/2017/w/Paper 41/

7 Copper(II) oxide reacts with dilute hydrochloric acid.

\[
\text{CuO(s) + 2HCl(aq) } \rightarrow \text{CuCl}_2(aq) + \text{H}_2\text{O(l)}
\]

6.00g of copper(II) oxide were added to 50.0cm\(^3\) of 1.00mol/dm\(^3\) hydrochloric acid. This was an excess of copper(II) oxide.

(a) The rate of the reaction can be increased by increasing the concentration of the hydrochloric acid or by heating it.

(i) In terms of collisions, explain why increasing the concentration of the hydrochloric acid increases the rate of the reaction.

(ii) In terms of collisions, explain why heating the hydrochloric acid increases the rate of the reaction.
Q# 9/ IGCSE Chemistry/2017/s/Paper 41/  
(e) The original graph has been drawn again.

On the grid, draw the graph expected if the concentration of dilute hydrochloric acid is changed from 0.1 mol/dm³ to 0.2 mol/dm³. All other conditions are the same as in the original experiment.

Explain, in terms of particles, why your graph is different from the original graph.

\[ \text{Q# 10/ IGCSE Chemistry/2016/w/Paper 41/} \]

8 Magnesium carbonate reacts with dilute hydrochloric acid.

\[ \text{MgCO}_3(s) + 2\text{HCl(aq)} \rightarrow \text{MgCl}_2(aq) + \text{H}_2\text{O(l)} + \text{CO}_2(g) \]

An excess of magnesium carbonate pieces was added to dilute hydrochloric acid. The apparatus in the diagram was used to measure the volume of gas produced. The total volume of gas collected was recorded every 20 seconds.
(a) The results obtained are shown on the graph.

![Graph showing total volume of gas collected over time.]

(i) Describe how the rate of this reaction changed during the reaction. Explain why the rate changed in this way.

(ii) The experiment was repeated using the same mass of **powdered** magnesium carbonate with the same volume and concentration of dilute hydrochloric acid.

Explain how the initial rate of reaction and total volume of gas collected would compare to the first experiment.

initial rate of reaction .................................................................

----------------------------------------------------------------------------------

total volume of gas .................................................................

----------------------------------------------------------------------------------

[4]
(b) A piece of magnesium ribbon was cleaned. The experiment was repeated using this clean magnesium ribbon instead of magnesium carbonate.

\[ \text{Mg(s)} + \text{2HCl(aq)} \rightarrow \text{MgCl}_2(\text{aq}) + \text{H}_2(\text{g}) \]

This reaction is exothermic.
The rate of the reaction gradually increased over the first 2 minutes.

Explain why the rate of the reaction increased.

Q# 11/ IGCSE Chemistry/2016/s/Paper 41/

3 When aqueous sodium thiosulfate and dilute hydrochloric acid are mixed, a precipitate of insoluble sulfur is produced. This makes the mixture difficult to see through.

\[ \text{Na}_2\text{S}_2\text{O}_3(\text{aq}) + \text{2HCl(aq)} \rightarrow \text{S(s)} + \text{2NaCl(aq)} + \text{H}_2\text{O(l)} + \text{SO}_2(\text{g}) \]

The time taken for the cross to disappear from view is measured.

A student adds the following volumes of aqueous sodium thiosulfate, dilute hydrochloric acid and distilled water to the conical flask.

The time taken for the formation of the precipitate of sulfur to make the cross disappear from view is recorded.
<table>
<thead>
<tr>
<th>experiment number</th>
<th>volume of sodium thiosulfate /cm³</th>
<th>volume of hydrochloric acid /cm³</th>
<th>volume of distilled water /cm³</th>
<th>time taken for cross to disappear from view /s</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>10</td>
<td>40</td>
<td>56</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>10</td>
<td>30</td>
<td>28</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(ii) Use collision theory to explain why increasing the concentration of sodium thiosulfate would change the rate of reaction.

(c) The student repeated experiment 1 at a higher temperature.

Use collision theory to explain why the rate of reaction would increase.

Q# 12/ IGCSE Chemistry/2016/w/Paper 41/
(b) Ammonia is also made when ammonium carbonate decomposes.

\[ \text{(NH}_4\text{)}_2\text{CO}_3(\text{s}) \rightleftharpoons 2\text{NH}_3(\text{g}) + \text{H}_2\text{O(}\text{g}) + \text{CO}_2(\text{g}) \]

The reaction is reversible and can reach a position of equilibrium.

The graph shows how the yield of ammonia at equilibrium changes with temperature and pressure.

![Graph showing yield of ammonia at different temperatures and pressures.]

(i) What is meant by the term *equilibrium* for a reversible reaction?

...........................................................................................................................................................................................................................................................................................................[2]
(iii) State and explain the effect of increasing the pressure on the yield of ammonia in this reaction.

.................................................................................................................................................. [3]

Q# 13/ IGCSE Chemistry/2016/m/Paper 42/
5 This question is about compounds of nitrogen.

(a) (i) Describe the Haber Process giving reaction conditions and a chemical equation. Reference to rate and yield is not required.

..................................................................................................................................................
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..................................................................................................................................................
..................................................................................................................................................
..................................................................................................................................................
..................................................................................................................................................

.................................................................................................................................................. [5]

Q# 14/ IGCSE Chemistry/2018/w/Paper 41/Q4
4 (a) Sulfuric acid is made industrially by a four-step process.

    step 1 Sulfur is burned in air to produce sulfur dioxide.
    step 2 Sulfur dioxide is converted into sulfur trioxide.
    step 3 Sulfur trioxide is reacted with concentrated sulfuric acid to produce oleum.
    step 4 Oleum is reacted with water to produce concentrated sulfuric acid.

(iii) Describe the conversion of sulfur dioxide into sulfur trioxide in step 2.

In your answer, include:

- a chemical equation for the reaction
- the essential reaction conditions.

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.................................................................................................................................................. [5]
5 Sulfuric acid is produced by the Contact process. The steps of the Contact process are shown.

\[
\text{starting material} \quad \text{step 1} \quad \text{sulfur dioxide} \quad \text{step 2} \quad \text{sulfur trioxide} \quad \text{step 3} \quad \text{oleum} \quad \text{step 4} \quad \text{sulfuric acid}
\]

(b) Describe step 2, giving reaction conditions and a chemical equation. Reference to reaction rate and yield is not required.

---

Extension Classroom Active Learning Tasks Dealing with Multi-mark Questions about Equilibria

84 marks Mark Scheme

Q# 1/ IGCSE Chemistry/2018/w/Paper 43/

<table>
<thead>
<tr>
<th></th>
<th>M1</th>
<th>M2</th>
</tr>
</thead>
<tbody>
<tr>
<td>5(a)</td>
<td>volume of gas</td>
<td>2</td>
</tr>
<tr>
<td>5(b)</td>
<td>rate decreases / reaction gets slower</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>concentration of acid decreases</td>
<td></td>
</tr>
<tr>
<td></td>
<td>fewer collisions per unit time</td>
<td></td>
</tr>
<tr>
<td>5(c)</td>
<td>particles have more kinetic energy</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>particles move faster</td>
<td></td>
</tr>
<tr>
<td></td>
<td>more collisions per unit time</td>
<td></td>
</tr>
<tr>
<td></td>
<td>more of the particles have energy greater than or equal to activation energy / more of the collisions have energy greater than or equal to activation energy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>more of the particles have sufficient energy to react / more of the collisions have sufficient energy to react</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A greater percentage or greater proportion or greater fraction of collisions are successful</td>
<td></td>
</tr>
</tbody>
</table>

Q# 2/ IGCSE Chemistry/2018/w/Paper 42/

<table>
<thead>
<tr>
<th></th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
</tr>
</thead>
<tbody>
<tr>
<td>4(c)</td>
<td>Time taken is less</td>
<td>more energy</td>
<td>move faster</td>
<td>More collisions (of particles) occur per second / per unit time</td>
<td>more of the particles / collisions have energy greater than activation energy</td>
</tr>
<tr>
<td></td>
<td>particles</td>
<td>more energy</td>
<td></td>
<td>or</td>
<td>or</td>
</tr>
<tr>
<td></td>
<td></td>
<td>moves faster</td>
<td></td>
<td>or</td>
<td>or</td>
</tr>
<tr>
<td></td>
<td></td>
<td>More of the particles / collisions have sufficient energy to react</td>
<td></td>
<td>A greater percentage / proportion / fraction of collisions (of particles) are successful</td>
<td></td>
</tr>
</tbody>
</table>
### Q# 3/ IGCSE Chemistry/2018/w/Paper 41/

<table>
<thead>
<tr>
<th>(d)(i)</th>
<th>M1 Faster and More particles per unit volume / dm³ / cm³</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>(d)(ii)</td>
<td>Reaction faster and (particles) have more energy or (particles) move faster</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>more collisions per second / unit time or greater collision rate</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>(more of the) particles / collisions have energy greater than the activation energy or more particles / collisions have sufficient energy to react or a greater percentage / proportion / fraction of collisions are successful</td>
<td>1</td>
</tr>
</tbody>
</table>

### Q# 4/ IGCSE Chemistry/2018/s/Paper 43/

<table>
<thead>
<tr>
<th>(d)(i)</th>
<th>(particles) have more energy / (particles) move faster</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>more collisions per second / greater collision rate</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>more of the colliding molecules have sufficient energy (activation energy) to react</td>
<td>1</td>
</tr>
</tbody>
</table>

### Q# 5/ IGCSE Chemistry/2017/w/Paper 43/

<table>
<thead>
<tr>
<th>(b)(i)</th>
<th>Reversible reaction in which the rate of the forward reaction equals the rate of the backward reaction</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Concentration of all reactants and products becomes constant / does not change</td>
<td>1</td>
</tr>
<tr>
<td>(b)(ii)</td>
<td>Forward reaction is endothermic</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>(increased temperature) causes equilibrium to shift to the right / to shift in the endothermic direction / to form more nitrogen dioxide / to form more product(s)</td>
<td>1</td>
</tr>
<tr>
<td>(b)(iii)</td>
<td>Less brown / lighter / paler / colour fades</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>More molecules / moles / volume on the right OR equilibrium shifts in the direction of fewer molecules / moles / lower volume</td>
<td>1</td>
</tr>
</tbody>
</table>

### Q# 6/ IGCSE Chemistry/2017/w/Paper 42/

| (a) | Both colours referred to correctly as observations in both parts of the answer | 1 |
|     | If sulfuric acid is added to solution Y, equilibrium moves to the right-hand side | 1 |
|     | Because the concentration of acid has increased | 1 |
|     | If sodium hydroxide is added to solution Y, equilibrium moves to the left-hand side | 1 |
|     | Because sodium hydroxide reacts with / neutralises sulfuric acid | 1 |
| (b)(ii) | Fewer moles / molecules / particles (of gas) on the right-hand side | 1 |
| (b)(iii) | Endothermic | 1 |
| (b)(iv) | Increases rate (of reaction) | 1 |

### Q# 7/ IGCSE Chemistry/2017/w/Paper 41/Q5

| (a)(i) | Becomes paler | 1 |
|        | Equilibrium moves right | 1 |
|        | (Because) fewer moles (of gas) on right | 1 |
| (b)(ii) | Equilibrium moved right / more N₂O₄ / less NO₂ | 1 |
|        | (Forward) reaction exothermic | 1 |

### Q# 8/ IGCSE Chemistry/2017/w/Paper 41/

| (i) | More particles (of acid) in a given volume / dm³ / cm³ | 1 |
|     | More collisions per second / unit time OR greater collision rate | 1 |
| (ii) | Particles have more energy / particles move faster / more collisions per second / greatere collisions per unit time / greater collision rate | 1 |
|     | (More of the) particles / collisions have energy greater than the activation energy / more particles have sufficient energy to react / more collisions have sufficient energy to react / a greater percentage of collisions are successful | 1 |
**Q# 9/ IGCSE Chemistry/2017/s/Paper 41/**

<table>
<thead>
<tr>
<th>Part</th>
<th>Text</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>5(d)</td>
<td>curve starts from (0,0) and has a lower gradient than the original curve because lumps have a lower surface area</td>
<td>1</td>
</tr>
<tr>
<td>5(d)</td>
<td>curve starts from (0,0) and has a lower gradient than the original curve because lumps have a lower surface area</td>
<td>1</td>
</tr>
</tbody>
</table>

**Q# 10/ IGCSE Chemistry/2016/w/Paper 41/**

<table>
<thead>
<tr>
<th>Part</th>
<th>Text</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>8(a)(i)</td>
<td>any 4 from: slowed down; acid became less concentrated or fewer particles per unit volume; fewer collisions per second or lower collision rate; then the reaction stopped; all the hydrochloric acid reacted</td>
<td>4</td>
</tr>
<tr>
<td>8(a)(ii)</td>
<td>any 4 from: faster (reaction); (powder has) larger surface area; more collisions per second or higher collision rate; same volume of gas; amount/moles hydrochloric acid is not changed</td>
<td>4</td>
</tr>
<tr>
<td>8(b)</td>
<td>any 5 from: temperature increased; particles have more energy; (particles) move faster; more collisions per second or higher collision rate; more particles have sufficient energy to react/activation energy; more of the collisions are successful</td>
<td>5</td>
</tr>
</tbody>
</table>

**Q# 11/ IGCSE Chemistry/2016/s/Paper 41/**

<table>
<thead>
<tr>
<th>Part</th>
<th>Text</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>3(b)(ii)</td>
<td>M1 more particles per unit volume; particles are closer together; M2 increases the rate of collisions; there are more collisions per unit time</td>
<td>2</td>
</tr>
<tr>
<td>3(c)</td>
<td>M1 particles gain more energy and move faster; M2 increasing rate of collisions/more collisions per unit time; M3 higher proportion of particles have sufficient energy to react/collisions have sufficient energy to react/are above the activation energy</td>
<td>3</td>
</tr>
</tbody>
</table>

**Q# 12/ IGCSE Chemistry/2016/w/Paper 41/**

<table>
<thead>
<tr>
<th>Part</th>
<th>Text</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>4(b)(i)</td>
<td>M1 forward and reverse reactions occur; M2 amounts/moles/concentrations of (reagents and products) constant or M2 rate of forward and reverse reactions equal</td>
<td>1</td>
</tr>
<tr>
<td>4(b)(ii)</td>
<td>endo/exo chemical yield increases as temperature increases</td>
<td>1</td>
</tr>
<tr>
<td>4(b)(ii)</td>
<td>M4 yield decreases (as pressure increases); M5 because more moles/molecules (of gas) on the right; M3 so position of equilibrium moves left</td>
<td>1</td>
</tr>
</tbody>
</table>

**Q# 13/ IGCSE Chemistry/2016/m/Paper 42/**

<table>
<thead>
<tr>
<th>Part</th>
<th>Text</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>5(a)(i)</td>
<td>pressure in range 150–300 atmospheres/atm; temperature in range 370–470°C; iron (catalyst); balanced equation: ( \text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3 ); equilibrium/reversible</td>
<td>5</td>
</tr>
</tbody>
</table>

**Q# 14/ IGCSE Chemistry/2018/w/Paper 41/**

<table>
<thead>
<tr>
<th>Part</th>
<th>Text</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>4(a)(iii)</td>
<td>M1 vanadium pentoxide or vanadium(V) oxide or ( \text{V}_2\text{O}_5 ) (catalyst); M2 1–5 atmospheres; (Units required); M3 450°C; units required; M4 ( 2\text{SO}_2 + \text{O}_2 \rightarrow 2\text{SO}_3 ); M5 equilibrium/reversible reaction in equation or text</td>
<td>1</td>
</tr>
</tbody>
</table>
16 Methanol is manufactured by reacting carbon monoxide and hydrogen together in the presence of an aluminium oxide catalyst.

The equation for the reaction is shown.

\[ CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \]

The reaction is a reversible reaction.

The forward reaction is exothermic.

Which change in conditions increases the yield of methanol?

A. decreasing the concentration of the carbon monoxide
B. increasing the pressure
C. increasing the rate of the reaction
D. increasing the temperature

16 Methanol is made by reacting carbon monoxide with hydrogen.

The reaction is exothermic and is a chemical equilibrium.

The equation for the reaction is shown.

\[ CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \]

Which changes in temperature and pressure increase the yield of methanol?

<table>
<thead>
<tr>
<th>temperature</th>
<th>pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>decrease</td>
</tr>
<tr>
<td>B</td>
<td>decrease</td>
</tr>
<tr>
<td>C</td>
<td>increase</td>
</tr>
<tr>
<td>D</td>
<td>increase</td>
</tr>
</tbody>
</table>
Topic Chem 7 Q# 3/ iGCSE Chemistry/2016/s/Paper 21/

16 Steam reacts with carbon in an endothermic reaction.

\[ C(s) + H_2O(g) \rightleftharpoons CO(g) + H_2(g) \]

Which conditions of temperature and pressure would give the largest yield of hydrogen?

<table>
<thead>
<tr>
<th></th>
<th>temperature</th>
<th>pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>high</td>
<td>high</td>
</tr>
<tr>
<td>B</td>
<td>high</td>
<td>low</td>
</tr>
<tr>
<td>C</td>
<td>low</td>
<td>high</td>
</tr>
<tr>
<td>D</td>
<td>low</td>
<td>low</td>
</tr>
</tbody>
</table>

Topic Chem 7 Q# 4/ iGCSE Chemistry/2016/m/Paper 22/

14 A reversible reaction is shown.

\[ 2NO_2(g) \rightleftharpoons N_2O_4(g) \quad \Delta H = -58 \text{ kJ/mol} \]

Which statement about an equilibrium mixture of NO\(_2\) and N\(_2\)O\(_4\) is correct?

A  If the pressure is decreased the amount of N\(_2\)O\(_4\) increases.
B  If the temperature is increased the amount of N\(_2\)O\(_4\) increases.
C  The rates of formation and decomposition of N\(_2\)O\(_4\) are not the same.
D  The decomposition of N\(_2\)O\(_4\) is an endothermic reaction.

Topic Chem 11 Q# 5/ iGCSE Chemistry/2018/w/Paper 23/

28 Ammonia is manufactured by the Haber process from nitrogen and hydrogen.

Which row gives the main sources of these two gases?

<table>
<thead>
<tr>
<th></th>
<th>hydrogen</th>
<th>nitrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>air</td>
<td>air</td>
</tr>
<tr>
<td>B</td>
<td>air</td>
<td>natural gas</td>
</tr>
<tr>
<td>C</td>
<td>natural gas</td>
<td>air</td>
</tr>
<tr>
<td>D</td>
<td>natural gas</td>
<td>natural gas</td>
</tr>
</tbody>
</table>

Topic Chem 11 Q# 6/ iGCSE Chemistry/2018/w/Paper 22/

28 Which statement about the Haber process is correct?

A  The hydrogen used is obtained from the air.
B  The nitrogen used is obtained from nitrates in the soil.
C  Nitrogen reacts with hydrogen to make ammonia.
D  The reaction takes place at room temperature and pressure.
28 Which statement describes the role of iron in the Haber process?

A  It is used as a catalyst.
B  It is used as a reducing agent.
C  It is used to condense the ammonia gas into a liquid.
D  It is used to increase the yield of ammonia.

31 Ammonia is manufactured by reacting hydrogen with nitrogen in the Haber process.

Which row describes the sources of hydrogen and nitrogen and the conditions used in the manufacture of ammonia in the Haber process?

<table>
<thead>
<tr>
<th></th>
<th>source of hydrogen</th>
<th>source of nitrogen</th>
<th>temperature of reaction/°C</th>
<th>pressure of reaction/atm</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>air</td>
<td>natural gas</td>
<td>250</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>air</td>
<td>natural gas</td>
<td>250</td>
<td>200</td>
</tr>
<tr>
<td>C</td>
<td>natural gas</td>
<td>air</td>
<td>450</td>
<td>2</td>
</tr>
<tr>
<td>D</td>
<td>natural gas</td>
<td>air</td>
<td>450</td>
<td>200</td>
</tr>
</tbody>
</table>

33 The raw materials for the Haber process are hydrogen and nitrogen.

What are the sources of the hydrogen and nitrogen?

A  hydrogen from ethanol and nitrogen from NPK fertilisers
B  hydrogen from methane and nitrogen from air
C  hydrogen from sulfuric acid and nitrogen from air
D  hydrogen from water and nitrogen from ammonium nitrate

31 The Haber process for making ammonia is carried out at a temperature of 450 °C and a pressure of 200 atmospheres in the presence of a catalyst.

Which statement is not correct?

A  Lowering the pressure increases the rate at which ammonia is produced.
B  Lowering the temperature slows down the rate at which ammonia is produced.
C  Maintaining a very high pressure is very difficult and needs expensive equipment.
D  The reaction is a reversible reaction which can proceed forwards and backwards.
31 Ammonia is made by the Haber process.

\[ \text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3 \]

What are the sources of the nitrogen and hydrogen used in the Haber process?

<table>
<thead>
<tr>
<th></th>
<th>nitrogen</th>
<th>hydrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>fertilisers</td>
<td>reacting methane with steam</td>
</tr>
<tr>
<td>B</td>
<td>fertilisers</td>
<td>the air</td>
</tr>
<tr>
<td>C</td>
<td>the air</td>
<td>reacting methane with steam</td>
</tr>
<tr>
<td>D</td>
<td>the air</td>
<td>the air</td>
</tr>
</tbody>
</table>

31 Which row gives the catalyst for the Haber process and the sources of the raw materials?

<table>
<thead>
<tr>
<th></th>
<th>catalyst</th>
<th>source of hydrogen</th>
<th>source of nitrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>iron</td>
<td>electrolysis</td>
<td>fertiliser</td>
</tr>
<tr>
<td>B</td>
<td>iron</td>
<td>methane</td>
<td>air</td>
</tr>
<tr>
<td>C</td>
<td>vanadium pentoxide</td>
<td>methane</td>
<td>air</td>
</tr>
<tr>
<td>D</td>
<td>vanadium pentoxide</td>
<td>methane</td>
<td>fertiliser</td>
</tr>
</tbody>
</table>

31 Which statement about the conditions used in the Haber process is not correct?

A. A high temperature is used because the forward reaction is exothermic.
B. A high pressure is used because there are fewer moles of gas in the products than in the reactants.
C. An iron catalyst is used to increase the rate of the forward reaction.
D. The unreacted hydrogen and nitrogen are recycled to increase the amount of ammonia produced.

32 Which row gives the conditions for the Haber process?

<table>
<thead>
<tr>
<th></th>
<th>temperature / °C</th>
<th>pressure / atm</th>
<th>catalyst</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>200</td>
<td>2</td>
<td>( V_2O_5 )</td>
</tr>
<tr>
<td>B</td>
<td>200</td>
<td>450</td>
<td>Fe</td>
</tr>
<tr>
<td>C</td>
<td>450</td>
<td>200</td>
<td>Fe</td>
</tr>
<tr>
<td>D</td>
<td>500</td>
<td>250</td>
<td>( V_2O_5 )</td>
</tr>
</tbody>
</table>
32 The Haber process for the manufacture of ammonia occurs at 450°C and 250 atmospheres. The nitrogen and hydrogen are supplied in a 1:3 ratio by volume. The reaction is exothermic.

$$\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g}) \quad \Delta H = -92 \text{ kJ/mol}$$

Which change causes an increase in the yield of ammonia?

A  decreasing the concentration of nitrogen
B  decreasing the pressure
C  decreasing the temperature
D  using equal amounts of the two reactants

32 Ammonia is manufactured by the Haber process, using an iron catalyst.

$$\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$$

It is not possible to obtain 100% yield.

What is the reason for this?

A  A high pressure is used.
B  Ammonia decomposes at high temperature.
C  Some of the ammonia is recycled.
C  The ammonia reacts with the catalyst.

32 Ammonia is manufactured by the Haber process. The reaction is exothermic.

$$\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g}) \quad \Delta H = -92 \text{ kJ/mol}$$

Which statement about the Haber process is correct?

A  The reaction is irreversible and produces only one product.
B  The reaction is reversible and produces less ammonia at high pressure.
C  The reaction is reversible and produces less ammonia at high temperature.
D  The reaction is slow because a catalyst is not used in the Haber process.

32 Ammonia is produced by the Haber process.

$$\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$$

Which statement about the Haber process is not correct?

A  An iron catalyst is used to increase the rate of reaction.
B  The reaction is carried out at high temperature to increase the rate of reaction.
C  The reaction is carried out at low pressure to increase the yield of ammonia.
D  The reaction is reversible.
Ammonia is manufactured by a reversible reaction.

\[ \text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g}) \]

The forward reaction is exothermic.

What is the effect of increasing the pressure on the percentage yield and rate of formation of ammonia?

<table>
<thead>
<tr>
<th></th>
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<th>rate of formation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>decreases</td>
<td>decreases</td>
</tr>
<tr>
<td>B</td>
<td>decreases</td>
<td>increases</td>
</tr>
<tr>
<td>C</td>
<td>increases</td>
<td>decreases</td>
</tr>
<tr>
<td>D</td>
<td>increases</td>
<td>increases</td>
</tr>
</tbody>
</table>

Ammonia is formed by a reversible reaction.

\[ \text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g}) \]

The forward reaction is exothermic.

Which changes in conditions would increase the yield of ammonia?

<table>
<thead>
<tr>
<th></th>
<th>increase in pressure</th>
<th>increase in temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>B</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>C</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>D</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

A farmer's soil is very low in both nitrogen (N) and phosphorus (P).

Which fertiliser would improve the quality of this soil most effectively?

<table>
<thead>
<tr>
<th></th>
<th>percentage</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>nitrogen (N)</td>
<td>phosphorus (P)</td>
<td>potassium (K)</td>
</tr>
<tr>
<td>A</td>
<td>11</td>
<td>11</td>
<td>27</td>
</tr>
<tr>
<td>B</td>
<td>12</td>
<td>37</td>
<td>10</td>
</tr>
<tr>
<td>C</td>
<td>28</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>D</td>
<td>31</td>
<td>29</td>
<td>9</td>
</tr>
</tbody>
</table>
32 Fertilisers are used to provide three elements needed to increase the yield of crops.

Which two compounds would provide all three of these elements?

A  ammonium nitrate and calcium phosphate
B  ammonium nitrate and potassium sulfate
C  potassium nitrate and calcium phosphate
D  potassium nitrate and potassium sulfate

33 Which statement about sulfur or one of its compounds is correct?

A  Sulfur occurs naturally as the element sulfur.
B  Sulfur dioxide is used to kill bacteria in drinking water.
C  Sulfuric acid is a weak acid.
D  Dilute sulfuric acid is a dehydrating agent.

15 In the Contact process, sulfur dioxide is converted into sulfur trioxide in a reversible reaction.

\[2\text{SO}_2(g) + \text{O}_2(g) \rightleftharpoons 2\text{SO}_3(g)\]

The forward reaction is exothermic.

Which conditions give the highest yield of sulfur trioxide at equilibrium?

<table>
<thead>
<tr>
<th></th>
<th>pressure / atmospheres</th>
<th>temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.5</td>
<td>high</td>
</tr>
<tr>
<td>B</td>
<td>0.5</td>
<td>low</td>
</tr>
<tr>
<td>C</td>
<td>1.5</td>
<td>high</td>
</tr>
<tr>
<td>D</td>
<td>1.5</td>
<td>low</td>
</tr>
</tbody>
</table>

33 Element Z forms an oxide, ZO₂. Three uses of ZO₂ are listed.

- bleaching agent
- killing bacteria
- manufacturing an important acid

What is Z?

A  carbon
B  lead
C  nitrogen
D  sulfur
15  Sulfur dioxide reacts with oxygen at 2 atmospheres pressure. The forward reaction is exothermic.

The equation for the reaction is shown.

\[2\text{SO}_2(g) + \text{O}_2(g) \rightleftharpoons 2\text{SO}_3(g)\]

The reaction reaches equilibrium. The pressure is then doubled.

How and why does the amount of sulfur trioxide formed change?

<table>
<thead>
<tr>
<th>amount of sulfur trioxide</th>
<th>reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>A decreases</td>
<td>the forward reaction is exothermic</td>
</tr>
<tr>
<td>B decreases</td>
<td>there are fewer molecules on the right</td>
</tr>
<tr>
<td>C increases</td>
<td>the forward reaction is exothermic</td>
</tr>
<tr>
<td>D increases</td>
<td>there are fewer molecules on the right</td>
</tr>
</tbody>
</table>

33  Which row describes the uses of sulfur and sulfur dioxide?

<table>
<thead>
<tr>
<th>sulfur</th>
<th>sulfur dioxide</th>
</tr>
</thead>
<tbody>
<tr>
<td>A extraction of aluminium</td>
<td>food preservative</td>
</tr>
<tr>
<td>B extraction of aluminium</td>
<td>water treatment</td>
</tr>
<tr>
<td>C manufacture of sulfuric acid</td>
<td>food preservative</td>
</tr>
<tr>
<td>D manufacture of sulfuric acid</td>
<td>water treatment</td>
</tr>
</tbody>
</table>

33  Which statement about sulfur and its compounds is not correct?

A  Sulfur dioxide is used as a food preservative.

B  Sulfur dioxide turns acidified aqueous potassium manganate(VII) from purple to colourless.

C  Sulfur forms a basic oxide.

D  Sulfur is used in the manufacture of sulfuric acid.

35  The Contact process is used to make sulfuric acid.

The steps in the process are listed.

1  Dissolve sulfur trioxide in 98% concentrated sulfuric acid.

2  Heat sulfur strongly in air.

3  Add oleum to water.

4  Pass sulfur dioxide over a vanadium(V) oxide catalyst.

Which sequence of steps is correct?

A  4 → 1 → 2 → 3

B  4 → 2 → 3 → 1

C  2 → 1 → 4 → 3

D  2 → 4 → 1 → 3
33 Which row shows the conditions used in the manufacture of sulfuric acid by the Contact process?

<table>
<thead>
<tr>
<th></th>
<th>temperature °C</th>
<th>pressure atm</th>
<th>catalyst</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>40</td>
<td>200</td>
<td>Fe</td>
</tr>
<tr>
<td>B</td>
<td>40</td>
<td>200</td>
<td>V₂O₅</td>
</tr>
<tr>
<td>C</td>
<td>400</td>
<td>2</td>
<td>Fe</td>
</tr>
<tr>
<td>D</td>
<td>400</td>
<td>2</td>
<td>V₂O₅</td>
</tr>
</tbody>
</table>

33 Which statement about sulfuric acid is correct?

A. It is made by the Haber process.
B. It is made in the atmosphere by the action of lightning.
C. It reacts with ammonia to produce a fertiliser.
D. It reacts with copper metal to produce hydrogen gas.

33 The ions present in ammonium sulfate are formed from the products of the Contact and Haber processes.

Both of these processes involve the use of a catalyst.

Which row is correct?

<table>
<thead>
<tr>
<th></th>
<th>ion</th>
<th>formed from</th>
<th>process</th>
<th>catalyst</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>ammonium</td>
<td>ammonia</td>
<td>Contact</td>
<td>iron</td>
</tr>
<tr>
<td>B</td>
<td>ammonium</td>
<td>ammonia</td>
<td>Haber</td>
<td>vanadium(V) oxide</td>
</tr>
<tr>
<td>C</td>
<td>sulfate</td>
<td>sulfuric acid</td>
<td>Contact</td>
<td>vanadium(V) oxide</td>
</tr>
<tr>
<td>D</td>
<td>sulfate</td>
<td>sulfuric acid</td>
<td>Haber</td>
<td>iron</td>
</tr>
</tbody>
</table>

33 The following scheme shows four stages in the conversion of sulfur to sulfuric acid.

In which stage is a catalyst used?
33 Sulfuric acid is manufactured by a series of chemical reactions, one of which is catalysed by vanadium(V) oxide.

What is the equation for the reaction catalysed by vanadium(V) oxide?

A  $S + O_2 \rightarrow SO_2$
B  $2S + 3O_2 \rightarrow 2SO_3$
C  $2SO_2 + O_2 \rightarrow 2SO_3$
D  $SO_3 + H_2O \rightarrow H_2SO_4$

33 Sulfuric acid is manufactured by the Contact process.

The most important reaction takes place in the presence of a catalyst.

What are the reactants and the catalyst for this reaction?

<table>
<thead>
<tr>
<th></th>
<th>reactants</th>
<th>catalyst</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>sulfur and oxygen</td>
<td>vanadium(V) oxide</td>
</tr>
<tr>
<td>B</td>
<td>sulfur dioxide and oxygen</td>
<td>vanadium(V) oxide</td>
</tr>
<tr>
<td>C</td>
<td>sulfur dioxide and steam</td>
<td>iron</td>
</tr>
<tr>
<td>D</td>
<td>sulfur trioxide and water</td>
<td>platinum</td>
</tr>
</tbody>
</table>

33 One step in the manufacture of sulfuric acid is the oxidation of sulfur dioxide to sulfur trioxide.

Which conditions are used for this step?

<table>
<thead>
<tr>
<th></th>
<th>temperature / °C</th>
<th>pressure / atmospheres</th>
<th>catalyst</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>450</td>
<td>1.5</td>
<td>iron</td>
</tr>
<tr>
<td>B</td>
<td>450</td>
<td>1.5</td>
<td>vanadium(V) oxide</td>
</tr>
<tr>
<td>C</td>
<td>450</td>
<td>200</td>
<td>iron</td>
</tr>
<tr>
<td>D</td>
<td>450</td>
<td>200</td>
<td>vanadium(V) oxide</td>
</tr>
</tbody>
</table>

33 The Contact process is used for the manufacture of sulfuric acid.

Which statement about this process is not correct?

A  A catalyst of iron is used.
B  Oxygen from the air is used to react with sulfur dioxide.
C  Sulfur trioxide dissolves in sulfuric acid to form oleum.
D  The temperature used is around 450 °C.
33 The equation for an exothermic reaction in the Contact process is shown.

\[ 2\text{SO}_2(g) + \text{O}_2(g) \rightarrow 2\text{SO}_3(g) \]

Which effects do increasing the temperature and using a catalyst have on the rate of formation of sulfur trioxide, \( \text{SO}_3 \)?

<table>
<thead>
<tr>
<th></th>
<th>increasing the temperature</th>
<th>using a catalyst</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>rate decreases</td>
<td>rate decreases</td>
</tr>
<tr>
<td>B</td>
<td>rate decreases</td>
<td>rate increases</td>
</tr>
<tr>
<td>C</td>
<td>rate increases</td>
<td>rate decreases</td>
</tr>
<tr>
<td>D</td>
<td>rate increases</td>
<td>rate increases</td>
</tr>
</tbody>
</table>

33 What is a property of concentrated sulfuric acid but not of dilute sulfuric acid?

A  It is a dehydrating agent.

B  It neutralises alkalis.

C  It produces a white precipitate with barium nitrate.

D  It reacts with metals to give a salt and hydrogen.
### 14.8.1 ESSENTIAL EXAM QUESTIONS Paper 2 Topic 7.3 Mark Scheme

<table>
<thead>
<tr>
<th>Q# 1</th>
<th>iGCSE Chemistry/2016/s/Paper 23</th>
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<tbody>
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<tr>
<td>31</td>
<td>A</td>
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ESSENTIAL EXAM QUESTIONS Paper 3/4 Topic 7.3 56 marks

Topic Chem 7.3 Q# 1/ iGCSE Chemistry/2011/w/Paper 31/
4 Reversible reactions can come to equilibrium. The following are three examples of types of gaseous equilibria.

\[ \text{reaction 1} \]
\[ A_2(g) + B_2(g) \rightleftharpoons 2AB(g) \]

\[ \text{reaction 2} \]
\[ A_2(g) + 3B_2(g) \rightleftharpoons 2AB_3(g) \]

\[ \text{reaction 3} \]
\[ 2AB_2(g) \rightleftharpoons 2AB(g) + B_2(g) \]

(a) Explain the term *equilibrium*.

(b) The following graphs show how the percentage of products of a reversible reaction at equilibrium could vary with pressure. For each graph, decide whether the percentage of products decreases, increases or stays the same when the pressure is increased, then match each graph to one of the above reactions and give a reason for your choice.

(i)

![Graph](image1)

effect on percentage of products  
reaction  
reason  

(ii)

![Graph](image2)

effect on percentage of products  
reaction  
reason  

[2]  
[3]
6 Iodine reacts with chlorine to form dark brown iodine monochloride.

\[ \text{I}_2 + \text{Cl}_2 \rightarrow 2\text{ICl} \]

This reacts with more chlorine to give yellow iodine trichloride.
There is an equilibrium between these iodine chlorides.

\[ \text{ICl}(l) + \text{Cl}_2(g) \rightleftharpoons \text{ICl}_3(s) \]

dark brown \hspace{1cm} yellow

(a) Explain what is meant by *equilibrium*.

..................................................................................................................................................

..................................................................................................................................................

.................................................................................................................................................. [2]

(b) When the equilibrium mixture is heated it becomes a darker brown colour.
Is the reverse reaction endothermic or exothermic? Give a reason for your choice.

..................................................................................................................................................

..................................................................................................................................................

.................................................................................................................................................. [2]
(c) The pressure on the equilibrium mixture is decreased.

(i) How would this affect the position of equilibrium and why?

It would move to the ............................................................................................................. [1]
reason ................................................................................................................................. [1]

(ii) Describe what you would observe.

............................................................................................................................................. [1]

---

(b) Sulfuric acid was first made in the Middle East by heating the mineral, green vitriol, FeSO₄·7H₂O. The gases formed were cooled.

\[
\text{FeSO}_4 \cdot 7\text{H}_2\text{O}(s) \rightarrow \text{FeSO}_4(s) + 7\text{H}_2\text{O}(g)
green \text{ crystals yellow powder}
\]

\[
2\text{FeSO}_4(s) \rightarrow \text{Fe}_2\text{O}_3(s) + \text{SO}_2(g) + \text{SO}_3(g)
\]

On cooling

\[
\text{SO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4 \quad \text{sulfuric acid}
\]

\[
\text{SO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_3 \quad \text{sulfurous acid}
\]

(i) How could you show that the first reaction is reversible?

............................................................................................................................................. [2]

---

Topic Chem 7.3 Q# 4/ iGCSE Chemistry/2008/s/Paper 31/

5 Carbonyl chloride, COCl₂, is a colourless gas. It is made by the following reaction.

\[
\text{CO}(g) + \text{Cl}_2(g) \underset{\text{heat}}{\overset{\text{cool}}{\rightleftharpoons}} \text{COCl}_2(g)
\]

(a) When the pressure on the equilibrium mixture is decreased, the position of equilibrium moves to left.

(i) How does the concentration of each of the three chemicals change?

............................................................................................................................................. [2]
(ii) Explain why the position of equilibrium moves to left.

............................................................................................................................................. [2]

.............................................................................................................................................

(b) Using the information given with the equation, is the forward reaction exothermic or endothermic? Give a reason for your choice.

............................................................................................................................................. [2]

(c) Methanol is made from carbon monoxide.

\[ \text{CO}(g) + 2\text{H}_2(g) \rightleftharpoons \text{CH}_3\text{OH}(g) \]

the forward reaction is exothermic

(iii) Which condition, high or low pressure, would give the maximum yield of methanol? Give a reason for your choice.

pressure .....................................................................................................................................

reason ................................................................................................................................... [2]


(b) Both of the following reactions are reversible.

reaction 1 \[ \text{N}_2(g) + \text{O}_2(g) \rightleftharpoons 2\text{NO}(g) \]
reaction 2 \[ 2\text{NO}(g) + \text{O}_2(g) \rightleftharpoons 2\text{NO}_2(g) \]

(i) Suggest a reason why an increase in pressure does not affect the position of equilibrium for reaction 1.

............................................................................................................................................. [1]

(ii) What effect would an increase in pressure have on the position of equilibrium for reaction 2? Give a reason for your answer.

............................................................................................................................................. [2]
3. Reversible reactions can come to equilibrium. They have both a forward and a backward reaction.

(a) When water is added to an acidic solution of bismuth(III) chloride, a white precipitate forms and the mixture slowly goes cloudy.

\[
\text{BiCl}_3(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{BiOCl}(\text{s}) + 2\text{HCl}(\text{aq})
\]

(i) Explain why the rate of the forward reaction decreases with time.

........................................................................................................................................ [2]

(ii) Why does the rate of the backward reaction increase with time?

........................................................................................................................................ [1]

(iii) After some time why does the appearance of the mixture remain unchanged?

........................................................................................................................................ [2]

(iv) When a few drops of concentrated hydrochloric acid are added to the cloudy mixture, it changes to a colourless solution. Suggest an explanation.

........................................................................................................................................ [2]
3. The simplest alcohol is methanol.

(a) It is manufactured by the following reversible reaction.

\[ \text{CO (g) + } 2\text{H}_2\text{ (g)} \rightleftharpoons \text{CH}_3\text{OH (g)} \]

\[ \frac{300^\circ C}{30\text{atm}} \]

(i) Reversible reactions can come to equilibrium. Explain the term *equilibrium*.

(ii) At 400°C, the percentage of methanol in the equilibrium mixture is lower than at 300°C. Suggest an explanation.

(iii) Suggest two advantages of using high pressure for this reaction. Give a reason for each advantage.

<table>
<thead>
<tr>
<th>Advantage</th>
<th>Reason</th>
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</table>

[5]
(b) Carbon monoxide is used to purify nickel. Nickel reacts with carbon monoxide to form a gaseous compound.

\[
\text{Ni(s) + 4CO(g)} \rightleftharpoons \text{Ni(CO)}_4(g)
\]
forward reaction is exothermic

(i) What reaction condition will favour the back reaction and reform nickel metal? Explain your choice.

[2]
14.10  ESSENTIAL EXAM QUESTIONS Paper 3/4 Haber process and nitrogen chemistry (Topic 11.1) 63 Marks

Topic Chem 11.3 Q# 1/ iGCSE Chemistry/2013/w/Paper 31/

3  Ammonia is manufactured by the Haber process.

\[ \text{N}_2(g) + 3\text{H}_2(g) \rightleftharpoons 2\text{NH}_3(g) \]

The forward reaction is exothermic.

(a) Describe how the reactants are obtained.

(i) Nitrogen

...........................................................................................................................................
........................................................................................................................................... [2]

(ii) Hydrogen

...........................................................................................................................................
........................................................................................................................................... [3]
(b) The percentage of ammonia in the equilibrium mixture varies with temperature and pressure.

(i) Which pair of graphs, A, B or C, shows correctly how the percentage of ammonia at equilibrium varies with temperature and pressure?

![Graphs A, B, and C showing percentage NH₃ at equilibrium with temperature and pressure.]

The pair with both graphs correct is ..................................................... [1]

(ii) Give a full explanation of why the pair of graphs you have chosen in (i) is correct.

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................................................................................................................................. [6]
(iii) Catalysts do not alter the position of equilibrium. Explain why a catalyst is used in this process.

(b) Ammonia is manufactured by the Haber Process. The economics of this process require that as much ammonia as possible is made as quickly as possible. Explain how this can be done using the following information.

The conditions for the following reversible reaction are:

- 450 °C
- 200 atmospheres pressure
- iron catalyst

\[ \text{N}_2(g) + 3\text{H}_2(g) \rightleftharpoons 2\text{NH}_3(g) \quad \text{the reaction is exothermic} \]
(b) Ammonia is made by the Haber Process.

\[ \text{N}_2(g) + 3\text{H}_2(g) \rightleftharpoons 2\text{NH}_3(g) \]  
Forward reaction is exothermic

The percentage of ammonia in the equilibrium mixture varies with conditions.

<table>
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<th>pressure/atmospheres</th>
<th>100</th>
<th>200</th>
<th>300</th>
<th>400</th>
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</thead>
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<tr>
<td>% ammonia at 300 °C</td>
<td>45</td>
<td>65</td>
<td>72</td>
<td>78</td>
</tr>
<tr>
<td>% ammonia at 500 °C</td>
<td>9</td>
<td>18</td>
<td>25</td>
<td>31</td>
</tr>
</tbody>
</table>

The conditions actually used are 200 atmospheres, 450 °C and an iron catalyst.

(i) The original catalyst was platinum. Suggest a reason why it was changed to iron.

(ii) Explain why the highest pressure gives the highest percentage of ammonia in the equilibrium mixture.

(iii) What happens to the unreacted nitrogen and hydrogen?

(iv) State one advantage and one disadvantage of using a lower temperature.

Advantage ................................................................................................................................................ [1]

Disadvantage ........................................................................................................................................... [1]
6 Ammonia is manufactured by the Haber process.

\[ \text{N}_2(g) + \text{3H}_2(g) \rightleftharpoons 2\text{NH}_3(g) \] the forward reaction is exothermic

(a) (i) Name the raw materials from which nitrogen and hydrogen are obtained.

nitrogen from .................................................................................................................. [1]

hydrogen from .................................................................................................................. [1]

(ii) Name the catalyst used in this process.

........................................................................................................................................ [1]

(iii) What is the most important use of ammonia?

........................................................................................................................................... [1]

(b) The following graph shows how the percentage of ammonia in the equilibrium mixture changes with temperature.

![Graph showing the percentage of ammonia at equilibrium vs. temperature]

(i) Explain the term equilibrium.

........................................................................................................................................... [2]

(ii) How does the percentage of ammonia vary with temperature?

........................................................................................................................................... [1]
(c) (i) Sketch a graph which shows how the percentage of ammonia in the equilibrium mixture varies with pressure.

(ii) Explain why the graph has the shape shown.

(ii) Name an important chemical that is made from hydrogen.

8 Large areas of the Amazon rain forest are cleared each year to grow soya beans. The trees are cut down and burnt.

(a) Why do these activities increase the percentage of carbon dioxide in the atmosphere?
5 Ammonia is manufactured by the Haber Process.

\[ \text{N}_2(g) + 3\text{H}_2(g) \rightleftharpoons 2\text{NH}_3(g) \]

200 atmospheres
450°C

The forward reaction is exothermic.

(a) (i) What is the catalyst for this reaction?

............................................................................................................................................... [1]

(ii) Newer catalysts have been discovered for this process. Using these catalysts, the operating temperature is lowered from 450°C to 400°C. What is the advantage of using a lower temperature? Explain your answer.

advantage .................................................................................................................................. [2]

explanation .................................................................................................................................. [2]

(b) After passing over the catalyst, the mixture contains 15% of ammonia. It is cooled and the ammonia liquefies and is separated from the unreacted nitrogen and hydrogen. They are recycled.

(i) How are the gases recycled?

............................................................................................................................................... [1]

(ii) Only ammonia gas liquefies. Suggest an explanation for this.

............................................................................................................................................... [1]

(c) Urea, CO(NH)₂, is one of the fertilisers manufactured from ammonia. Ammonia is heated with carbon dioxide.

(i) Write an equation for the manufacture of urea.

............................................................................................................................................... [2]

(ii) Explain why urea on its own might not be very effective in promoting crop growth.

............................................................................................................................................... [1]
7 In 1909, Haber discovered that nitrogen and hydrogen would react to form ammonia. The yield of ammonia was 8%.

\[ \text{N}_2 (g) + 3\text{H}_2 (g) \rightleftharpoons 2\text{NH}_3 (g) \]  
the forward reaction is exothermic

catalyst platinum  
temperature 600 °C  
pressure  200 atm

(a) Describe how hydrogen is obtained for the modern process.

.................................................................................................................................................................................. [2]

(b) (i) What is the catalyst in the modern process?

.................................................................................................................................................................................. [1]

(ii) Explain why the modern process, which uses a lower temperature, has a higher yield of 15%.

.................................................................................................................................................................................. [2]

Topic Chem 11.3 Q#9/ iGCSE Chemistry/2004/s/Paper 3/ Q2

(b) About one third of this production of acid is used to make nitrogen and phosphorus-containing fertilisers.

(i) Name the third element that is essential for plant growth and is present in most fertilisers.

.................................................................................................................................................................................. [1]

(ii) Name a nitrogen-containing fertiliser that is manufactured from sulphuric acid.

.................................................................................................................................................................................. [1]
1 Ammonia contains the elements nitrogen and hydrogen. It is manufactured from these elements in the Haber process.

\[ N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \]

The forward reaction is exothermic.

(ii) Name two raw materials from which hydrogen is manufactured.

(b) The table shows how the percentage of ammonia in the equilibrium mixture varies with pressure at 600 °C.

<table>
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<th>8</th>
<th>12</th>
<th>15</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>pressure/atm</td>
<td>200</td>
<td>300</td>
<td>400</td>
<td>500</td>
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</table>

(i) Explain why the percentage of ammonia increases as the pressure increases.

(ii) How would the percentage of ammonia change if the measurements had been made at a lower temperature? Explain your answer.

(iii) State two of the reaction conditions used in the Haber Process.

3 A major food retailer in the UK is going to distribute sandwiches using hydrogen-powered vehicles.
(c) Outline how hydrogen is manufactured from water.

...........................................................................................................................

...........................................................................................................................[2]
14.10.1 ESSENTIAL EXAM QUESTIONS Paper 3/4 Contact Process and Sulfur Chemistry (Topic 12) 79 Marks

Topic Chem 12 Q# 1/ iGCSE Chemistry/2014/w/Paper 31/
The main use of sulfur dioxide is the manufacture of sulfuric acid.

(a) State two other uses of sulfur dioxide.

(b) One source of sulfur dioxide is burning sulfur in air.
Describe how sulfur dioxide can be made from the ore zinc sulfide.

(c) The Contact process changes sulfur dioxide into sulfur trioxide.

\[2\text{SO}_2(g) + \text{O}_2(g) \leftrightarrow 2\text{SO}_3(g)\]
the forward reaction is exothermic
temperature 400 to 450 °C
low pressure 1 to 10 atmospheres
catalyst vanadium(V) oxide

(i) What is the formula of vanadium(V) oxide?

(ii) Vanadium(V) oxide is an efficient catalyst at any temperature in the range 400 to 450 °C. Scientists are looking for an alternative catalyst which is efficient at 300 °C. What would be the advantage of using a lower temperature?

(iii) The process does not use a high pressure because of the extra expense. Suggest two advantages of using a high pressure? Explain your suggestions.
(d) Sulfuric acid is made by dissolving sulfur trioxide in concentrated sulfuric acid to form oleum. Water is reacted with oleum to form more sulfuric acid. Why is sulfur trioxide not reacted directly with water?

(b) Basic lead(II) carbonate is heated in the apparatus shown below. Water and carbon dioxide are produced.

(i) Silica gel absorbs water. Silica gel often contains anhydrous cobalt(II) chloride. When this absorbs water it changes from blue to pink. Suggest a reason.

(ii) Soda lime is a mixture of sodium hydroxide and calcium oxide. Why do these two substances react with carbon dioxide?

(iii) Name two substances formed when soda lime reacts with carbon dioxide.
(b) Sulfur dioxide is used to make sulfur trioxide in the Contact Process.

\[ 2\text{SO}_2(g) + \text{O}_2(g) \rightleftharpoons 2\text{SO}_3(g) \]

The forward reaction is exothermic. The conditions used are:

- temperature: 450°C
- pressure: 2 atmospheres
- catalyst: vanadium(V) oxide

Explain, mentioning both position of equilibrium and rate, why these conditions give the most economic yield.

------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------ [4]

---


(b) Sulfuric acid was first made in the Middle East by heating the mineral, green vitriol, FeSO₄.7H₂O. The gases formed were cooled.

\[ \text{FeSO}_4.7\text{H}_2\text{O}(s) \rightarrow \text{FeSO}_4(s) + 7\text{H}_2\text{O}(g) \]

green crystals yellow powder

\[ 2\text{FeSO}_4(s) \rightarrow \text{Fe}_2\text{O}_3(s) + \text{SO}_2(g) + \text{SO}_3(g) \]

On cooling

\[ \text{SO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4 \text{ sulfurous acid} \]

\[ \text{SO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_3 \text{ sulfurous acid} \]

(ii) Sulfurous acid is a reductant. What would you see when acidified potassium manganate(VII) is added to a solution containing this acid?

------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------ [2]

------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------ [1]

(iii) Suggest an explanation why sulfurous acid in contact with air changes into sulfuric acid.
6  (a) Sulfuric acid is made by the Contact process.

\[ 2\text{SO}_2 + \text{O}_2 \rightleftharpoons 2\text{SO}_3 \]

This is carried out in the presence of a catalyst at 450°C and 2 atmospheres pressure.

(i) How is the sulfur dioxide made?

(ii) Give another use of sulfur dioxide.

(iii) Name the catalyst used.

(iv) If the temperature is decreased to 300°C, the yield of sulfur trioxide increases. Explain why this lower temperature is not used.

(v) Sulfur trioxide is dissolved in concentrated sulfuric acid. This is added to water to make more sulfuric acid. Why is sulfur trioxide not added directly to water?

Topic Chem 12 Q# 6/ iGCSE Chemistry/2008/s/Paper 31/

1 For each of the following select an element from Period 4, potassium to krypton, that matches the description.

(g) One of its oxides is the catalyst in the Contact Process.
4. Zinc is extracted from zinc blende, ZnS.

(a) Zinc blende is heated in air to give zinc oxide and sulphur dioxide. Most of the sulphur dioxide is used to make sulphur trioxide. This is used to manufacture sulphuric acid. Some of the acid is used in the plant, but most of it is used to make fertilisers.

(i) Give another use of sulphur dioxide.

........................................................................................................................................... [1]

(ii) Describe how sulphur dioxide is converted into sulphur trioxide.

........................................................................................................................................... [3]

(iii) Name a fertiliser made from sulphuric acid.

........................................................................................................................................... [1]

Topic Chem 12 Q# 8/ iGCSE Chemistry/2006/s/Paper 3/ Q5 (b)

(iii) Explain, mentioning both rate and percentage yield, why the temperature used in the Contact process is 450°C.

........................................................................................................................................... [2]

(iv) Describe how the sulphur trioxide is changed into concentrated sulphuric acid.

........................................................................................................................................... [2]

Topic Chem 12 Q# 9/ iGCSE Chemistry/2006/s/Paper 3/
5 Sulphuric acid is made by the Contact process in the following sequence of reactions.

\[ \text{sulphur} \rightarrow \text{sulphur dioxide} \rightarrow \text{sulphur trioxide} \rightarrow \text{sulphuric acid} \]

(a) (i) How is sulphur dioxide made from sulphur?

................................................................................................................................... [1]

(ii) Sulphur dioxide has other uses. Why is it used in the manufacture of paper?

................................................................................................................................... [1]

(iii) How does it preserve food?

................................................................................................................................... [1]

(b) The equation for a stage of the Contact process is

\[ 2\text{SO}_2 + \text{O}_2 \rightleftharpoons 2\text{SO}_3 \]

The percentage of sulphur trioxide in the equilibrium mixture varies with temperature.

![Graph showing the percentage of sulphur trioxide decreases with temperature.]

(i) How does the percentage of sulphur trioxide in the equilibrium mixture vary as the temperature increases? Circle the correct answer.

- Increases
- Stays the same
- Decreases

................................................................................................................................... [1]

(ii) Is the forward reaction in the equilibrium \( 2\text{SO}_2 + \text{O}_2 \rightleftharpoons 2\text{SO}_3 \) exothermic or endothermic? Give a reason for your choice.

................................................................................................................................... [2]
(c) Sulphuric acid is manufactured by the Contact Process. Sulphur dioxide is oxidised to sulphur trioxide by oxygen.

\[ \text{2SO}_2 + \text{O}_2 \rightarrow \text{2SO}_3 \]

(i) Name the catalyst used in this reaction.

........................................................................................................................................ [1]

(ii) What temperature is used for this reaction?

........................................................................................................................................ [1]

(iii) Describe how sulphur trioxide is changed into sulphuric acid.

........................................................................................................................................ [2]
4  The Carlsbad caverns in New Mexico are very large underground caves. Although the walls of these caves are coated with gypsum (hydrated calcium sulphate), the caves have been formed in limestone.

(a)  It is believed that the caves were formed by sulphuric acid reacting with the limestone.

(i)  Complete the word equation.

\[
calcium \quad + \quad sulphuric \quad acid \quad \rightarrow \quad calcium \quad + \quad .................. \quad + \quad .................. \quad [1]
\]

(ii)  Describe how you could test the water entering the cave to show that it contained sulphate ions.

\[
test \quad ................................................................. \quad ................................................................. \quad [2]
\]

(iii)  How could you show that the water entering the cave has a high concentration of hydrogen ions?

\[
................................................................. \quad [1]
\]

(b)  Hydrogen sulphide gas which was escaping from nearby petroleum deposits was being oxidised to sulphuric acid.

(i)  Complete the equation for this reaction forming sulphuric acid.

\[
H_2S \quad + \quad .................. \quad O_2 \quad \rightarrow \quad .................. \quad [2]
\]

(ii)  Explain why all the hydrogen sulphide should be removed from the petroleum before it is used as a fuel.

\[
................................................................. \quad [1]
\]
2 Sulphur is used to make sulphuric acid. In the UK, the annual production of the acid is about 2.5 million tonnes.

(a) The reactions in the manufacture of sulphuric acid by the Contact Process are shown below.

<table>
<thead>
<tr>
<th>Reaction</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>S \rightarrow SO_2</td>
</tr>
<tr>
<td>2</td>
<td>2SO_2 + O_2 \rightarrow 2SO_3</td>
</tr>
<tr>
<td>3</td>
<td>SO_3 \rightarrow H_2S_2O_7</td>
</tr>
<tr>
<td>4</td>
<td>H_2S_2O_7 + water \rightarrow H_2SO_4</td>
</tr>
</tbody>
</table>

(i) Give a large scale source of the element sulphur.

...................................................................................................................................................... [1]

(ii) State another use of sulphur dioxide.

...................................................................................................................................................... [1]

(iii) How is sulphur changed into sulphur dioxide?

...................................................................................................................................................... [1]

(iv) Name the catalyst used in reaction 2.

...................................................................................................................................................... [1]

(v) Reaction 2 is exothermic. Why is a catalyst, rather than a higher temperature, used to increase the rate of this reversible reaction?

...................................................................................................................................................... [2]

(vi) Write a word equation for reaction 3.

...................................................................................................................................................... [1]

(vii) Write a symbol equation for reaction 4.

...................................................................................................................................................... [1]
Topic Chem 12 Q# 13/ iGCSE Chemistry/2003/w/Paper 3/

5  Sulphur dioxide, SO$_2$, and sulphur trioxide, SO$_3$, are the two oxides of sulphur.
   (a) Sulphur dioxide can kill bacteria and has bleaching properties. Give a use of sulphur
dioxide that depends on each of these properties.
      (i) ability to kill bacteria .....................................................................................[1]
      (ii) bleaching properties .......................................................................................[1]
   (b) Sulphur trioxide can be made from sulphur dioxide.
      (i) Why is this reaction important industrially?
      ......................................................................................................................................[1]
      (ii) Complete the word equation.
        sulphur dioxide + ................................................. → sulphur trioxide ..............[1]
      (iii) What are the conditions for this reaction?
        .....................................................................................................................................[2]

Topic Chem 12 Q# 14/ iGCSE Chemistry/2002/w/Paper 3/

1  (a) Sulphuric acid is made by the Contact Process.
    
    \[ 2\text{SO}_2(g) + \text{O}_2(g) \rightleftharpoons 2\text{SO}_3(g) \quad \text{forward reaction is exothermic} \]
    
    (i) What are the reaction conditions for the Contact Process?
    ........................................................................................................................................[3]
    (ii) Would the yield of sulphur trioxide increase, decrease or stay the same when the
temperature is increased? Explain your answer.
    ........................................................................................................................................
    ........................................................................................................................................[2]
    (iii) Describe how sulphur trioxide is changed into concentrated sulphuric acid.
    ........................................................................................................................................[2]
5  (a) In the USA, sulphur is obtained from underground deposits. It burns to form sulphur dioxide. This is used in paper making, to preserve food and in the manufacture of sulphuric acid.

(i) Why is sulphur dioxide needed in paper making?

(ii) How does sulphur dioxide preserve food?

14.10.2 ESSENTIAL EXAM QUESTIONS Paper 3/4 Topic 7.3 56 marks Mark Scheme

Topic Chem 7.3 Q# 1/ iGCSE Chemistry/2011/w/Paper 31/

4  (a) rate of forward reaction equals rate of back reaction
concentrations do not change / macroscopic properties remain constant (with time) accept: amounts

(b) (i) increase
reaction 2
Vr > Vp

(ii) same
reaction 1
Vr = Vp

(iii) decrease
reaction 3
Vp > Vr
accept: moles of gas / molecules of gas as an alternative to volume

Topic Chem 7.3 Q# 2/ iGCSE Chemistry/2010/s/Paper 31/

6  (a) rates equal
concentrations do not change / macroscopic properties remain constant accept amounts do not change

(b) endothermic
cond favoured by high temperatures

(c) (i) move to left
cond bigger volume / more moles etc do not insist on “gas”

(ii) less yellow solid / more brown liquid accept yellow to brown / less solid more liquid / goes brown
(b) (i) add water to yellow powder or to anhydrous salt
it would go green
5  (a) (i) (concentration) of reactants/CO and C_b increases
(concentration) of product decreases/C OcL_2) [1]

(ii) (decrease in pressure favours side)
with more molecules or moles or side with bigger volume (of gas)
NB [2] or [0] [1]

(b) forward reaction is exothermic
COND because it is favoured by low temperatures or cool
ACCEPT argument re back reaction

5  (a) (i) high pressure
COND forward reaction volume decrease
or volume of reactants greater than that of products
or fewer moles of gas on the right
or fewer gas molecules on right
NOTE accept correct arguments about either reactants or products [1]

5  (b)(i) No change in volume or same number of moles on
both sides

(ii) move to right
Increase in pressure favour side with smaller volume or
smaller number of moles (of gas) or moves to side that
 tends to reduce pressure

5  (a)(i) because concentration of BiC_b decreases
bismuth chloride used up ONLY [1]

(ii) products are being formed or concentration of products
 increases. Concentration mark given either (i) or (ii) [1]

(iii) reaction has come to equilibrium
rates equal or no change in concentration [1]

(iv) equilibrium to left or favours backward reaction or
equilibrium moves to use up hydrochloric acid
BiCl used up or BiCl_b formed [1]

5  (a) (i) no change in concentration of reagents or rates equal
Accept no change in amounts or it is as if the reaction has Stopped [1]

(ii) back reaction is endothermic or the forward reaction is exothermic
Increase in temperature favours the endothermic reaction which is the back
reaction or vice versa. NB look for correct conclusion re thermoncity and comment re position of
equilibrium.
(iii) increased rate
because molecules collide more frequently or concentration of molecules is increased or molecules are closer
NOT they have more KE
increased yield
high pressure favours side with few molecules or smaller volume or moves to reduce the pressure
this is product side this can be implied

(b) (i) high temperature or heat
back reaction endothermic or moves to left

OR low pressure
left side has higher volume of gases or more moles of gas

OR remove carbon monoxide
reaction try to replace it

OR energy needed
bonds breaking or to decompose Ni(CO)₄

14.10.2.1 ESSENTIAL EXAM QUESTIONS Haber process and nitrogen chemistry 63 Marks
Mark Scheme

Topic Chem 11.3 Q# 1/ iGCSE Chemistry/2013/w/Paper 31/
3  (a)  (i)  fractional distillation
   (liquid) air

   (ii) cracking / heat in presence of catalyst
        of alkane / petroleum
        to give an alkene and hydrogen

        OR: electrolysis (1)
        named electrolyte (1)
        hydrogen at cathode (1)

        OR: from methane (1)
        react water / steam (1)
        heat catalyst (1)
        only ACCEPT: water with methane or electrolysis

(b)  (i)  the pair with both graphs correct is C

   NOTE: mark (b)(ii) independent of (b)(i)

   (ii) high pressure favours side with lower volume / fewer moles
        this is RHS / product / ammonia
        %NH₃ / yield increases as pressure increases

        the forward reaction is exothermic
        exothermic reactions favoured by low temperatures
        %NH₃ / yield decreases as temperature increases
        ACCEPT: reverse arguments

   (iii) increases reaction rate
        ACCEPT: reduces activation energy
        OR: decreases the amount of energy particles need to react
        OR: economic rate at lower temperature so higher yield

   [Total: 14]
(b) any five from:

- high pressure favours lower volume side / movement to right / ammonia side, or high pressure increases the yield
- high pressure increases rate
- low temperature favours exothermic reaction / increases yield / favours the forward reaction
- low temperature gives low rate or vice versa
- catalyst increases rate or lowers activation energy
- 450 °C low enough to give an economic yield but with catalyst gives a fast enough rate note need whole concept to get this compromise temperature point [5]

Topic Chem 11.3 Q# 3/ iGCSE Chemistry/2010/w/Paper 31/ Q4

(b) (i) expensive metal / iron cheaper / better catalyst [1]

(ii) high pressure favours side with smaller volume / fewer moles this is right hand side / product / ammonia side [1]

(iii) recycled / sent over catalyst again accept used again [1]

(iv) advantage high yield disadvantage slow reaction rate etc [1]

Topic Chem 11.3 Q# 4/ iGCSE Chemistry/2009/s/Paper 31/

6 (a) (i) air (liquid) petroleum or crude oil or alkanes or methane or water or steam or steam reforming or suitable aqueous solution e.g. brine or sea water [1]

NOTE: cannot crack methane [1]

(ii) iron [1]

(iii) (as a) fertiliser or to make fertilisers or to make nitric acid [1]

(b) (i) concentrations/macroscopic properties do not change accept amounts stay the same NOT no change rate of forward and back reactions equal [1]

(ii) it decreases with increase temperature or it increases with decrease temperature [1]
(c) (i) shows an increase either a line or curve
(any decrease = 0) [1]

(ii) increase pressure favours the side with lower volume or molecules or moles
that is RHS or products side
ignore any mention of rates [1]

Topic Chem 11.3 Q# 5/ iGCSE Chemistry/2008/w/Paper 31/ Q5

(ii) ammonia or methanol or hydrogen chloride or margarine NOT nylon [1]

Topic Chem 11.3 Q# 6/ iGCSE Chemistry/2008/s/Paper 31/)

8 (a) burning wood produces carbon dioxide
less photosynthesis or trees take up carbon dioxide [1]

Topic Chem 11.3 Q# 7/ iGCSE Chemistry/2006/w/Paper 3/)

5 (a) (i) iron [1]

(ii) advantage higher yield
explanation lower temperature favours the exothermic reaction
(that is the forward reaction) [1]

(b) (i) Sent over the catalyst again or used to make more ammonia
NOT just reused [1]

(ii) It has the highest boiling point [1]

(c) (i) \( \text{CO}_2 + 2\text{NH}_3 = \text{CO} (\text{NH}_2)_2 + \text{H}_2\text{O} \)
Not balanced [1]

(ii) Any comment based on deficiency of PK/or ONLY provides Nitrogen as a nutrient
NOT soil pH [1]

Topic Chem 11.3 Q# 8/ iGCSE Chemistry/2005/w/Paper 3/)

Question 7

(a) from methane [1]
and water [1]

OR electrolysis [1]
suitable electrolyte [1]

OR alkane [1]
cracking [1] [2]

(b) (i) iron [1]

(ii) lower temperature moves equilibrium to right
because forward reaction is exothermic [1]

Topic Chem 11.3 Q# 9/ iGCSE Chemistry/2004/s/Paper 3/ Q2

(b) (i) potassium [1]

(ii) ammonium sulphate [1]

Topic Chem 11.3 Q# 10/ iGCSE Chemistry/2003/w/Paper 3/)

1. (a) (i) different boiling points
   (ii) methane or water or petroleum or named petroleum fraction or alkane
   Any TWO

   (b) (i) volume decrease for forward reaction or fewer moles of gas on products side
   favoured by increase in pressure
   or increase in pressure moves position of equilibrium to right
   (ii) increase exothermic reaction favoured by lower temperature
   (iii) 300 to 600 °C
   1:3 volume ratio
   iron (catalyst)
   150 to 300 atm
   Any TWO


(c) (steam) and alkane
heat or catalyst or details of chemistry -- forms carbon monoxide/dioxide and (hydrogen)
OR electrolysis
brine or acidified water
or hydrogen forms at cathode
OR carbon/coke
heat or details of chemistry -- forms carbon monoxide/dioxide and (hydrogen)

14.10.2.1 ESSENTIAL EXAM QUESTIONS Contact Process and Sulfur Chemistry 79 Marks
Scheme

Topic Chem 12 Q# 1/ iGCSE Chemistry/2014/w/Paper 31/
3 (a) Any two from:
bleach/making wood pulp/making paper
food/fruit juice/wine preservative
fumigant/sterilising/insecticide

(b) heating/roasting/burning (zinc sulfides)
in air/oxygen COND on M

(c) (i) $V_2O_5$

(ii) position of equilibrium shifts right/yield increases
to save energy

(iii) faster reaction/rate

more collisions per second/higher collision frequency

fewer moles/molecules (of gas) on right

(so) position of equilibrium shifts right/yield increases

(d) (the reaction is) too violent/too exothermic or produces mist/fumes (of acid)

Topic Chem 12 Q# 2/ iGCSE Chemistry/2013/w/Paper 31/ Q6

(b) (i) anhydrous cobalt chloride becomes hydrated

ACCEPT: hydrous

(ii) carbon dioxide is acidic

sodium hydroxide and calcium oxide are bases / alkalis

(iii) Any two of:

water, calcium carbonate and sodium carbonate

ACCEPT: sodium bicarbonate

Topic Chem 12 Q# 3/ iGCSE Chemistry/2011/s/Paper 31/ Q4

(b) for a high yield need low temperature

then rate would be too slow or uneconomic

a discussion of optimum temperature could score mark 1 and 2

presence of catalyst would increase rate (at same temperature)

does not alter the yield (at that temperature)

/ economic rate at lower temperature, therefore higher yield

higher pressure which would increase yield / rate

yield high enough / high pressure expensive

max [4]

accept reverse arguments

note increase yield = position of equilibrium to right

(ii) change from purple or pink to colourless NOT clear

(iii) reacts with oxygen in air

6 (a) (i) burn sulfur in air or oxygen or heat a metal sulfide in air

(ii) bleach for wood pulp/cloth/straw or preserve food or sterilising or making wine or fumigant or refrigerant Accept making paper

(iii) vanadium(V) oxide accept vanadium oxide or V₂O₅ or vanadium pentoxide oxidation state not essential but if given it has to be (V)

(iv) rate too slow or rate not economic

(v) reaction too violent or forms a mist

(g) vanadium

ACCEPT name or symbol

4 (a) (i) bleach for wood pulp or preserving food or sterilising or in wine making or as a refrigerant or in metallurgy or (liquid) sulphur dioxide is used in the petroleum industry or kill microbes(etc) or insecticide

(ii) (react with) oxygen or air NOT burnt/burnt in air/oxygen 450°C vanadium oxide catalyst (if oxidation state given has to be correct) or platinum If four conditions are given which include high pressure then MAX [2] High pressure is incorrect MAX 10 atm.

(iii) ammonium sulphate or superphosphate or potassium sulphate or magnesium sulphate
Topic Chem 12 Q# 8/ iGCSE Chemistry/2006/s/Paper 3/Q5 (b)

(iii) Low enough for good yield
High enough for (economic) rate
Any similar explanation will be awarded the mark
**NOT** just that it is the optimum temperature

(iv) bubble into (conc) sulphuric acid
add water
**NOT** consequential

Topic Chem 12 Q# 9/ iGCSE Chemistry/2006/s/Paper 3/

5 (a) (i) Burn sulphur in air (or oxygen)
(ii) as a bleach
(iii) kill bacteria/micro-organisms
**NOT** prevents food going bad or rotten or decaying

(b) (i) decrease
(ii) exothermic
**COND** increase temperature favours back reaction so it is endothermic, so forward reaction must be exothermic
**OR** any similar explanation will be awarded the mark, for example
The forward reaction is not favoured by an increase in temperature so it is exothermic (rather than endothermic)

(iii) Low enough for good yield
High enough for (economic) rate
Any similar explanation will be awarded the mark
**NOT** just that it is the optimum temperature


(c) (i) vanadium oxide or vanadium(V) oxide or vanadium pentoxide or V₂O₅
Must be correct oxidation state if one given

(ii) 400 to 500°C

(iii) add to (concentrated) sulphuric acid **NOT** dilute
**COND** (upon sulphuric acid) above then add water


---

4. (a) (i) correct word equation (carbon dioxide and water) 
Accept correct symbol equation 

(ii) Must have a correct reagent otherwise wo = 0 
add (acidified) barium chloride(aq) or nitrate or add barium ions 
COND white precipitate 
NOT lead(II) compounds 

(iii) low pH or universal indicator turns red(aq) 
pH 3 or less 

(b) (i) \[ H_2S + 2O_2 = H_2SO_4 \] 
unbalanced \[ 1 \]

(ii) unpleasant smell or it is poisonous or when burnt forms acid rain or forms sulphur dioxide or forms sulphuric acid 
NOT it is a pollutant 

(iii) 2H to 1S 
COND 8e around sulphur atom 
2e per hydrogen atom 
THREE correct 
TWO from above \[ 1 \] 
Ionic structure = \[ 0 \]

---


2. (a) (i) USA or Texas or Poland or Mexico or Japan or Ethiopia 
Australia or Sicily 
accept other sources of sulphur eg petroleum 
or natural gas or metal sulphides or volcanoes 
NOT coal, NOT underground 

(ii) Preserving food or bleaching or sterilising or 
disinfecting or making paper or bleaching wood pulp 
or wine or jam or fumigation or making paper 
NOT making wood pulp 

(iii) burnt/roast in oxygen or air 

(iv) vanadium(V) oxide or vanadium oxide or platinum 
ignore oxidation state of vanadium 

(v) Increase temperature (increases rate) but reduces yield 
catalyst only increases rate or a catalyst does not 
influence position of equilibrium 
NOT a definition of a catalyst 

(vi) sulphur trioxide + sulphuric acid = oleum 
correct symbol equation acceptable 

(vii) \[ H_2S_2O_7 + H_2O = 2H_2SO_4 \] 

---

Topic Chem 12 Q# 13/ iGCSE Chemistry/2003/w/Paper 3/
5  (a) (i) preserve food or sterilising
(ii) making paper

(b) (i) making sulphuric acid or Contact Process
(ii) oxygen
(iii) vanadium oxide as catalyst (ignore oxidation state)
    400 to 500 °C
    pressure less than 10 atm
Any TWO
1 (a) (i) vanadium(V) oxide as catalyst - ignore oxidation state
   and accept no oxidation state
   temperature 300 to 600 °C
   pressure up to 10 atmos, accept atmospheric pressure
   volume ratio of gases either 2:1 or slight excess of oxygen
   ANY three [3]
   (ii) decrease [1]
   COND back reaction is endothermic or same argument based on
   forward reaction is exothermic [1]
   or increase in temp favours back reaction
   (iii) dissolve in (conc) sulphuric acid NOT dilute [1]
   add water or dilute [1]

Topic Chem 12 Q# 15/ iGCSE Chemistry/2001/w/Paper 3/Q4
5 (a) (i) bleach [1]
   (ii) kills bacteria or germs or micro organisms [1]

14.11  FUNDAMENTAL Assessed Activity 1 Keyword Test

<table>
<thead>
<tr>
<th>English</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>reversible reaction</td>
<td></td>
</tr>
<tr>
<td>carbon cycle</td>
<td></td>
</tr>
<tr>
<td>acid rain this</td>
<td></td>
</tr>
<tr>
<td>dynamic (chemical) equilibrium</td>
<td></td>
</tr>
<tr>
<td>equilibrium</td>
<td></td>
</tr>
<tr>
<td>artificial fertiliser</td>
<td></td>
</tr>
<tr>
<td>Contact process</td>
<td></td>
</tr>
<tr>
<td>nitrogen cycle</td>
<td></td>
</tr>
</tbody>
</table>
Haber process
Topic Chem 7 Q# 1/
15 The reversible reaction between methane and steam is shown.

\[ \text{CH}_4(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{CO}(\text{g}) + 3\text{H}_2(\text{g}) \]

The forward reaction is endothermic.

Which changes in pressure and temperature move the equilibrium to the right?

<table>
<thead>
<tr>
<th></th>
<th>pressure</th>
<th>temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>decrease</td>
<td>decrease</td>
</tr>
<tr>
<td>B</td>
<td>decrease</td>
<td>increase</td>
</tr>
<tr>
<td>C</td>
<td>increase</td>
<td>decrease</td>
</tr>
<tr>
<td>D</td>
<td>increase</td>
<td>increase</td>
</tr>
</tbody>
</table>

Topic Chem 7 Q# 2/
15 Methanol is prepared by the reversible reaction shown.

\[ \text{CO}(\text{g}) + 2\text{H}_2(\text{g}) \rightleftharpoons \text{CH}_3\text{OH}(\text{g}) \]

The forward reaction is exothermic.

Which conditions produce the highest equilibrium yield of methanol?

<table>
<thead>
<tr>
<th></th>
<th>temperature</th>
<th>pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>high</td>
<td>high</td>
</tr>
<tr>
<td>B</td>
<td>high</td>
<td>low</td>
</tr>
<tr>
<td>C</td>
<td>low</td>
<td>high</td>
</tr>
<tr>
<td>D</td>
<td>low</td>
<td>low</td>
</tr>
</tbody>
</table>

Topic Chem 7 Q# 3/
15 When BiCl₃ reacts with water, a white precipitate of BiOCl is formed. The equation for the reaction is shown.

\[ \text{BiCl}_3(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{BiOCl}(\text{s}) + 2\text{HCl}(\text{aq}) \]

Which statements are correct?

1. The reaction is reversible.
2. When dilute hydrochloric acid is added to the reaction mixture, more of the white precipitate forms.
3. When aqueous sodium hydroxide is added to the reaction mixture, more of the white precipitate forms.

A 1, 2 and 3  B 1 and 2 only  C 1 and 3 only  D 2 and 3 only
15 The formation of sulfur trioxide is a reversible reaction.

The equation is shown.

\[ 2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g}) \]

The forward reaction is exothermic.

Which conditions produce the highest equilibrium yield of sulfur trioxide?

<table>
<thead>
<tr>
<th></th>
<th>pressure</th>
<th>temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>high</td>
<td>high</td>
</tr>
<tr>
<td>B</td>
<td>high</td>
<td>low</td>
</tr>
<tr>
<td>C</td>
<td>low</td>
<td>high</td>
</tr>
<tr>
<td>D</td>
<td>low</td>
<td>low</td>
</tr>
</tbody>
</table>

17 Some nitrogen dioxide gas was put in a gas syringe. The end of the gas syringe is sealed.

A reversible reaction occurs. The reaction reaches equilibrium.

\[ 2\text{NO}_2(\text{g}) \rightleftharpoons \text{N}_2\text{O}_4(\text{g}) \]

dark brown light yellow

The forward reaction is exothermic.

Which statement about the reaction is correct?

A. If the gas syringe is placed in a cold water bath, the colour becomes darker.

B. If the gas syringe is placed in a hot water bath, the colour becomes lighter.

C. If the volume in the gas syringe is increased, the colour becomes lighter.

D. If the volume in the gas syringe is decreased, the colour becomes lighter.

18
The following reaction has reached equilibrium in a closed system.

\[ 2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g}) \]

The forward reaction is exothermic.

Which row shows the effect of increasing the pressure on the equilibrium mixture?

<table>
<thead>
<tr>
<th></th>
<th>reaction rate</th>
<th>amount of SO₂</th>
<th>amount of SO₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>increases</td>
<td>decreases</td>
<td>increases</td>
</tr>
<tr>
<td>B</td>
<td>increases</td>
<td>increases</td>
<td>decreases</td>
</tr>
<tr>
<td>C</td>
<td>unchanged</td>
<td>decreases</td>
<td>increases</td>
</tr>
<tr>
<td>D</td>
<td>unchanged</td>
<td>increases</td>
<td>decreases</td>
</tr>
</tbody>
</table>

**Topic Chem 7 Q# 7/16**

The formation of sulfur trioxide from sulfur dioxide is a reversible reaction.

\[ 2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g}) \]

The forward reaction is exothermic.

Which changes would increase the equilibrium yield of SO₃?

1. increasing the pressure
2. lowering the temperature
3. decreasing the concentration of oxygen

A 1, 2 and 3 B 1 and 2 only C 1 only D 2 and 3 only

**Topic Chem 7 Q# 8/16**

Methane reacts with steam to produce hydrogen and carbon monoxide.

The equation for the reaction is shown.

\[ \text{CH}_4(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons 3\text{H}_2(\text{g}) + \text{CO}(\text{g}) \]

The reaction is reversible. The forward reaction is endothermic.

Which changes in temperature and pressure increase the equilibrium yield of carbon monoxide?

<table>
<thead>
<tr>
<th></th>
<th>temperature</th>
<th>pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>decrease</td>
<td>decrease</td>
</tr>
<tr>
<td>B</td>
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<td>increase</td>
</tr>
<tr>
<td>C</td>
<td>increase</td>
<td>decrease</td>
</tr>
<tr>
<td>D</td>
<td>increase</td>
<td>increase</td>
</tr>
</tbody>
</table>
Topic Chem 7 Q# 9/

16 Hydrogen is produced when methane reacts with steam.

The equation for the reaction is shown.

\[ \text{CH}_4(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{CO}(\text{g}) + 3\text{H}_2(\text{g}) \]

The forward reaction is endothermic.

Which conditions produce the highest yield of hydrogen?

<table>
<thead>
<tr>
<th></th>
<th>pressure</th>
<th>temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>high</td>
<td>high</td>
</tr>
<tr>
<td>B</td>
<td>high</td>
<td>low</td>
</tr>
<tr>
<td>C</td>
<td>low</td>
<td>high</td>
</tr>
<tr>
<td>D</td>
<td>low</td>
<td>low</td>
</tr>
</tbody>
</table>

Topic Chem 7 Q# 10/

16 The reaction used to manufacture ammonia from nitrogen and hydrogen is reversible.

An equilibrium can be established between ammonia, nitrogen and hydrogen.

Which statement describes the equilibrium?

A Both the forward reaction and the backward reaction have the same rate.
B The rate of the backward reaction is greater than the rate of the forward reaction.
C The rate of the forward reaction is greater than the rate of the backward reaction.
D The forward and backward reactions have both stopped.

Topic Chem 7 Q# 11/

16 Nitrogen, hydrogen and ammonia gases are placed inside a container. The container is then sealed. After some time, an equilibrium forms.

\[ \text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g}) \]

Which statement describes the equilibrium in this container?

A The amount of ammonia remains constant from the moment the container is sealed.
B The amounts of ammonia, nitrogen and hydrogen in the container are always equal.
C The rate of formation of ammonia is equal to the rate of decomposition of ammonia.
D The rate of formation of ammonia is faster than the rate of decomposition of ammonia.

Topic Chem 7 Q# 12/
The equation for the reversible reaction between hydrogen and iodine to form hydrogen iodide is shown.

The colours of the reactants and products are shown.

\[
H_2(g) + I_2(g) \rightleftharpoons 2HI(g)
\]

colourless  purple  colourless

The forward reaction is exothermic.

Which statement is correct?

A  An increase in pressure has no effect on the equilibrium position.
B  The purple colour fades when the reaction mixture is heated.
C  When equilibrium is reached, both forward and reverse reactions stop.
D  When more hydrogen gas is added, the purple colour increases.
16 Chlorine can be manufactured by the following reaction. The reaction is exothermic.

\[ 4\text{HCl}(g) + \text{O}_2(g) \rightleftharpoons 2\text{H}_2\text{O}(g) + 2\text{Cl}_2(g) \]

Which change increases the yield of chlorine at equilibrium?

A adding more HCl(g)
B adding more H_2O(g)
C decreasing the pressure
D increasing the temperature

16 At 400°C the reaction between hydrogen and iodine reaches an equilibrium. The reaction is exothermic.

\[ \text{H}_2(g) + \text{I}_2(g) \rightleftharpoons 2\text{HI}(g) \quad \Delta H = -13 \text{ kJ/mol} \]

Which change in conditions would increase the percentage of hydrogen iodide in the equilibrium mixture?

A a decrease in pressure
B a decrease in temperature
C an increase in pressure
D an increase in temperature

16 The following reversible reaction takes place in a closed vessel at constant temperature.

\[ \text{P}(g) + \text{Q}(g) + \text{R}(g) \rightleftharpoons \text{S}(g) + \text{T}(g) \]

When the system has reached equilibrium, more T is added.

After the addition of T, which substances increase in concentration?

A P, Q, R and S
B P and Q only
C P, Q and R only
D S only
Q#1 Iodine reacts with chlorine to form a dark brown liquid, iodine monochloride.

\[ \text{I}_2(s) + \text{Cl}_2(g) \rightarrow 2\text{ICl}(l) \]

When more chlorine is added and the tube is sealed, a reversible reaction occurs and the reaction comes to equilibrium.

\[ \text{ICl}(l) + \text{Cl}_2(g) \rightleftharpoons \text{ICl}_3(s) \]

(i) Give another example of a reversible reaction. ............................................................................................................................................................................................... [1]

(ii) Explain the term *equilibrium*. ............................................................................................................................................................................................... [2]

(d) Chlorine is removed from the tube and a new equilibrium is formed.

Explain why there is less of the yellow solid and more dark brown liquid in the new equilibrium mixture.

..................................................................................................................................................................................................................................................................... [2]
(e) A sealed tube containing the equilibrium mixture is placed in ice-cold water. There is an increase in the amount of yellow solid in the equilibrium mixture.

What can you deduce about the forward reaction in this equilibrium?

$$\text{ICI}(l) + \text{Cl}_2(g) \rightleftharpoons \text{ICl}_3(s)$$

Explain your deduction.

Chem 7.3 Q# 2/ 5 Carbonyl chloride, COCl$_2$, is widely used in industry to make polymers, dyes and pharmaceuticals.

(b) Carbonyl chloride is now made by the reversible reaction given below.

$$\text{CO}(g) + \text{Cl}_2(g) \rightleftharpoons \text{COCl}_2(g)$$

The forward reaction is exothermic.
The reaction is catalysed by carbon within a temperature range of 50 to 150°C.

(i) Predict the effect on the yield of carbonyl chloride of increasing the pressure. Explain your answer.

(ii) If the temperature is allowed to increase to above 200°C, very little carbonyl chloride is formed. Explain why.

(iii) Explain why a catalyst is used.

Chem 7.3 Q# 3/ 4 Vanadium is a transition element. It has more than one oxidation state. The element and its compounds are often used as catalysts.
Vanadium(V) oxide is used to catalyse the exothermic reaction between sulfur dioxide and oxygen in the Contact Process.

\[ 2\text{SO}_2 + \text{O}_2 \rightleftharpoons 2\text{SO}_3 \]

The rate of this reaction can be increased either by using a catalyst or by increasing the temperature. Explain why a catalyst is used and not a higher temperature.

[2]

14.14 EXTENSION Mind Map For Topics 7.3 Reversible Reactions, 11.3 Nitrogen & Fertilisers & 12 Sulfur (Equilibria)
14.15 ESSENTIAL End of Topic Review and Reflection

Looking at the goals you could have achieved and the goals you actually achieved try to reflect on your progress.

Try to be as honest and as detailed as possible. Sometimes you may think you have thought about an idea well, but when you talk with someone else, or write it out, it helps you better understand and allows you think more completely and more clearly.

Did you achieve more goals this topic than last topic?

Fill in this table

<table>
<thead>
<tr>
<th>Level</th>
<th>Number of goals achieved at each level</th>
<th>Success rate, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>FUNDAMENTAL</td>
<td>/5</td>
<td></td>
</tr>
<tr>
<td>ESSENTIAL</td>
<td>/10</td>
<td></td>
</tr>
<tr>
<td>EXTENSION</td>
<td>/13</td>
<td></td>
</tr>
<tr>
<td>EXCEPTIONAL</td>
<td>/10</td>
<td></td>
</tr>
</tbody>
</table>

Do you feel you tried harder? If yes, what helped you to do so? If not, why not?

__________________________________________________________

What could you do differently next time, in addition to what you are already doing to improve, not only your score in the end of topic tests and other assessed activities, but also in how you learn. How could you become a more effective student to get more learning out of the time you are investing in your studies?

__________________________________________________________

What did you enjoy most about this topic?

__________________________________________________________

What did you find most difficult?

__________________________________________________________

What did you find easiest?

__________________________________________________________

On a scale of 1 being hardest and 5 being most difficult, circle how challenging you found this topic

1  2  3  4  5

What could be done to make this topic easier to understand?

__________________________________________________________

Do you have any questions about this topic?

__________________________________________________________
14.16 Exceptional Additional Activities, Further Reading and Exploring Beyond the Syllabus

14.16.1 EXCEPTIONAL Active Learning Activity Can you think of why these molecules look wrong? 

What rules do they break that you have learnt at iGCSE? 

Try to find as many reasons these molecules should not exist as possible and explain why in the space below.

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Now go online to try to find out why they exist, and if there are any additional problems that these chemical structures ignore or get wrong

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Exceptional Extra Credit Science in Context

May have saved more lives than any other person in human history, but his contribution to society did not only save lives, he also helped develop and introduce a variety of weapons that many feel have made the world a less safe place. Using the internet, and the resources that are available in this section of my website (under Topic 11):

https://www.smashingsciencecn.org/igcse-chem-additional-resources

Find out about the man and create a short presentation about one aspect of his life or his contribution to society.

You can find out more about how to make a lasting impression with your presentation here:

https://13c35962-6df0-4843-9028-c26407054a5a.filesusr.com/ugd/d26cc6_c85f76e6275141b1b2b98fc6530a5753.pptx?dn=Basics%20to%20a%20good%20presentation.pptx

And what kinds of things that matter in the best presentations here:

https://13c35962-6df0-4843-9028-c26407054a5a.filesusr.com/ugd/d26cc6_9a753109001c4ad5a6b630adb8e64ccc.pdf?index=true

Alternatively, you could look at the Contact Process.

Why do you think it is included in the syllabus? About 30 years ago it used to be suggested that the more sulfuric acid a country uses the more developed it is. Is this still true? If not, why not? Why is this chemical so important to society?

https://13c35962-6df0-4843-9028-c26407054a5a.filesusr.com/ugd/d26cc6_9038cccb606643c889dc09c257e5dbb4.pdf?index=true

To find out more, you could buy this book, which is just $5,000 US (or about 36,000RMB); maybe writing these kinds of books might make for an interesting career?: https://www.researchandmarkets.com/reports/4793190/global-sulfuric-acid-market-by-raw-material-by

## 15.1 EXTENSION Keywords

You do not need to understand these words to score a good A, or even a low A* but if you are aiming for a good or high A* then understanding words like these here will be helpful.

<table>
<thead>
<tr>
<th>Topic #</th>
<th>English</th>
<th>Chinese</th>
</tr>
</thead>
<tbody>
<tr>
<td>x1</td>
<td><strong>absolute temperature</strong> a temperature measured with respect to absolute zero on the Kelvin scale – absolute zero is the lowest possible temperature that can be achieved</td>
<td>绝对温度相对于开氏温标上的绝对零测量的温度– 绝对零是可以达到的最低温度</td>
</tr>
<tr>
<td>x1</td>
<td><strong>atmospheric pressure</strong> the pressure exerted by the atmosphere on the surface of the Earth due to the weight of the atmosphere</td>
<td>大气压力由于大气层的重量，大气层在地球表面施加的压力</td>
</tr>
<tr>
<td>x1</td>
<td><strong>centrifugation</strong> the separation of an insoluble solid from a liquid by rapid spinning during which the solid collects at the bottom of the sample tubes – the liquid can then be decanted off carefully</td>
<td>离心通过快速旋转从液体中分离出不溶性固体，在此期间固体收集在样品管的底部，然后可以小心地倾析出液体</td>
</tr>
<tr>
<td>x1</td>
<td><strong>distillate</strong> the liquid distilling over during distillation</td>
<td>蒸馏过程中蒸馏出的液体</td>
</tr>
<tr>
<td>x1</td>
<td><strong>immiscible</strong> if two liquids form two layers when they are mixed together, they are said to be immiscible</td>
<td>如果两种液体混合在一起时形成两层，则称它们是不溶混的</td>
</tr>
<tr>
<td>x1</td>
<td><strong>miscible</strong> if two liquids form a completely uniform mixture when added together, they are said to be this.</td>
<td>如果将两种液体加在一起形成完全均匀的混合物，则可以混溶。</td>
</tr>
<tr>
<td>x1</td>
<td><strong>solubility curve</strong> a graph showing how the solubility of a substance in a solvent changes with temperature</td>
<td>溶解度曲线表示物质在溶剂中的溶解度如何随温度变化的曲线图</td>
</tr>
<tr>
<td>x3</td>
<td><strong>ceramics</strong> materials such as pottery made from inorganic chemicals, like clay, by high-temperature processing</td>
<td>陶瓷材料，例如由粘土等无机化学物质通过高温加工制成的陶器</td>
</tr>
<tr>
<td>x3</td>
<td><strong>ductile</strong> a word used to describe the property that metals can be drawn out and stretched into wires</td>
<td>延性这个词用来描述金属可以被拉出并拉成金属丝的特性</td>
</tr>
<tr>
<td>x3</td>
<td><strong>half-life</strong> the time taken for half of the radioactive atoms in a sample of a radio isotope to decay</td>
<td>半衰期放射性同位素样品中一半放射性原子衰变所需的时间</td>
</tr>
<tr>
<td>x3</td>
<td><strong>mass spectrometer</strong> an instrument in which atoms or molecules are ionised and then accelerated; the ions are then separated according to their mass</td>
<td>质谱仪一种将原子或分子离子化然后加速的仪器；然后根据它们的质量分离离子</td>
</tr>
<tr>
<td>x3</td>
<td><strong>volatile</strong> term that describes a liquid that which evaporates easily; it is a liquid with a low boiling point having only weak intermolecular forces between the molecules in the liquid</td>
<td>挥发性术语，描述易于蒸发的液体；它是一种低沸点的液体，液体中分子之间的分子间力很弱</td>
</tr>
<tr>
<td>x3</td>
<td><strong>volatility</strong> the property of how easily a liquid can become a gas</td>
<td>挥发性液体容易变成气体的特性</td>
</tr>
<tr>
<td>x4</td>
<td><strong>Avogadro constant</strong> another name for a mole</td>
<td>Avogadro常数的另一个名字</td>
</tr>
<tr>
<td>x4</td>
<td><strong>mass concentration</strong> the measure of the concentration of a solution in terms of the mass of the solute, in grams, dissolved per cubic decimetre of solution (g/dm³)</td>
<td>质量浓度，以每立方分米溶液中溶解的溶质质量（克）为单位的溶液浓度的量度（g / dm³）</td>
</tr>
<tr>
<td>Topic #</td>
<td>English</td>
<td>Chinese</td>
</tr>
<tr>
<td>-------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>x4</td>
<td>relative atomic mass (Ar) the average mass of an atom of an element, taking account of the isotopes of the element, on a scale where a carbon-12 atom has a mass of exactly 12</td>
<td>相对原子质量（Ar）元素的原子平均质量，考虑到元素的同位素，碳12原子的质量恰好为12</td>
</tr>
<tr>
<td>x5</td>
<td>non-electrolytes liquids or solutions that do not take part in electrolysis: they do not contain ions</td>
<td>不参与电解的非电解质液体或溶液：它们不含离子</td>
</tr>
<tr>
<td>x6</td>
<td>heat of neutralisation the heat change which takes place when one mole of hydrogen ions is completely neutralised</td>
<td>中和热当一摩尔氢离子完全被中和时发生的热变化</td>
</tr>
<tr>
<td>x7</td>
<td>spontaneous (reaction) a reaction that can take place simply by mixing the reactants</td>
<td>通过混合反应物即可发生的自发反应</td>
</tr>
<tr>
<td>x8</td>
<td>antacid compound used medically to treat indigestion by neutralising excess stomach acid</td>
<td>用于中和过量胃酸的消化不良的抗酸药</td>
</tr>
</tbody>
</table>
15.2 APPENDIX EXCEPTIONAL Statistics Relating to the Course

PAPERS 1, 3 and 6 (2016 onwards renamed Papers 2, 4 & 6)
Percentage of all WEIGHTED marks awarded for each topic from w2001 to w2015 (green triangles) and % of Paper 4 marks (red crosses)

<table>
<thead>
<tr>
<th>Topic</th>
<th>1</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
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</thead>
<tbody>
<tr>
<td>Paper 2</td>
<td>7.7</td>
<td>8.3</td>
<td>4.4</td>
<td>4.7</td>
<td>5.7</td>
<td>12.8</td>
<td>21.1</td>
<td>3.5</td>
<td>9.3</td>
<td>7.4</td>
<td>1.7</td>
<td>1.0</td>
<td>12.4</td>
</tr>
<tr>
<td>Paper 4</td>
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<td>18.7</td>
<td>7.9</td>
<td>4.2</td>
<td>2.2</td>
<td>8.0</td>
<td>10.6</td>
<td>3.1</td>
<td>10.1</td>
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<td>2.4</td>
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<td>Totals</td>
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</tbody>
</table>

Greener = Better; “Words per %...” refers to the words in the syllabus versus weighted marks awarded since w2001

15.3 Topics in Rank Order

<table>
<thead>
<tr>
<th>Topic</th>
<th>14</th>
<th>3</th>
<th>10</th>
<th>7</th>
<th>8</th>
<th>11</th>
<th>4</th>
<th>5</th>
<th>9</th>
<th>1</th>
<th>12</th>
<th>6</th>
<th>13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rank ALL Papers</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>6</td>
<td>9</td>
<td>8</td>
<td>11</td>
<td>7</td>
<td>12</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>Rank P3: A* Focus</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>10</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>All Syllabus Word Count RANK</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>6</td>
<td>4</td>
<td>9</td>
<td>7</td>
<td>10</td>
<td>8</td>
<td>12</td>
<td>11</td>
<td>13</td>
</tr>
</tbody>
</table>

C = Core  S = Supplement

15.4 Key Points about these graphs and data

- To do well, you must learn T8 (40 and 10.5% of P6 & P3) but to get an A* T14 is essential (20.2% of P3).
- Paper 3 (after 2016 renamed Paper 4) is easily the most important paper, it has gotten more challenging over the last 5 years with the same questions being asked, but with less help with the answer that is required (so more 5 or 6 marks questions), also the same questions are being asked but have fewer marks attached meaning that you not only need to know the answer, but you need to better understand the priority (e.g. many sources of sulfur, but the main source, from petroleum, is the only acceptable answer).
- However, these changes only make it harder for the less well prepared student, if you have not only answered these questions before, and checked your answers, but also looked at how some questions change with time (ANALYSED the trends) then it is in fact easier than ever before. There are fewer new questions than ever before!
- These are just averages, so for instance T13 is not often examined, so appears less relevant, but when it is in a paper (P3) it will be on average 5 marks, and because it is all supplement material, these will be a lot of the higher marks. This data should hopefully allow you to prioritise topics in your revision.
- T4 is the most efficient topic to learn (least to learn per mark awarded), provided you are good at maths (predicted to get at least a B grade), otherwise it is by far the least worthwhile topic (which these numbers don’t show but has been my experience in teaching) if you struggle with maths. You can still get an A* without this topic, but you’ll not be able to drop many marks in any other topic.
- If there was a fire and you had to leave one topic behind, T5 would be the one taking a hit for the team.
- Most important topics to your grades are 14, 8, 3, 10, 7 and 11, in that order.

### Multiple Choice Paper (B4 2016=P1, after=P2)

Percentage of all marks awarded for each topic from s2002-w12 and marks per topic for the new P2 (green triangle) s16 to s19

<table>
<thead>
<tr>
<th>Topic Number</th>
<th>P2 2016-17</th>
<th>P1 2002-12</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.3</td>
<td>8.6</td>
</tr>
<tr>
<td>3</td>
<td>9.8</td>
<td>12.0</td>
</tr>
<tr>
<td>4</td>
<td>6.2</td>
<td>4.1</td>
</tr>
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% of Marks awarded for each topic

0620 PAPER 4 (pre2016 called Paper 3)
Percentage of all marks awarded for each topic from s2013 to w2015 (red cross) and for 2016m to 2018w (green triangle)

PAPER 6
Percentage of all marks awarded for each topic from w2001 to w2015 (red crosses) and from m2016 to s2019 (green triangles)
Above are the main experiments and the main question types in Paper 6. Word files broken down by these categories are available on my website (e.g. s

15.4.1 Raw Data Info Used to Make the Graphs

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15.4.2

Comments

Yellow indicates the paper range for P1 is not the same as for the other papers, this is because P1 is changing, and taking apart that paper is particularly soul destroying, I can’t justify the hours of mind-numbing tedium if the information is going to be increasingly irrelevant.

Blue indicates the substantial difference in the total number of marks I should be able to account for (Total Marks All Papers) and the ones that have gone into the topic calculations. This is hopefully the result of a RANDOM error where some questions have had parts duplicated and I have not filtered these duplications out. Realistically, though it isn’t. When I started to break this paper down by topic I was not systematic in my process; my intentions were disorganised and I wasn’t thinking about being able to account for every mark, just for every question. So some topics were duplicated.
15.5 Words per topic statistics from the syllabus

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Although this is only one course so there is very little data at present to go on, a possible generalisation which might be of value when studying for other CIE subjects is that the more words there are in the syllabus, the more important that topic is to the exam. So to get an idea, count the words (can be done electronically: 1. Mark for redaction all of the section of the syllabus for supplement 2. Redact 3. Copy and past all of it to word 4. Do the same for supplement 5. Highlight the topic and word will give you the number of words). The actual results of this will not probably be too surprising, but outcome of this exercise and why it will help is it will force you to think objectively about the syllabus. Instead of thinking about the things that you didn’t like or you didn’t think you were good at, you will have the opportunity to get a different perspective on the subject. And hopefully, instead of thinking of the subject as a whole, you will start to break it down into more manageable chunks and begin the process of prioritisation, which when done well, is perhaps the most important principle in thought.

[Looking back on this project to count the words in the syllabus, which I did about 5 years ago, I cannot say it produced anything really interesting or useful. But it was super boring to do! Would not recommend doing it]
15.6 Papers Used to create the revision resources I use

This is an example of an Open Source resource, indicating exactly which exam papers I have used. Students are unlikely to learn anything about chemistry from it, but hopefully it is an introduction to the Open Source community (to find out more look here: https://opensource.org/history) It could be of use for teachers and also, if printed in colour or seen through the electronic version of this book, looks super science, very colourful and splendidly pretty

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### Data Sheet

**The Periodic Table of the Elements**

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*58-71 Lanthanoid series
190-103 Actinoid series

**Key**

- a = relative atomic mass
- X = atomic symbol
- b = proton (atomic) number

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).