CAIE iGCSE Chemistry
PreA Physical 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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9.1 End of Topic 7.1 & 7.2 Goals Checklist
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9.3 ESSENTIAL Glossary for Keywords for Topic 7.1 & 7.2
9.4 EXTENSION Keywords
9.5 ESSENTIAL Classroom Active Learning Tasks Drawing Graphs Based on the Rate of a Reaction from Paper 6 3 marks
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9.7 ESSENTIAL EXAM QUESTIONS Paper 2 Topic 7.1 & 7.2 12marks
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10.4 ESSENTIAL Classroom Active Learning Tasks 1 The Haber Process
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10.6 Extension Classroom Active Learning Task 2 Concentrated and dilute sulfuric acid Venn Diagram
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10.8 ESSENTIAL EXAM QUESTIONS Paper 2 Topic 7.3
10.8.1 ESSENTIAL EXAM QUESTIONS Paper 2 Topic 7.3 Mark Scheme
10.9 ESSENTIAL EXAM QUESTIONS Paper 3/4 Topic 7.3 56 marks
10.10 ESSENTIAL EXAM QUESTIONS Paper 3/4 Haber process and nitrogen chemistry (Topic 11.1) 63 Marks
13 Topic 10 Metals

13.1 End of Topic 10 Goals Checklist

13.2 Essential Topic 10 Syllabus

13.3 Essential Classroom Active Learning Tasks 1 Reactivity of Metals

13.4 Essential Classroom Active Learning Tasks 2 Reactivity of Metals with Water, Steam, Dilute Acids and Air

13.5 Extension INFORMATION Reactivity of Metals with Water, Steam, Dilute Acids and Air

13.6 Extension Classroom active learning task 2 Comparing the Reactivity of Two Metals

13.7 Extension Classroom active learning task 3 Extracting Metals Multi-mark questions about extracting Iron, Aluminium and Zinc

13.8 Exceptional Analysis Classroom active learning task 4 Comparing the Reactivity of Two Metals

13.9 Essential Classroom Active Learning Tasks 4 Uses of Metals

13.10 Essential Exam Questions Topic 10 Paper 2 50 marks

13.11 Essential Exam Questions Topic 10 Paper 2 50 marks Mark Scheme

13.12 Fundamental Assessed Activity 1 Keyword Test

13.13 Essential Assessed Activity 2 Topic 10 Paper 2 16 marks

13.14 Essential Assessed Activity 3 28 marks Topic 10 Paper 3/4

13.15 Exceptional Additional Activities, Further Reading and Exploring Beyond the Syllabus

14 Paper 6 Alternative to Practical Unit

14.1 End of Paper 6 Alternative to Practical Unit Goals Checklist

14.2 Essential Exam Questions Paper 6 Essay type questions by topic 12 marks

14.3 Mark Schemes Essential Exam Questions Paper 6 Essay type questions by topic 12 marks

14.4 Essential Assessed Activity 3

14.5 Essential End of Topic Review and Reflection

14.6 Exceptional Additional Activities, Further Reading and Exploring Beyond the Syllabus

15 Appendix – Glossary of the Complete IGCSE Syllabus

15.1 Essential Glossary for Keywords for this topic

15.2 Extension Keywords

15.3 Appendix Exceptional Statistics Relating to the Course

15.4 Topics in Rank Order

15.5 Key Points about these graphs and data

15.5.1 Raw Data Info Used to Make the Graphs

15.6 Words per topic statistics from the syllabus

15.7 Papers Used to create the revision resources I use

15.8 Fundamental Periodic Table of elements
1.4 FUNDAMENTAL – Explaining the different sections of each chapter

<table>
<thead>
<tr>
<th>Section title</th>
<th>What is it</th>
<th>How and why it can help you</th>
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</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 exceptional students 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 for expanding your academic vocabulary and particularly useful for exceptional students.</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. Exceptional students 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. Exceptional students 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>
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<tr>
<td>Essential 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, 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>Essential 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>
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</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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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>
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<td>1</td>
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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 each topic 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 CAIE iGCSE Chemistry (and all other CAIE subjects)

<table>
<thead>
<tr>
<th>Command word</th>
<th>Meaning</th>
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<tbody>
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<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 &quot;by looking at it&quot;).</td>
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<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>
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<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>
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<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>
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<td>Find</td>
<td>is a general term that may interpreted as calculate, measure, determine, etc.</td>
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<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>
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<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>
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<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>
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<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>
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<tr>
<td>Sketch</td>
<td>when applied to graph work, implies that the shape and/or proportions 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>
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**DATA SHEET**

**The Periodic Table of the Elements**

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<th>Group</th>
<th>I</th>
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*The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).

**Key**

- a = relative atomic mass
- X = atomic symbol
- b = proton (atomic) number

**FUNDAMENTAL Periodic Table of elements**

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Page 15 of 773
1.11 **FUNDAMENTAL** Recording your scores and keeping track of your performance

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Average of the first 60 assessed activities

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Target grade: 
Target Score: 
%
## FUNDAMENTAL School Calendar

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<thead>
<tr>
<th>Week #</th>
<th>Monday starting</th>
<th>Contents</th>
</tr>
</thead>
</table>
| 10-Aug | Mon 10 to 14 G1 & PreA Students Orientation Week  
**Tue 11th All teachers back in office**  
Fri 14th Full staff meeting/Department meeting Welcome Buffet  
Sun 16th C6 AS & A2 students registration  
**Sun 16th UCS Opening Ceremony All Staff am: G1, G2 & PreA, pm AS, A2 & IB1/2** |
| 1 17-Aug | Mon 17th Teaching Begins |
| 2 24-Aug | **Fri 28th Dead Line for G1, ASD and IB1 to change options**  
Tue 26th Activities Fair  
Wed 26th-30th Student Union Elections |
| 3 31-Aug | Fri 11th G1 and PreA Parents consultation day  
**Fri 11th Dead Line for A2 Students to drop options** |
| 4 7-Sep | Fri 18th IB2 Parents' consultation day  
Fri 11th Open day for G1 and PreA parents |
| 5 14-Sep | **Fri 18th Dead Line for A2 Predicted grades** |
| 6 21-Sep | **Sat 26th Make up day (Tuesday)** |
| 7 28-Sep | Thu 1st Oct First day of National Holiday |
| 5-Oct | 10th Oct Last day of National Holiday  
**Sun 11th Make-up Day (Friday’s timetable)** |
| 8 12-Oct | **SAT 17 Make-up Day (Sports Day) (or Wednesday if weather is bad)** |
| 9 19-Oct | Fri 23rd International Mole day |
| 10 26-Oct | Wed 28th Alternative sports day  
26th-30th Art Week |
| 11 2-Nov | **Fri 6th Deadline for 1st observation for returning teachers** |
| 12 9-Nov | Mon 9th to Fri 13th IB2 MS EXAMS  
Wed 11th Physics Day  
Fri 13th CAIE Winter Session Begins  
**Fri 13th DeadLine for inputting marks for Mid Semester Reports** |
| 13 16-Nov | |
| 14 23-Nov | Mon 23rd G1,2 PreA, AS and A2 Reports  
Fri 27th AS, A2 and IB1 Parents Consultation  
Fri 27th Completion of the first Student Survey  
**Sat 28th Makeup day G1, G2, PreA and Pre IB Parents Consultation day** |
<p>| 15 30-Nov | |
| 16 7-Dec | |
| 17 14-Dec | 13th CAIE Winter session ends |
| 18 21-Dec | |
| 28-Dec | |</p>
<table>
<thead>
<tr>
<th>Week #</th>
<th>Monday starting</th>
<th>Contents</th>
<th>Your Notes</th>
</tr>
</thead>
</table>
| 19    | 4-Jan          | Sun 3rd Jan Last day of Xmas holiday  
Mon 4th to Sat 9th End of Semester Exams  
Sat 9th Jan make up day |           |
| 20    | 11-Jan         | Mon 18th Deadline for input of all makrs in SIMS for EOS Reports  
Fri 22nd Annual Party & Long Service Awards Celebration |           |
| 21    | 18-Jan         | Mon 25th G1,2, PreA, AS and A2 reports issued  
Thur 28th IB1, AS and A2 Parents Consultation Day (PM only)  
Fri 29th G1,2 PreA, PrelB Parents Consultation Day (Whole day)  
Sat 30th Spring Festival Holiday begins |           |
| 22    | 25-Jan         | Chinese New Year Holiday  
Sat 20th Winter Holiday ends  
Sun 21st AM All students and form tutors in school for registration  
Sun 21st PM Students Assembly |           |
| 1-Feb |                | Chinese New Year Holiday |           |
| 8-Feb |                | Chinese New Year Holiday |           |
| 15-Feb|                | Chinese New Year Holiday  
Sat 20th Winter Holiday ends  
Sun 21st AM All students and form tutors in school for registration  
Sun 21st PM Students Assembly |           |
| 23    | 22-Feb         | Mon 22nd Semester 2 Teaching begins  
Sun 28th New spring classes in school for registration |           |
| 24    | 1-Mar          | Tue 2nd to Fri 12th IB2 Mock Exam  
Wed 3rd Graduation Picture Day (Weather permitting) |           |
| 25    | 8-Mar          | Fri 12th End of IB2 Mock  
Fri 12th G2 and PreA Optional Course Information Day  
Fri 12th Completion of 2nd Student survey |           |
| 26    | 15-Mar         | Mon 15th Deadline for G2, PreA, AS and A2 End of Year Exam Papers to AAO for printing |           |
| 27    | 22-Mar         | Mon 22nd Guided Revision Starts  
Wed 24 UCS Spring Concert  
Fri 26th Teaching of G2, PreA, AS, A2 syllabi completed  
Fri 26th Deadline for all Observations |           |
| 28    | 29-Mar         | Mon 29th- Thur 1st April CAIE Oral English Exam  
Thur 1st Guided Revision Ends  
Fri 2nd April QingMing Holiday Begins (3 days)  
Wed 31st Drama Class End of Year Performance |           |
| 29    | 5-Apr          | Mon 5th EOY (G2, PreA, AS & A2) begins |           |
| 30    | 12-Apr         | Fri 16th EOY ends |           |
| 31    | 19-Apr         | Thur 29th IB External Exams Begin |           |
| 32    | 26-Apr         | Thur 29th IB External Exams Begin |           |
### 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 your Organic or Physical Chemistry teacher. There may be changes depending on special events or lessons that are missed for other reasons.

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 and the teaching order is again different as a result of the split of the class for 2 different teachers. **Exceptional students** will not only be following the topic being taught outside of class but also preparing for the next topic.

<table>
<thead>
<tr>
<th>CAIE Topic ID</th>
<th>My topic ID</th>
<th>Textbook Chapter</th>
<th>PhysC OrgC?</th>
<th>Teaching Week #</th>
<th>CAIE Topic Name</th>
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<tr>
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### Assessment Structure

**2020-2021 weekly scheme of work for PreA Physical Chemistry**

#### Pre Chemistry Semester 1

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic &amp; Subtopics</th>
<th>Assessment</th>
<th>Practical work</th>
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<tbody>
<tr>
<td>1</td>
<td>Intro to lab</td>
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<tr>
<td>2</td>
<td>Naming Equipment</td>
<td>Assessed activity 1</td>
<td>T2</td>
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<tr>
<td>3</td>
<td>Separating techniques</td>
<td>Assessed Activity 2</td>
<td>T2</td>
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<td>4</td>
<td>Naming chemicals, balanced chemical equations with state symbols</td>
<td>End of Topic 2 Test</td>
<td>How much Na₂CO₃ in a mixture with NaCl</td>
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<td>5</td>
<td>Ionic half equations</td>
<td>End of Topic 4.1 Test</td>
<td>Assessed Activity 1</td>
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<td>6</td>
<td>Oxidation and reduction</td>
<td>End of Topic Test</td>
<td>Assessed Activity 2</td>
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<td>7</td>
<td>Electrolysis</td>
<td>Assessed Activity 2</td>
<td>T5</td>
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<td>8</td>
<td>Electroplating, Galvanic cells</td>
<td>Assessed Activity 1</td>
<td>T5</td>
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<td>9</td>
<td>Enthalpy, Endo &amp; Exo</td>
<td>End of Topic 5 Test</td>
<td>Endo thermic and Exothermic reactions</td>
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<td>Calculating enthalpy changes from bond energies</td>
<td>Assessed Activity 1</td>
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<td>11</td>
<td>How to measure rate of reaction</td>
<td>End of Topic 6 Test</td>
<td>Measuring the volume of gas produced against time</td>
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<td>12</td>
<td>Rate of reaction curves and collision theory</td>
<td>Long answer questions on rate</td>
<td>Measuring the rate</td>
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<tr>
<td>13</td>
<td>Reversible reactions including tests for water</td>
<td>Assessed Activity 1</td>
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#### Pre Chemistry Semester 2

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<td>13</td>
<td>Cumulative HW (O3)</td>
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</tbody>
</table>

#### Resources:
- A 400-side book (200 pages) accompanies this course that includes exercises, past exam questions, and formative assessment activities.
- Lab protocols and tests will be printed as needed throughout the year.

**Lab Equipment and Materials**
- Universal indicator
- Assorted test tubes
- Assorted reagents
- Assorted laboratory equipment
- Assorted chemicals

**Exams**
- EOY (%): 40%
- No cumulative assessment

**Pre Chemistry Semester 2**

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic &amp; Subtopics</th>
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<th>Practical work</th>
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<td>Cumulative HW (O6)</td>
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The protocols and lists will be printed as needed throughout the year."
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<tr>
<th>Weeks</th>
<th>Dates</th>
<th>School events/ key dates</th>
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<tbody>
<tr>
<td>27</td>
<td>22-26 March</td>
<td>Q3 and Q4 Advanced lab techniques</td>
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<tr>
<td>28</td>
<td>29-2 April</td>
<td>Guided revision starts</td>
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<tr>
<td>29</td>
<td>5-9 April</td>
<td>EOY</td>
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<td>30</td>
<td>12-16 April</td>
<td>Going through the EOY exam</td>
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<td>31</td>
<td>19-23 April</td>
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<tr>
<td>32</td>
<td>26-30 April</td>
<td>30th completion of self-reflection</td>
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<tr>
<td>33</td>
<td>3-7 May</td>
<td>CAIE EXAMS CAIE starts</td>
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<td>10-14 May</td>
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| 15 | 30-4 December | Contact process Assessed Activity 1 T11 |
| 16 | 7-11 December | Definitions, strong and weak acids and bases End of Topic Test Making salts 1 (CuSO₄ from CuO, BaSO₄ by precipitation) |
| 17 | 13-18 December | Making salts Revise Making salts 2 NaCl by Titration |
| 18 | 20-25 December | Mock EoS Exam Mock EoS Exam Going through the exam |
| 19 | 4-8 January | EOS (excluding acids and bases) 9 January make up day |
| 20 | 11-15 January | Flame test, Test for anions Assessed Activity 1 T8 Flame tests Tests for ions 18th DL SIMS 22nd annual Party |
| 21 | 18-22 January | Test for cations Assessed Activity 2 T8 Test for ions 18th DL SIMS |
| 22 | 25-29 January | Reactivity series of metals and displacement End of T8 test Displacement of Cu from CuSO₄ and Zn |
| 23 | 22-26 February | Extraction of iron and Zinc Assessed Activity 1 Thermite 28th New Spring |
| 24 | 1-5 March | Extraction of copper and its purification Assessed Activity 2 Electroplating using copper sulfate |
| 25 | 8-12 March | Uses of metals and sacrificial protection End of T10 test Galvanic cells 12th Course info. Day 12th student survey |
| 26 | 15-19 March | Q1 and Q2 Focus Preparing salts 15th EOY to AAO |
| 27 | 22-26 March | 60° completion of set experiment |
| 28 | 29-5 April | 120° completion of set experiment |

**Chapter [CAIE Topic #]**

- **Sub-topics**
  - Assessment/ HW
  - Practical work
  - School events/ key dates

**Weeks**

- **Chapter [CAIE Topic #]**
  - Assessment/ HW
  - Practical work
  - School events/ key dates

**Dates**

- **School events/ key dates**
  - Contact process Assessed Activity 1 T11
  - Definitions, strong and weak acids and bases End of Topic Test
  - Making salts 1 (CuSO₄ from CuO, BaSO₄ by precipitation)
  - Mock EoS Exam
  - EOS (excluding acids and bases) 9 January make up day
  - Flame test, Test for anions Assessed Activity 1 T8
  - Test for cations Assessed Activity 2 T8
  - Reactivity series of metals and displacement End of T8 test
  - Displacement of Cu from CuSO₄ and Zn
  - Extraction of iron and Zinc Assessed Activity 1 Thermite 28th New Spring
  - Extraction of copper and its purification Assessed Activity 2 Electroplating using copper sulfate
  - Uses of metals and sacrificial protection End of T10 test
  - Galvanic cells 12th Course info. Day 12th student survey
  - Q1 and Q2 Focus Preparing salts 15th EOY to AAO
  - 60° completion of set experiment
  - 120° completion of set experiment
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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2 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

---

¹ [https://help.open.ac.uk/active-reading](https://help.open.ac.uk/active-reading)
2.2 FUNDAMENTAL Active Reading Advice

2.3 EXTENSION Active Reading Advice

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 voluntarily. You can also write down key words to help you recall where important points are discussed. Above all, strive to engage in 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" from 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 →*

**Active Reading Strategies**


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, you need 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 ideas have 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 part of a process known as Active Learning². 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 reading³ 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 the processes, but they are not always included in markschemes for CAIE iGCSE Chemistry, which in addition to valuing what is true, also requires from its 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 its colour, shape, size and the direction it was travelling, but really only its speed would matter if you hoped to survive. Not all things are accurate (close to the being the “true”⁴ value) are equally relevant, and this exam board sometimes requires you to understand and list the most relevant factors, properties or characteristics first.

### Activity

**What you should do**

**Why it helps**

**When you should do it**

<table>
<thead>
<tr>
<th>Activity</th>
<th>What you should do</th>
<th>Why it helps</th>
<th>When you should do it</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FUNDAMENTAL 1. Translation</strong></td>
<td>Translate ALL new words, especially the ones in <strong>bold</strong>, 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>
</tr>
<tr>
<td><strong>FUNDAMENTAL 2. Underlining</strong></td>
<td>Underline, <strong>highlight</strong> *, put a * star or symbol Ð next to the biggest new ideas. 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>
</tr>
<tr>
<td><strong>FUNDAMENTAL 3. Answers</strong></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 ways.</td>
</tr>
<tr>
<td><strong>FUNDAMENTAL 4. Checking Answers</strong></td>
<td>Check your answers with the answers provided at the end of 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 have finished reading both ways.</td>
</tr>
<tr>
<td><strong>ESSENTIAL 5. Key Points</strong></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 you long-term memory. This will also help to write out better exam questions.</td>
<td>After you have finished the next two pages.</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.

A6 (B&B) Cue questions
Fill this in AFTER finishing the section.

Alkali metals are metals with low densities, melting and boiling points, and with very high reactivity. They are generally soft and can be cut with a knife to reveal a silvery white section.

Activities To Do (complete as you are reading)
A1. Translating
A2. Underlining
A3. Key Points

Thermal decomposition

When we heat some carbonates, nitrates and hydrazides, they break down into their constituent parts. We call this type of reaction thermal decomposition. For example, the reaction:

$$\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$$

represents the thermal decomposition of calcium carbonate.

Thermal decomposition of metal hydrazides

Most metal hydrazides decompose when heated. Metal hydrides and hydrazides are formed. For example:

$$\text{MgH}_2 \rightarrow \text{Mg} + \text{H}_2$$

Hydrazides are the least reactive of all the metals. So thermal decomposition depends on the activity of the metal. We shall look at the decomposition of nitrates and carbonates to answer this question.

Thermal decomposition of nitrates

All nitrates decompose when heated. But there are differences in how the metals decompose. The metal nitrates decompose to form metal oxides and nitrogen. You can see that the metal ion is similar to the nitrite ion in the reaction but has one fewer oxygen atoms:

$$\text{2NH}_4\text{NO}_3 \rightarrow \text{2N}_2 + \text{4H}_2 \text{O} + \text{O}_2$$

In solution, the metal nitrates decompose to form metal ions and nitrites. If we add another metal nitrate to the reaction, we get:

$$\text{2NH}_4\text{NO}_3 + \text{Ca(NO}_3)_2 \rightarrow \text{2N}_2 + \text{4H}_2 \text{O} + \text{O}_2 + \text{Ca(NO}_3)_2$$

A7. Summary Section: Do this after you have answered the post exam questions and write, in your own words, only one or two sentences that sums up the important points on this page.

The more reactive the metal, the more stable its nitrite, carbonate or hydride.

A9 Top Tips - Do this after you’ve taken the end of topic test. Write any difficult, odd or unexpected marks you come across from your tests and revision and especially from working through post exam questions.

- Only alkali metal nitrates decompose to form metal nitrates and oxygen. Other metals don’t.
- Most of the alkali metal hydrazides (except Li) don’t decompose.

SUMMARY QUESTIONS

1. Copy and complete using the words below:

- Metal nitrate decomposes when heated to form the metal _______ and _______.
- Decomposition is the process by which a compound ________ into its constituent parts.
- When we heat some carbonates, nitrates and hydrazides, they ________ into their constituent parts. We call this type of reaction thermal decomposition.

Thermal decomposition of carbonates

The table shows the temperatures at which the Group II carbonates decompose.

<table>
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<th>Nitrate</th>
<th>Decomposition temperature/°C</th>
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<td>Magnesium nitrate</td>
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<tr>
<td>Calcium nitrate</td>
<td>540</td>
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</table>

The reaction of the Group II metal nitrate, RNO₃, decomposes in a similar way. When heated, the metal nitrate decomposes to form metal oxide, water and nitrogen. You can see from the table that there are some variations in the temperature at which they decompose. The more reactive the metal, the more stable its nitrate, carbonate or hydride.
ESSENTIAL Examples of Mind Maps

Mind Map 1 of Section 10.1 & 10.2

The Metal Reactivity Series
From metal oxides to metals

More about reactivity Series
A more reactive metal will displace a less reactive metal from the solution of the latter.

The series are approximate and do not always run in sequence.

The order of the reactive metals is not the same way to That is not a.”
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 student’s brain with skills and techniques to learn faster, better and longer. The more you know, for 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 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 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

https://psychology.stackexchange.com/questions/8377/how-are-these-review-forgetting-curve-calculated

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.
3.3 Fundamental Cornell Notetaking Basics

3.3.1 Essential Cornell Notetaking for More Able Students

The Cornell Notetaking System

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

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 "WHY'S" and "HOW'S" with some of these guys thrown in.

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 mind maps, tables, or whatever takes your fancy—make it personal to you.

You might say this column is for the

**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.
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

---

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.
- 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):

---

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
After the lecture, write a summary at the bottom of your notes.
- Use complete sentences in the summary.
- Choose the key points.
- Organize ideas.
- Link ideas together.

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.
**How I Write Outlines/take notes**

**RONNIOH: UMLETHODE:**

- **Main Topic:**
  - **Section Name:**
    - **Paragraphs:**
      - **Main Points:**
        - **Points:**
          - **Details:**

**MY USUAL OUTLINE METHOD:**

- **Section Name:**
  - **Paragraphs:**
    - **Main Points:**
      - **Points:**
        - **Details:**

---

**How to Illustrate Your Notes**

- **Choose Your Bag:**
  - **Tools/Colors:**
    - **Pens/Felt Tips:**
      - **Colors:**
        - **Pen늪:**
          - **Colors:**
        - **Felt Tips:**
          - **Colors:**

- **Choose Your Scoop:**
  - **Fonts/Colors:**
    - **Fonts:**
      - **Colors:**
    - **Colors:**
      - **Colors:**

- **Choose Your Sweet:**
  - **Colors:**
    - **Colors:**
      - **Colors:**

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**Patrick Brannan**

### Questions & Translations

*Fill this in AFTER lesson*

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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.

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

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### Summary Section
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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.
## Questions & Translations

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**Idea**

Why it matters

Adding to your answers at the end

For most students. The harder explain questions, or other multi-mark questions often will require more detail than the 25-35 words that are the right amount of time per mark, MOVE ON 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, but only if you have the time!

Annotating your multiple-choice questions

For ALL students! 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.

Annotating your questions

For ALL students! 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 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.

Checking your exam paper

For most students. 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 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.

For the most able students 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.

Chemical equations

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 you will allow to get the mark. It is an example of REDUNDENCY or a FAIL-SAFE.

Crossing out mistakes

Never cross out work that you think is a mistake unless you have already provided another answer, so draw a box around you intend to replace, then write your new answer IN a neat cross through that box. Your cross-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 then 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 the difference, without saying if the value would be larger or smaller, one student suggested that it would be smaller in their cross out work, but only different in their final answer, but they had shown they understood how it would be different and got the mark.

Diagrams

For ALL students! 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.

Drawing graphs

In pencil!!! 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! For ALL students!

Eliminating the wrong answers in multiple choice questions

For ALL students! 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 getting it right 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.

Exam Questions

For ALL students! Almost none of the marks are awarded for answering actual questions (you will also have a question mark!!!). What are commonly referred to as 'command words'. 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.

FAIL SAFE or REDUNDENCY

Give some properties/etc

For most able students. 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. This is essential for a candidate to hope for a good A*!!!

For the least able students. 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.

Give ALL properties/conditions/etc

For ALL Students! 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 4 is correct, you could lose the mark. If one of the answers is wrong, then you will most likely lose the mark. They don't reward candidates who try to use ambiguity to increase their score, and in fact actively penalise it.

Name

For most students. 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 lose the mark.

Plurals

For ALL students! 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. PAY ATTENTION TO THIS!!!

Showing your working in calculations

For ALL students! 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 to you what you are doing, each step, even if it seems obvious, each step should be clearly labeled 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.

Selling

For ALL students! 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.

State or identify

For ALL students! 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 "Bromine (Br)" when in fact Br2, you will likely lose the mark. Or "Bromine (Br)" when it is the bromide ion, you will also lose the mark.

State symbols

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.

The order you answer questions

For ALL students! 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.

DON'T ANSWER EXAM QUESTIONS IN THE ORDER THEY APPEAR ON THE EXAM PAPER!!
### 4. Topic 2 Experimental Techniques

#### 4.1 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!

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<th>What you should have done</th>
<th>Yes/No</th>
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<td>Interacted with your teacher</td>
<td>Ask your teacher 1 question, about anything, once a week</td>
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<td>Try to answer one question asked by your teacher at least once a week</td>
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<td>Ask your teacher one question about something you do not understand in science once a week</td>
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<td>Ask your teacher one question about something to do with science every lesson</td>
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<td>Notes and follow up notes</td>
<td>Complete set of class note</td>
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<td>Cornell Notetaking Completed to an exemplary standard</td>
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<td>Attempted the Mind Map for this topic</td>
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<td>Completed the Mind Map for this topic</td>
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<td>Read ahead before the topic has been started</td>
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<td>Highlighted key ideas and translate new words</td>
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<td>Completed the questions at the end of each 2 page spread in your exercise book</td>
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<td>Added to your class notes ideas and important information from the textbook that you learnt</td>
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<td>Past Exam Questions</td>
<td>Worked on at least 25% of the exam questions in this workbook</td>
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<td>Attempted more than 25% of the questions and those questions you have marked in a different colour pen</td>
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<td>Completed and marked all questions here</td>
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<td>Completed, marked and additional key ideas where you have located the most difficult marks added to your notebook</td>
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<td>Used the resources available online to answer additional questions not found in this workbook on the current topic</td>
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<td>Ask your teacher about an exam question that they cannot answer</td>
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<td>EXCEPTIONALLY SMASHING!!</td>
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<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>
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<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>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>
</tbody>
</table>
### 4.2 Topic 2 Syllabus

#### 2 Experimental techniques

##### 2.1 Measurement

- Name appropriate apparatus for the measurement of time, temperature, mass, and volume, including burettes, pipettes, and measuring cylinders.

##### 2.2 Purity

#### 2.2.1 Criteria of purity

- Demonstrate knowledge and understanding of paper chromatography.
- Interpret simple chromatograms, including the use of $R_f$ values.
- Outline how chromatography techniques can be applied to colourless substances by exposing chromatograms to substances called locating agents. (Knowledge of specific locating agents is not required.)

#### 2.2.2 Methods of purification

- Describe and explain methods of purification by the use of a suitable solvent, filtration, crystallisation and distillation (including use of a fractionating column). (Refer to the fractional distillation of petroleum in section 14.2 and products of fermentation in section 14.6.)
- Suggest suitable purification techniques, giving information about the substances involved.

#### 4.3 ESSENTIAL Glossary for Keywords for this topic

<table>
<thead>
<tr>
<th>English</th>
<th>Chinese</th>
</tr>
</thead>
<tbody>
<tr>
<td>chromatogram the result of a paper chromatography run, showing where the spots of the samples have moved to</td>
<td>纸层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 a technique employed for the separation of mixtures of dissolved substances, which was originally used to separate coloured dyes</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 the process of forming crystals from a saturated solution</td>
<td>结晶从饱和溶液中形成晶体的过程</td>
</tr>
<tr>
<td>decanting the process of removing a liquid from a solid which has settled or from an immiscible heavier liquid by careful pouring</td>
<td>通过仔细倾倒，析取沉淀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 the process of boiling a liquid and then condensing the vapour produced back into a liquid: used to purify liquids and to separate liquids from solutions</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；用于纯化液体和将液体与液体分离</td>
</tr>
<tr>
<td>downward delivery a method of collecting a gas which is denser than air by passing it downwards into a gas jar</td>
<td>向下输送一种向重于空气的气体的方法；该方法将比空气更重的气体向下传送到一个装有气体的罐中</td>
</tr>
<tr>
<td>filtrate the liquid that passes through the filter paper during filtration</td>
<td>过滤液在过滤过程中通过滤纸的液体</td>
</tr>
<tr>
<td>filtration the separation of a solid from a liquid, using a fine filter paper which does not allow the solid to pass through</td>
<td>使用不允许固体通过的细滤纸过滤从液体中分出的固体</td>
</tr>
<tr>
<td>fractional distillation a method of distillation using a fractionating column, used to separate liquids with different boiling points</td>
<td>分馏通过分馏塔进行蒸馏的方法，用于分离具有不同沸点的液体</td>
</tr>
<tr>
<td>insoluble term that describes a substance that does not dissolve in a solvent</td>
<td>不溶性术语，描述了不溶于溶剂的物质</td>
</tr>
<tr>
<td>locating agent a compound that reacts with invisible, colourless spots separated by chromatography to produce a coloured product which can be seen</td>
<td>定位剂一种化合物，它与色谱图中分离出的无色无色斑点反应，生成有色产物，可以看到</td>
</tr>
<tr>
<td>mixture a system of two or more substances that can be separated by physical means</td>
<td>混合两种或多种可以通过物理方法分离的物质的系统</td>
</tr>
<tr>
<td>pure substance a single chemical element or compound – it melts and boils at definite temperatures</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 the solid left behind in the filter paper after filtration has taken place</td>
<td>过滤后残留在滤纸中的固体残留物</td>
</tr>
<tr>
<td>$R_f$ value in chromatography, the ratio of the distance travelled by the solute to the distance travelled by the solvent front</td>
<td>色谱中的移动值：溶质移动距离与溶剂前沿移动距离之比</td>
</tr>
<tr>
<td>risk assessment an evaluation of the methods and chemical substances used in a particular experiment to see what safety issues may be involved</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 a solution which contains as much dissolved solute as possible at a particular temperature</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>
4.4 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>1</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>危害</td>
</tr>
<tr>
<td>2</td>
<td>Corrosive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Irritant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Harmful</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Flammable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Poisonous</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</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.

4.5 EXTENSION Activity 1 WS Safety in the Lab

Find the danger and create a rule to stop it.

A
B
C
D
E
F
G
H
I
J
K
L
M

Where the problem is: Student could transfer harmful chemicals on the bench to his food with his hands

What could happen as a result: Never eat or drink in a lab!

Write a rule to prevent this danger from causing harm:

A
B
C
D
E
F
G
H
I
J
K
L
M
4.6 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>1</td>
<td></td>
<td>Corrosive</td>
<td>This may dissolve or burn materials, including skin</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Health hazard (Harmful)</td>
<td>This includes irritants, harmful substances, and some low-hazard substances</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Explosive</td>
<td>This contains dangerous organisms such as bacteria</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Flammable</td>
<td>This can be poisonous and possibly deadly</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>Toxic</td>
<td>This may explode</td>
</tr>
<tr>
<td>6</td>
<td>Corrosive (Irritant)</td>
<td>Caution</td>
<td>This can catch fire easily</td>
</tr>
</tbody>
</table>

4.7 ESSENTIAL Activity 3 Laboratory apparatus

Apparatus is a scientific name for equipment. Use the list below to label this equipment.

- (Round bottom) flask
- Burette
- Clamp stand
- Conical flask
- Evaporating basin
- Funnel
- Glass beaker
- Heat proof gauge
- Measuring cylinder
- Mortar
- Pistil
- Spatula
- Stirring rod
- Test pipette
- Test tube brush
- Test tube holder
- Test tube rack
- Thermometer
- Tongs
- Tripod and Bunsen burner
- Volumetric flask
- Volumetric pipette
- Wash bottle (filled with distilled water)
4.8 ESSENTIAL EXAM QUESTIONS Paper 2 Topic 2 11 marks

Q# 1/ IGCSE Chemistry/2018/w/Paper 21/
2. The diagrams show four pieces of laboratory equipment.

What 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>X</td>
<td>X</td>
<td>X</td>
<td>✓</td>
</tr>
<tr>
<td>B</td>
<td>✓</td>
<td>X</td>
<td>X</td>
<td>✓</td>
</tr>
<tr>
<td>C</td>
<td>X</td>
<td>✓</td>
<td>X</td>
<td>✓</td>
</tr>
<tr>
<td>D</td>
<td>✓</td>
<td>X</td>
<td>✓</td>
<td>X</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 Rf values of the dyes in the three mixtures are shown.

<table>
<thead>
<tr>
<th>dye</th>
<th>Rf values from mixture 1</th>
<th>Rf values from mixture 2</th>
<th>Rf 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>0.01</td>
<td>0.01</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.

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

Which diagram shows the chromatogram obtained?

A. ![Diagram A]
B. ![Diagram B]
C. ![Diagram C]
D. ![Diagram D]

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
Q# 4/ IGCSE Chemistry/2018/a/Paper 21/

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.

source of ammonia gas  

\[ \text{damp red litmus paper} \]

source of hydrogen chloride gas  

\[ \text{damp blue litmus paper} \]

apparatus 1  

apparatus 2

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 R_f value of 0.7?

\[ \begin{array}{llll}
\text{solvent front} & \text{baseline} & \text{dyes} \\
A & B & C & D
\end{array} \]

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?

1  

2  

3  

4  

5

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.

Solvent front  

Substance S  

Baseline  

How is the R_f value of substance S calculated?

A. \( \frac{X}{Y} \)  
B. \( \frac{W}{Z} \)  
C. \( \frac{Y}{X} \)  
D. \( \frac{Y}{W} \)
4.8.1 ESSENTIAL EXAM QUESTIONS Paper 2 T2 11marks Mark Scheme

Q# 1/ iGCSE Chemistry/2018/w/Paper 21/
2 A
2 D
3 A
Q# 3/ iGCSE Chemistry/2018/s/Paper 22/
2 C
3 D

4.9 ESSENTIAL EXAM QUESTIONS Paper 6 Labelling Equipment and Understanding Experiments
iGC Chem 2 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(I) nitrate as shown. Carbon dioxide was produced.

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

lumps of copper(II) carbonate

dilute nitric acid

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

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

(d) Name the process in F.

(e) How could the purity of the sodium chloride obtained be checked?

Q# 3/ iGCSE Chemistry/2018/w/Paper 61/Q1
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 → …… → …… → …… → …… → ……

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

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

(d) Name the process in F.

(e) How could the purity of the sodium chloride obtained be checked?
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? [1]

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

![Chromatogram Diagram]

(d) Give one conclusion that can be drawn about dye B. [1]

(e) Suggest why dye C remained on the baseline. [1]

(f) $R_f$ values are used to identify compounds. $R_f = \frac{\text{distance travelled by the compound}}{\text{distance travelled by the solvent}}$. Calculate the $R_f$ value of dye A. [2]

$R_f = \ldots$ [2]

[Total: 8]
(b) Which of the reactants was in excess?

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

(ii) Suggest why this apparatus would not work.

Q# 10/ IGCSE Chemistry/2017/s/Paper 63/Q1
1 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) (i) 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

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.

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

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.

(b) Suggest a reason why the U-tube is surrounded by ice.

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

(b) Label the arrows on the condenser. [1]

(c) Identify one mistake in the apparatus. [1]

(d) Which liquid would collect first? Explain your answer. [2]

(e) Why would it be better to use an electrical heater instead of a Bunsen burner to heat the water and ethanol mixture? [1]

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.

(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]

4.9.1 Mark Scheme IGC Chem 2 EQ.18w to 16m Labelling Equipment

<table>
<thead>
<tr>
<th>Q# 1/ IGCSE Chemistry/2018/w/Paper 63/Q1</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Y(x)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mortar</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Test/dropper/dropper</td>
<td></td>
</tr>
</tbody>
</table>

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

| (a) Tongs | |
|----------|---|---|
4.10 ESSENTIAL EXAM QUESTIONS Paper 6 Topic 2 Experimental Techniques 79 marks

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

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

(a) Name this method of separation. 

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

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

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

(e) \( R_f \) values are used to identify compounds.

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

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

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

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.

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 cm³ 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 cm³ 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 cm³ 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/cm³</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="image1" alt="Diagram" /></td>
<td>195</td>
</tr>
<tr>
<td></td>
<td></td>
<td><img src="image2" alt="Diagram" /></td>
<td>190</td>
</tr>
<tr>
<td></td>
<td></td>
<td><img src="image3" alt="Diagram" /></td>
<td>185</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td><img src="image4" alt="Diagram" /></td>
<td>75</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td><img src="image5" alt="Diagram" /></td>
<td>65</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td><img src="image6" alt="Diagram" /></td>
<td>50</td>
</tr>
</tbody>
</table>

(e) Plot the results on the grid below and draw a smooth line graph.
(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 cm³. 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 57 g in 100 cm³ of water. Suggest, with a reason, the effect of using 8 g of salt D instead of 4 g 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 .................................................................

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

Q# 4/GCSE 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.

(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.

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

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]
Q# 5/IGCSE Chem/2014s/Paper 6/
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. [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. [2]

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. [1]

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

(d) Why was the yeast in Step 3 not added until the liquid was at room temperature? [2]
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.

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, [2]
   (ii) where the sample of water would collect.
(c) State the purpose of the ice cubes. [1]
(d) Describe a physical test for pure water.
   test ………………………………………………………………………………………………………………………………..
   result …………………………………………………………………………………………………………………………... [2]
ESSENTIAL EXAM QUESTIONS Paper 6
Topic 2 Experimental Techniques

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

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

(c) The label on the paint tin states

''Touch-dry in three hours''

(i) How could you check this value?

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

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 cm³ of ethanol.
2 Crush the sweets.
3 Place the crushed sweets in the beaker containing 100 cm³ 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?

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

(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.

(d) State the purpose of the watch glass.

(e) Explain the term decant.

4.10.1 ESSENTIAL EXAM QUESTIONS Paper 6 Topic 2 Experimental Techniques

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>2a</td>
<td>chromotrope</td>
<td>1</td>
<td>A: dropper glass rod</td>
</tr>
<tr>
<td>2b</td>
<td>test tube (capillary tube)</td>
<td>1</td>
<td>A: dropper glass rod</td>
</tr>
<tr>
<td>3c</td>
<td>water/organic solvent</td>
<td>1</td>
<td>R: it reacts with the solvent</td>
</tr>
<tr>
<td>3d</td>
<td>compound Q is insoluble</td>
<td>1</td>
<td>R: it reacts with the solvent</td>
</tr>
<tr>
<td>3e</td>
<td>between (3.7 and 5.1) divided by (5.2 or 5.3); answer: between 0.74 and 0.92;</td>
<td>1</td>
<td>R: correct answer with no working scores 2</td>
</tr>
</tbody>
</table>
Q# 2/ iGCSE Chem/2015 March/Paper 6/
1 (a) thermometer (1)
   condenser (1)
   (b) (i) ethanoic acid (1)
       lower boiling point / evaporates first (1)
       (ii) temperature reading will rise / gap in liquid coming over / no more collected at
            118°C (1)
   (c) larger surface area (1)
   (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
   (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)
   (f) value from graph for 20 cm³ water, 50–53 (1) ± half a small square
      shown clearly by extrapolation (1)
      unit, °C (1)

   (g) clear / colourless liquid forms / no solid / crystals / salt visible (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
   (i) sketch graph always above line (1)
      label (1)
   (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
Q# 3/ iGCSE Chem/2014 March/Paper 6/
3 (a) (i) chromatography (1)
   (ii) to prevent loss / evaporation of solvent (1)
   (b) when the solvent is near the top of the paper / before the solvent reaches the top of the
      paper (1)
   (c) (i) 4 (1)
   (ii) yes, one artificial dye (1)
      at same height / matches (1)
Q# 4/ iGCSE Chem/2014 June/Paper 6/
1 (a) thermometer (1)
   condenser (1)
   allow condensing tube, condensing tube, etc. (1)
   (b) arrows labelled – water (in) and water (out) (1)
   (c) fractional (1)
      distillation (1)
Q# 6/ IGCSE Chem/2013s/Paper 6/
2 (a) to prevent air/oxygen/bacteria entering jar (1)
(b) pestle and/or mortar (1)
(c) diagram of funnel and filter paper (1) labelled (1)
(d) yeast would not work at high temperatures/kills yeast/denatures enzymes/ovtta (1)
(e) (i) bubbles/froth (1)
   not: gas/CO₂ given off/tums cloudy
   (ii) collect gas and measure volume/count bubbles (1)
      over certain time interval (1)
      allow: one mark for timing until bubbles/reaction stopped
(f) fractional distillation (1)
Q# 7/ IGCSE Chem/2012s/Paper 6/
3 (a) pestle (1) mortar (1)
   (b) stir/mix/shake (1) allow: heat/boil (1)
   (c) diagram showing funnel (1)
      indication of filter paper (1) note: labels not necessary (1)
   (d) heat/evaporation (1)
      to crystallising point or desorption (1)
      in fume cupboard (1) max 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/ovtta (1)
   (d) physical test ignore chemical tests boiling point/freezing point (1)
      100°C (1)
Q# 9/ IGCSE Chem/2010s/Paper 6/
6 (a) paint sample + water (1) filter (1) solid residue (1) max 2
   (i) apply paint, start timer (1) method of checking dry, note time (1)
      no painting = 0
   (ii) correct method (1) e.g. hair dryer/wind/fan/increase temperature NOT catalyst.
Q# 10/ IGCSE Chem/2009s/Paper 6/
2 (a) Larger surface area (1)
   quicker to extract colour/more colour extracted (1) not easier/faster
   (b) Reference to ethanol (1)
   (c) Reference to flammability of ethanol (1)
   (d) To prevent loss of solvent (1) not splash/evaporation
   (e) Pour off liquid (1)
Ethanediolic acid dihydrate, $\text{H}_2\text{C}_2\text{O}_4\cdot 2\text{H}_2\text{O}$, 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.

(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. .................................................................

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

1. ................................................................. [2]
2. .................................................................
Q6  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)

Q7  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.
Q#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)?

(d) Describe how Step 4 is carried out.

Q#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.

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.
Q# 5/ 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 cm³ of ethanol.
2 Crush the sweets.
3 Place the crushed sweets in the beaker containing 100 cm³ 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.

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

4.11.1 EXTENSION EXAM QUESTIONS Paper 6 Topic 2 Long Answer Questions 53 marks

Mark Scheme

Q# 1/ iGCSE Chem/2013/s/Paper 6/

1 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) [7]

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

5 (a) both lose mass (1)
not: change mass [1]

(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) [3]

(c) goggles / lab coat / tongs / fume cupboard / well ventilated area any two
ignore: reference to hair [2]

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

6 measured volume of seawater (1)

using measuring cylinder (1)

no evaporating dish/beaker (1)

pre-weighed (1)

evaporate/heat (1)

so dryness/constant mass (1)

re-weigh (1)

indication of calculation method (1)

would not work = max [6]
4.12 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>the process of boiling a liquid and then condensing the vapour produced back into a liquid: used to purify liquids and to separate liquids from solutions</td>
</tr>
<tr>
<td>downward delivery</td>
<td>a method of collecting a gas which is denser than air by passing it downwards into a gas jar</td>
</tr>
<tr>
<td>risk assessment</td>
<td>an evaluation of the methods and chemical substances used in a particular experiment to see what safety issues may be involved</td>
</tr>
<tr>
<td>Rf value</td>
<td>in chromatography, the ratio of the distance travelled by the solute to the distance travelled by the solvent front</td>
</tr>
<tr>
<td>chromatogram</td>
<td>the result of a paper chromatography run, showing where the spots of the samples have moved to locating agent</td>
</tr>
<tr>
<td>locating agent</td>
<td>a compound that reacts with invisible, colourless spots separated by chromatography to produce a coloured product which can be seen</td>
</tr>
<tr>
<td>soluble</td>
<td>term that describes a solute that dissolves in a particular solvent</td>
</tr>
<tr>
<td>saturated solution</td>
<td>a solution which contains as much dissolved solute as possible at a particular temperature</td>
</tr>
<tr>
<td>solvent front</td>
<td>the moving boundary of the liquid solvent that moves up the paper during chromatography</td>
</tr>
<tr>
<td>solubility</td>
<td>a measure of how much of a solute dissolves in a solvent at a particular temperature</td>
</tr>
<tr>
<td>chromatography</td>
<td>a technique employed for the separation of mixtures of dissolved substances, which was originally used to separate coloured dyes</td>
</tr>
<tr>
<td>filtrate</td>
<td>the liquid that passes through the filter paper during filtration</td>
</tr>
<tr>
<td>mixture</td>
<td>a system of two or more substances that can be separated by physical means</td>
</tr>
<tr>
<td>pure substance</td>
<td>a single chemical element or compound – it melts and boils at definite temperatures</td>
</tr>
<tr>
<td>crystallisation</td>
<td>the process of forming crystals from a saturated solution</td>
</tr>
<tr>
<td>fractional distillation</td>
<td>a method of distillation using a fractionating column, used to separate liquids with different boiling points</td>
</tr>
</tbody>
</table>
### English | Meaning
--- | ---
**decanting** |  
**upward delivery** |  
**filtration** |  
**solute** |  
**solvent** |  
**residue** |  
**insoluble** |  
**solution** |  

### 4.13 ESSENTIAL Assessed Activity 2 –Which separation technique?

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

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

[Total: 6]

#### 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  

[Total: 6]
4.14 ESSENTIAL Assessed Activity 3 Labelling equipment

Q# 2/
1 The volume of hydrochloric acid that reacts with 25.0 cm³ of aqueous sodium hydroxide can be found using the apparatus below.

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

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

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

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.

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

(b) Label the arrows.
(c) Identify and explain a possible hazard in this experiment.

Q# 6/
(a) 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.

(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.

1 iron powder was added until all the sulfuric acid had reacted

50 cm³ of dilute sulfuric acid was measured and added to a beaker

the mixture was allowed to cool

solution of iron(II) sulfate

1 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.

(b) Use labelled arrows to indicate:
   (i) where the heat is applied,
   (ii) where the sample of water would collect.

(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.
   (ii) Indicate on the diagram, with an arrow, where heat is applied.

1 Q# 10/ IGCSE Chem/2010s/Paper 6/
4.15 Extension Mind Map for Topic 2 Experimental Techniques and Separation

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.

4.16 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?
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 notes</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>Completed the Mind Map for this topic</td>
<td></td>
<td>EXCEPTIONAL</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>EXCEPTIONAL</td>
</tr>
<tr>
<td>Past Exam Questions</td>
<td>Attempted more than 25% of the 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>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>EXCEPTIONAL</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>EXCEPTIOAL</td>
</tr>
<tr>
<td></td>
<td>Scored over 95%</td>
<td></td>
<td>SMASHING!!</td>
</tr>
</tbody>
</table>

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.smashingscience.org/jace-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.rewewicinst.com/
  https://www.scientificamerican.com/
  National Institute of Health: https://kids.nihs.nih.gov/
  Smithsonian website: https://si.edu/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 the 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 https://www.smashingscience.org/jace-chem-additional-resources webpage.

### 5.3 ESSENTIAL Glossary for Keywords for this topic (4.1 Stoichiometry)

<table>
<thead>
<tr>
<th>English</th>
<th>Chinese</th>
</tr>
</thead>
<tbody>
<tr>
<td>balanced chemical (symbol) equation</td>
<td>平衡化学（符号）方程式，使用化学式进行化学反应的平衡，涉及反应物和产物的相对原子数。</td>
</tr>
<tr>
<td>chemical reaction</td>
<td>化学反应形成新物质的变化</td>
</tr>
<tr>
<td>formula (chemical)</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>离子方程式涉事离子物质的反应的简化方程式：仅显示参与反应的离子。</td>
</tr>
<tr>
<td>law of conservation of mass</td>
<td>物质守恒定律在反应中不会丢失或获得—反应物的总质量等于产品的总质量</td>
</tr>
<tr>
<td>molecular formula</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>分子量相对较大，另一个名称是相对分子量。</td>
</tr>
<tr>
<td>products (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 (in a chemical reaction) the chemical substances that react together in a chemical reaction</td>
<td>作用物（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>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>标准原子使用质谱仪测量所有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>状态符号，用于显示化学反应中反应物和产物的物理状态：它是（s）固体，（l）液体，（g）气体，和（aq）溶液在水中的溶液。</td>
</tr>
<tr>
<td>symbol (chemical)</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>词方程式，是使用反应物和产物的名称进行的化学反应的摘要。</td>
</tr>
<tr>
<td>relative formula mass (Mr) 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) the sum of all the relative atomic masses of the atoms present in a molecule</td>
<td>相对分子质量（Mr）分子中所有原子的相对原子质量的总和</td>
</tr>
</tbody>
</table>
5.3.1 Other Keywords that are needed for Topic 4.2 which will be covered later on in your studies:

<table>
<thead>
<tr>
<th>Topic #</th>
<th>English</th>
<th>Chinese</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</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，溶液可以是稀溶液 (高比例的溶剂)，也可以是浓溶液 (高比例的溶质)</td>
</tr>
<tr>
<td>1</td>
<td>empirical formula a formula which shows the simplest ratio of atoms present</td>
<td>经验公式，表示存在的最简单的原子比例</td>
</tr>
<tr>
<td>1</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离子化合物</td>
</tr>
<tr>
<td>1</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，以每立方分米溶液中溶解的溶质的摩尔数表示 (mol/dm³)</td>
</tr>
<tr>
<td>1</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>1</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，以克为单位</td>
</tr>
<tr>
<td>1</td>
<td>mole the measure of amount of substance in chemistry; one mole of a substance has a mass equal to its relative atomic mass (Ar) times 12 (the Avogadro constant) atoms, molecules or formula units depending on the substance considered</td>
<td>摩尔，化学中物质的量；一摩尔物质的质量等于其相对原子质量 (Ar) 与 12 (Avogadro常数) 原子、分子或分子式的质量，具体取决于考虑的物质</td>
</tr>
<tr>
<td>1</td>
<td>percentage purity 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>
<td>纯度百分比，通过实验进行的反应的产物纯度的百分比：纯度百分比 = 纯产物质量 / 混合产物质量 × 100</td>
</tr>
<tr>
<td>1</td>
<td>percentage yield 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>
<td>实际百分比，实验中进行的反应的实际产量与理论产量的百分比：实际百分比 = 实际产量 / 预测产量 × 100</td>
</tr>
<tr>
<td>1</td>
<td>structural formula 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>
<td>结构公式，有机分子的结构公式的原子和键如何在空间中排列：必须显示所有原子和共价键</td>
</tr>
<tr>
<td>1</td>
<td>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</td>
<td>用溶液进行定量的分析方法：一种溶液慢慢加入到已知体积的另一种溶液中，直至达到终点</td>
</tr>
<tr>
<td>1</td>
<td>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</td>
<td>结晶水，某些盐结晶过程中的水；例如，五水硫酸铜 (CuSO₄.5H₂O) 每分子硫酸铜 (Cu²⁺) 包含五分子结晶水</td>
</tr>
</tbody>
</table>

5.4 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>English</th>
<th>Chinese</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avogadro constant another name for a mole</td>
<td>Avogadro常数的另一个名字</td>
</tr>
<tr>
<td>mass concentration 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 (g) 为单位的溶液浓度的量 (g/dm³)</td>
</tr>
<tr>
<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>

5.5 ESSENTIAL Active Learning Activity 1 Balancing chemical equations

Part 1
5.5.1 Active Learning Activity Balancing chemical equations Mark Scheme

Part 1

Part 2

5.6 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>Formula</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:

http://www.chemguide.co.uk/inorganic/transition/features.html#top

Extension activity

Name as many of the chemicals above as you can.
5.7 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(C₂H₃O₂)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:

<table>
<thead>
<tr>
<th>Ion</th>
<th>Systematic Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Sulfur difluoride</td>
<td>g. Ammonium acetate</td>
</tr>
<tr>
<td>b. Sulfur hexafluoride</td>
<td>h. Ammonium hydrogen carbonate</td>
</tr>
<tr>
<td>c. Sodium phosphate</td>
<td>i. Cobalt (III) nitrate</td>
</tr>
<tr>
<td>d. Lithium nitride</td>
<td>j. Copper (II) chloride</td>
</tr>
<tr>
<td>e. Chromium (III) carbonate</td>
<td>k. Potassium sulfite</td>
</tr>
<tr>
<td>f. Tin (II) fluoride</td>
<td>l. Sodium hydroxide</td>
</tr>
<tr>
<td>g. CF₄</td>
<td></td>
</tr>
<tr>
<td>h. KCl</td>
<td></td>
</tr>
</tbody>
</table>

3. EXTENSION Name each of the following compounds:

<table>
<thead>
<tr>
<th>Ion</th>
<th>Systematic Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. CuF</td>
<td>i. NaNO₃</td>
</tr>
<tr>
<td>b. CdI₂</td>
<td>j. Ca(NO₃)₂</td>
</tr>
<tr>
<td>c. HI</td>
<td>k. Mg₃(PO₄)₂</td>
</tr>
<tr>
<td>d. NO</td>
<td>l. H₃P</td>
</tr>
<tr>
<td>e. NF₃</td>
<td>m. Na₃PO₄</td>
</tr>
<tr>
<td>f. N₂Cl₂</td>
<td>n. Ca(HCO₃)₂</td>
</tr>
<tr>
<td>g. CF₄</td>
<td></td>
</tr>
<tr>
<td>h. KCl</td>
<td></td>
</tr>
</tbody>
</table>

Table of Ions and Charges

Polynuclear Ions

-1 charge
acetate, C₂H₃O₂⁻, or CH₃COO⁻
chlorate, ClO₃⁻
chlorite, ClO₂⁻
cyanide, CN⁻
hydrogen carbonate, HCO₃⁻
(hypoiodite, ClO₃⁻)
iodate, IO₃⁻
nitrate, NO₃⁻
perchlorate, ClO₄⁻

-2 charge
carbonate, CO₃⁻
chromate, Cr₂O₇⁻²
dichromate, Cr₂O₇⁻²
sulfate, SO₄²⁻

-3 charge
phosphate, PO₄³⁻
phosphite, PO₃⁻³

+1 charge
ammonium, NH₄⁺

Transition Metals without varying charges:

Ag⁺ silver
Cd²⁺ cadmium
Zn²⁺ zinc

Transition Metals with varying charges:

<table>
<thead>
<tr>
<th>Ion</th>
<th>Systematic Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe³⁺</td>
<td>iron(III)</td>
</tr>
<tr>
<td>Fe²⁺</td>
<td>iron(II)</td>
</tr>
<tr>
<td>Cu²⁺</td>
<td>copper(II)</td>
</tr>
<tr>
<td>Cu⁺</td>
<td>copper(I)</td>
</tr>
<tr>
<td>Co³⁺</td>
<td>cobalt(II)</td>
</tr>
<tr>
<td>Co²⁺</td>
<td>cobalt(I)</td>
</tr>
<tr>
<td>Sn⁴⁺</td>
<td>tin(V)</td>
</tr>
<tr>
<td>Sn³⁺</td>
<td>tin(II)</td>
</tr>
<tr>
<td>Pb⁴⁺</td>
<td>lead(IV)</td>
</tr>
<tr>
<td>Pb²⁺</td>
<td>lead(II)</td>
</tr>
</tbody>
</table>
5.7.1 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

g. copper (I) fluoride
h. calcium hydroxide
i. calcium carbonate
j. calcium bicarbonate

2. a. SF₂
b. SF₆
c. Na₃PO₄
d. Li₃N
e. Cr₂(CO₃)₃
f. SnF₂
g. NH₄C₂H₃O₂ or NH₄CH₃COO
h. NH₄HCO₃
i. Co(NO₃)₃
j. CuCl₂
k. K₂SO₃
l. NaOH

3. a. copper (I) fluoride
b. cadmium iodide
c. hydrogen monoxide
d. nitrogen monoxide
e. nitrogen trifluoride
f. dinitrogen dichloride
g. carbon tetrafluoride
h. potassium chloride
i. sodium nitrate
j. calcium nitrate
k. magnesium phosphate
l. trihydrogen monophosphate
m. sodium fluoride
n. calcium hydrogen carbonate or calcium bicarbonate

5.8 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.

NaCl sodium chloride
(NH₄)₂SO₄ ammonium sulfate
NaHCO₃ sodium bicarbonate

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>Zn²⁺</td>
<td>zinc</td>
</tr>
<tr>
<td>Ca²⁺</td>
<td>calcium</td>
</tr>
<tr>
<td>H⁺</td>
<td>hydrogen</td>
</tr>
<tr>
<td>K⁺</td>
<td>potassium</td>
</tr>
<tr>
<td>Sr²⁺</td>
<td>strontium</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>Fe³⁺</td>
<td>ferric</td>
</tr>
<tr>
<td>Sn²⁺</td>
<td>stannous</td>
</tr>
<tr>
<td>Sn⁴⁺</td>
<td>stannic</td>
</tr>
<tr>
<td>Cu⁺</td>
<td>cuprous</td>
</tr>
<tr>
<td>Cu²⁺</td>
<td>cupric</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>Fe³⁺</td>
<td>iron(III)</td>
</tr>
<tr>
<td>Sn²⁺</td>
<td>tin(II)</td>
</tr>
<tr>
<td>Sn⁴⁺</td>
<td>tin(IV)</td>
</tr>
<tr>
<td>Cu⁺</td>
<td>copper(I)</td>
</tr>
<tr>
<td>Cu²⁺</td>
<td>copper(II)</td>
</tr>
</tbody>
</table>

Polyatomic positive ions often have common names ending with the suffix -onium.

H₃O⁺    hydronium
NH₄⁺    ammonium

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>O²⁻</td>
<td>oxide</td>
</tr>
<tr>
<td>Cl⁻</td>
<td>chloride</td>
</tr>
<tr>
<td>S²⁻</td>
<td>sulfide</td>
</tr>
<tr>
<td>Br⁻</td>
<td>bromide</td>
</tr>
<tr>
<td>N³⁻</td>
<td>nitride</td>
</tr>
<tr>
<td>I⁻</td>
<td>iodide</td>
</tr>
<tr>
<td>P⁵⁻</td>
<td>phosphide</td>
</tr>
<tr>
<td>H⁻</td>
<td>hydride</td>
</tr>
<tr>
<td>C⁺</td>
<td>carbide</td>
</tr>
</tbody>
</table>
Common Polyatomic Negative Ions

1 ions
- HCO₃⁻ bicarbonate
- CH₃CO₂⁻ acetate
- NO₃⁻ nitrate
- NO₂⁻ nitrite
- MnO₄⁻ permanganate
- CN⁻ cyanide

2 ions
- HSO₄⁻ hydrogen sulfate (bisulfate)
- CO₃²⁻ carbonate
- SO₃²⁻ sulfite
- SO₄²⁻ sulfate
- CrO₄²⁻ chromate
- Cr₂O₇²⁻ dichromate
- S₂O₃²⁻ thiosulfate
- PO₄³⁻ phosphate
- BO₃³⁻ borate

3 ions
- HPO₄³⁻ hydrogen phosphate

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 NO₂⁻ ion is the nitrite ion.

The -ate ending indicates a high oxidation state. The NO₃⁻ 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 ClO₄⁻ 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 (O₂²⁻) 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.

- HCl hydrogen chloride
- NO nitrogen oxide
- BrCl bromine chloride

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.

1 mono- 6 hexa-
2 di- 7 hepta-
3 tri- 8 octa-
4 tetra- 9 nona-
5 penta- 10 deca-

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.

Acids containing ions ending with ide often become hydro-ic acid
- Cl⁻ chloride HCl hydrochloric acid
- F⁻ fluoride HF hydrofluoric acid
- S²⁻ sulfide H₂S hydrosulfuric acid

Acids containing ions ending with ate usually become -ic acid

### Active Learning Activity 4 Word and Symbol Equations

#### Task 1: Complete the following word equations

1. Calcium carbonate + hydrochloric acid $\rightarrow$ calcium chloride + water + _______

2. __________ + sulfuric acid $\rightarrow$ magnesium sulfate + hydrogen

3. Magnesium + nitric acid $\rightarrow$ __________ + hydrogen

4. Zinc hydroxide + __________ $\rightarrow$ zinc chloride + water

5. __________ + hydrochloric acid $\rightarrow$ magnesium chloride + water + carbon dioxide

6. Aluminium + hydrochloric acid $\rightarrow$ __________ + hydrogen

7. Sodium hydroxide + hydrochloric acid $\rightarrow$ __________ + __________

8. Sodium carbonate + __________ $\rightarrow$ sodium sulfate + water + _______

9. __________ + nitric acid $\rightarrow$ calcium nitrate + water + carbon dioxide

10. __________ + sulfuric acid $\rightarrow$ iron(II) sulfate + hydrogen

#### Task 2: Complete the following word equations

1. Hydrochloric acid + sodium hydroxide $\rightarrow$ __________ + __________

2. Sodium + water $\rightarrow$ __________ + __________

3. Magnesium + oxygen $\rightarrow$ __________

4. Sulfuric acid + magnesium carbonate $\rightarrow$ __________ + __________ + __________

5. Zinc + copper sulfate $\rightarrow$ __________ + __________

6. Sulfuric acid + sodium hydroxide $\rightarrow$ __________ + __________

7. Hydrogen + oxygen $\rightarrow$ __________

8. Carbon + oxygen $\rightarrow$ __________

9. Aluminium + nitric acid $\rightarrow$ __________ + __________

### Complex Acids

- Acids containing ions ending with "ite" usually become "ous acid".
  - ClO$_2^-$ (chlorite) $\rightarrow$ ClO$_2$ (chlorous acid)
  - NO$_2^-$ (nitrite) $\rightarrow$ HNO$_2$ (nitrous acid)
  - SO$_3^{2-}$ (sulfite) $\rightarrow$ H$_2$SO$_3$ (sulfurous acid)
  - ClO$^-$ (hypochlorite) $\rightarrow$ HClO (hypochlorous acid)

Complex acids can be named by indicating the presence of an acidic hydrogen as follows.

- NaHCO$_3$ (sodium hydrogen carbonate, also known as sodium bicarbonate)
- NaHSO$_3$ (sodium hydrogen sulfite, also known as sodium bisulfite)
- KH$_2$PO$_4$ (potassium dihydrogen phosphate)
10. Sodium + sulfur → .................................................................

Task 3: Complete and balance the symbol equations
(you are allowed to write in the spaces only)

1. ______________ + 2HCl(aq) → MgCl₂(aq) + H₂O(l) + ____________
2. Mg(OH)_2(s) + H₂SO₄(aq) → ______________ + ______________
3. CuO(s) + ______________ → Cu(NO₃)₂(aq) + H₂O(l)
4. ______________ + H₂SO₄(aq) → MgSO₄(aq) + H₂O(l)
5. ______________ + H₂SO₄(aq) → MgSO₄(aq) + H₂O(l) + CO₂(g)
6. Zn(OH)₂(s) + 2HCl(aq) → ZnCl₂(aq) + ______________
7. Mg(s) + H₂SO₄(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: ...........................................................................................................

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

Reaction 2:
Carbon monoxide, a poisonous gas, is also formed by the reaction of oxygen and carbon (present in fuels).
Car manufactures use catalytic converters to change these gases into the less harmful products nitrogen, oxygen and carbon dioxide.
.................................................................................................................................
.................................................................................................................................

Reaction 3:
During the process of photosynthesis, plants combine carbon dioxide gas from the atmosphere and water from the soil to produce glucose (C₆H₁₂O₆) and oxygen gas.
.................................................................................................................................
.................................................................................................................................

Reaction 4:
In respiring, some living organisms burn glucose to produce carbon dioxide gas and water vapor. (Reaction 4).
.................................................................................................................................
.................................................................................................................................

Reaction 5:
In an industrial process, limestone (calcium carbonate) is strongly heated to produce quicklime (calcium oxide) and carbon dioxide gas (reaction 5).
.................................................................................................................................
.................................................................................................................................

Reaction 6:
.................................................................................................................................
In the presence of water, iron (and steel) articles react with oxygen in the air to form iron (III) oxide (Reaction 6).

\[ \text{3} \]

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 (reaction 7)

\[ \text{3} \]

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)

\[ \text{3} \]

5.9.1 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. MgCO₃(aq) → CO₂(g)
2. MgSO₄(aq) + H₂O(l)
3. 2HNO₂(aq)
4. Mg(OH)₂(s)
5. MgCO₃(s)
6. H₂O(l)
7. MgSO₄(s) + H₂O(g)

Task 4
1. Calcium chloride + water + carbon dioxide
   CaCO₃(s) + 2 HCl (aq) → CaCl₂ (aq) + H₂O(l) + CO₂(g)
2. Iron (III) Sulfate + water
   Fe₂O₃ (s) + 3H₂SO₄(aq) → Fe₂(SO₄)₃ + 3H₂O(l)
3. Sodium carbonate + sulfuric acid
   Na₂CO₃(s) + H₂SO₄(aq) → Na₂SO₄(aq) + CO₂(g) + H₂O(l)
4. Zinc + hydrochloric acid
   Zn(s) + 2HCl(aq) → ZnCl₂(aq) + H₂(g)
5. Aluminium + Nitric acid
   2Al(l) + 6HNO₃(aq) → 2Al(NO₃)₃(aq) + 3H₂O(l)

Task 6
1. 2N₂(g) + O₂(g) → 2NO₂(g)
2. 2C(s) + O₂(g) → 2CO(g)
3. 6CO₂(g) + 6H₂O(l) → C₆H₁₂O₆(aq) + 6O₂(g)
4. 2Al₂O₃(aq) → 3Al₂O₃(s) + 6H₂O(l)
5. CaCO₃(s) → CaO(s) + CO₂(g)
6. 4Fe(s) + 3O₂(g) → 2Fe₂O₃(s)
7. 2ZnS(s) → 2ZnO(s) + SO₂(g)
8. C(s) + 2ZnO(s) → 2Zn(s) + ZnO(aq) + CO₂(g)
5.10 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.

\[ C_3H_8 + 5O_2 \rightarrow rCO_2 + sH_2O \]

Which values of \( r \) and \( s \) balance the equation?

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
</tr>
<tr>
<td>C</td>
<td>3</td>
</tr>
<tr>
<td>D</td>
<td>3</td>
</tr>
</tbody>
</table>

10 Which formula represents a compound containing three atoms?

A HNO₃  B H₂O  C LiF  D ZnSO₄

Q# 17 / iGCSE Chemistry/2004/s/Paper 1/

9 The oxide PbOₓ reacts with dilute nitric acid to form lead(II) nitrate, lead(IV) oxide and another product.

What is the equation for this reaction?

A PbOₓ + 4HNO₃ \rightarrow 2Pb(NO₃)₂ + PbO₂ + 2H₂O
B PbOₓ + 2HNO₃ \rightarrow Pb(NO₃)₂ + PbO₂ + H₂
C PbOₓ + 4HNO₃ \rightarrow Pb(NO₃)₄ + 2PbO₂ + 2H₂O
D 2PbOₓ + 2HNO₃ \rightarrow 2Pb(NO₃)₂ + 2PbO₂ + H₂

Q# 18 / iGCSE Chemistry/2004/s/Paper 1/

10 The compound ethyl mercaptan, C₂H₅SH, 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.

\[ X_2 + Y_2 \rightarrow 2XY \]

reactants  product

When measured at the same temperature and pressure, what is the value of

\[ \frac{\text{volume of product}}{\text{volume of reactants}} \]
5.10.1 FUNDAMENTAL EXAM QUESTIONS

T4.1 Paper 1 12 marks Mark Scheme

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 $\text{CaCO}_3 + 4\text{HCl} \rightarrow \text{CaCl}_2 + \text{CO}_2 + \text{H}_2\text{O}$
D $\text{Ca(HCO}_3)_2 + \text{HCl} \rightarrow \text{CaCl}_2 + 2\text{CO}_2 + \text{H}_2\text{O}$

10 A gas has the molecular formula NOCl.
Which diagram could show molecules of the pure gas NOCl?

A  
B  
C  
D  

[diagram with options A, B, C, D showing N, O, Cl]

11 Butanedioic acid has the structure shown:

[structure diagram of butanedioic acid]

What is the molecular formula of butanedioic acid?

A $\text{CHO}$
B $\text{C}_2\text{H}_4\text{O}_4$
C $\text{C}_4\text{H}_8\text{O}_2$
D $\text{C}_6\text{H}_12\text{O}_6$

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>copper(II) oxide</th>
<th>sulphur hexafluoride</th>
</tr>
</thead>
<tbody>
<tr>
<td>A \ CuO</td>
<td>S\text{O}_2\text{F}</td>
</tr>
<tr>
<td>B \ CuO</td>
<td>S\text{F}_6</td>
</tr>
<tr>
<td>C \ Cu_2O</td>
<td>S\text{F}_6</td>
</tr>
<tr>
<td>D \ Cu_2O</td>
<td>S\text{F}_6</td>
</tr>
</tbody>
</table>
5.11 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 $\text{Fe}^{3+}$ and $\text{CrO}_4^{2-}$.

What is the formula of iron(III) chromate?

A $\text{FeCrO}_4$  B $\text{Fe}_2\text{CrO}_4$  C $\text{Fe}_3\text{CrO}_4$  D $\text{Fe}_2\text{CrO}_4\text{h}$

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>$\text{Ti}^{4+}$</td>
<td>$\text{PO}_4^{3-}$</td>
</tr>
<tr>
<td>$\text{Al}^{3+}$</td>
<td>$\text{SO}_4^{2-}$</td>
</tr>
<tr>
<td>$\text{Mg}^{2+}$</td>
<td>$\text{NO}_3^{-}$</td>
</tr>
<tr>
<td>$\text{K}^+$</td>
<td>$\text{Cl}^{-}$</td>
</tr>
</tbody>
</table>

Which formula is not correct?

A $\text{Al}_{2}(\text{SO}_4)_3$  B $\text{K}_2\text{PO}_4$  C $\text{Mg}(\text{NO}_3)_2$  D $\text{TiCl}_4$

Q# 3/ iGCSE Chemistry/2018/w/Paper 21/

9 Iron can react with sulfur to form two ionic compounds.

The iron is present as $\text{Fe}^{3+}$ in one compound and as $\text{Fe}^{2+}$ in the other compound.

The sulfur ions are present as $\text{S}^{2-}$ in both compounds.

What are the formulae of the two compounds?

A $\text{FeS}$ and $\text{Fe}_2\text{S}_3$  B $\text{FeS}$ and $\text{Fe}_3\text{S}_2$  C $\text{Fe}_2\text{S}_3$ and $\text{Fe}_2\text{S}_3$  D $\text{FeS}_3$ and $\text{Fe}_2\text{S}_3$

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 $\text{Ca}_2\text{SiO}_3$  B $\text{CaSiO}_3$  C $\text{Ca}_2\text{Si}_2\text{O}_3$  D $\text{Ca}_3\text{SiO}_4$

Q# 5/ iGCSE Chemistry/2017/w/Paper 22/

7 The equation for the reaction between phosphorus and oxygen is shown.

$$x\text{P}_4 + y\text{O}_2 \rightarrow z\text{P}_2\text{O}_5$$

Which values of $x$, $y$ and $z$ balance the equation?

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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</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 $\text{Fe}_2(\text{SO}_4)_3(\text{aq}) + 3\text{NaOH}(\text{aq}) \rightarrow \text{Fe}(	ext{OH})_3(\text{s}) + 3\text{Na}_2\text{SO}_4(\text{aq})$

B $\text{Fe}_2(\text{SO}_4)_3(\text{aq}) + 3\text{NaOH}(\text{aq}) \rightarrow \text{Fe}(	ext{OH})_3(\text{s}) + 3\text{Na}_2\text{SO}_4(\text{aq})$

C $\text{Fe}_2(\text{SO}_4)_3(\text{aq}) + 3\text{NaOH}(\text{aq}) \rightarrow 2\text{Fe}(	ext{OH})_3(\text{s}) + 3\text{Na}_2\text{SO}_4(\text{aq})$

D $2\text{Fe}_2(\text{SO}_4)_3(\text{aq}) + 6\text{NaOH}(\text{aq}) \rightarrow 4\text{Fe}(	ext{OH})_3(\text{s}) + 6\text{Na}_2\text{SO}_4(\text{aq})$

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 $\text{ZnCO}_3 + 2\text{HCl} \rightarrow \text{ZnCl}_2 + \text{CO}_2 + \text{H}_2\text{O}$

3 $\text{Mg}(\text{NO}_3)_2 + \text{NaOH} \rightarrow \text{Mg(OH)}_2 + 2\text{NaNO}_3$

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>
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<tbody>
<tr>
<td>A</td>
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<td>B</td>
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<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/ GCSE 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 $\text{Mg}_2\text{N}_2$  B $\text{Mg}_2\text{N}_3$  C $\text{Mg}_3\text{N}_2$  D $\text{Mg}_3\text{N}_2$

5.11.1 FUNDAMENTAL EXAM QUESTIONS Paper 2 9marks mark Scheme

Q# 1/ GCSE Chemistry/2018/w/Paper 22/
9

Q# 2/ GCSE Chemistry/2018/w/Paper 21/
9

Q# 3/ GCSE Chemistry/2017/w/Paper 23/
8

Q# 4/ GCSE Chemistry/2017/w/Paper 22/
7

Q# 5/ GCSE Chemistry/2017/j/Paper 23/
7

Q# 6/ GCSE Chemistry/2017/j/Paper 22/
8

Q# 7/ GCSE Chemistry/2017/j/Paper 21/
7

Q# 8/ GCSE Chemistry/2016/m/Paper 22/
9

5.12 ESSENTIAL EXAM QUESTIONS T4.1 Paper 4 9marks

Q# 1/ GCSE 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, $\text{Li}_3\text{N}$.

(i) Write the equation for the reaction between lithium and nitrogen.

(ii) ................................................................................................................................................................................................................................................................................................................................................... [2]

Q# 2/ GCSE Chemistry/2013/j/Paper 31 / Q6
Ammonia is a compound with the molecular formula NH$_3$
(c) Another compound which contains only nitrogen and hydrogen is hydrazine, N$_2$H$_4$.

Complete the equation for the preparation of hydrazine from ammonia.

$\cdots\text{NH}_3 + \text{NaClO} \rightarrow \text{N}_2\text{H}_4 + \cdots + \text{H}_2\text{O}$ [2]

Q# 3/ GCSE Chemistry/2013/j/Paper 31 / Q6
A small piece of marble, $\text{CaCO}_3$, was added to 5.0 cm$^3$ of hydrochloric acid, concentration 1.0 mol dm$^{-3}$, at 25°C. The time taken for the reaction to stop was measured. The experiment was repeated using 5.0 cm$^3$ 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 $^\circ\text{C}$</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 dm$^{-3}$</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.

$\text{CaCO}_3(s) + 2\text{H}^+(aq) \rightarrow \cdots + \cdots + \cdots$ [1]

Q# 4/ GCSE Chemistry/2013/s/Paper 31/
3 An organic compound decomposes to form nitrogen.

$\text{C}_6\text{H}_5\text{N}_2\text{Cl}(aq) \rightarrow \text{C}_6\text{H}_5\text{Cl}(l) + \text{N}_2(g)$

(a) Explain the state symbols.

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

(b) The following compounds contain two elements. Predict their formulae.

aluminium sulphide ................................................................. [2]
silicon phosphide ................................................................. [2]

5.12.1 EXAM QUESTIONS T4.1 Paper 4 9marks

Q# 1/ GCSE Chemistry/2014/w/Paper 31/
7 (a) (i) 6\text{Li} + \text{N}_2 = 2\text{Li}_3\text{N}

Q# 2/ GCSE Chemistry/2013/j/Paper 31 / Q6
2\text{NH}_3 + \text{NaClO} \rightarrow \text{N}_2\text{H}_4 + \text{NaCl} + \text{H}_2\text{O}

(c) not balanced only 1 [2]

Q# 3/ GCSE Chemistry/2013/s/Paper 31 / Q3
1 \text{Ce}^{3+} + \text{CO}_3^{2-} + \text{H}_2\text{O} [1]

Q# 4/ GCSE Chemistry/2004/s/Paper 3/
5.13 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>

5.14 ESSENTIAL Assessed Activity 2 T4.1 Paper 1 (Core only material) 15 marks

Q# 1/  
8 A compound has the formula CH$_2$CO$_2$H.  
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 MgSO$_4$ is 120.  
Which mass of magnesium sulfate will be formed if 12 g of magnesium are reacted with sulfuric acid?  
A 5g  
B 10g  
C 60g  
D 120g

Q# 3/  
8 The relative formula mass, $M_r$, of copper(II) sulfate, CuSO$_4$, is 160.  
Which mass of sulfur is present in 160 g of copper(II) sulfate?  
A 16g  
B 32g  
C 64g  
D 128g

Q# 4/  
8 What is the relative molecular mass ($M_r$) of HNO$_3$?  
A 5  
B 31  
C 32  
D 63
Q# 5/
10 The chemical compositions of two substances, W and X, are given.

W: Na(AlSi₃)O₈
X: Ca(Al₂Si₃)O₈

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 \( \text{2H} + \text{2Cl} \rightarrow \text{2HCl} \)
B \( \text{2H} + \text{2Cl} \rightarrow \text{H₂Cl₂} \)
C \( \text{H₂} + \text{Cl₂} \rightarrow \text{2HCl} \)
D \( \text{H₂} + \text{Cl₂} \rightarrow \text{H₂Cl₂} \)

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 \( \text{C}_3\text{H}_4\text{O}_2 \)
C \( \text{C}_2\text{H}_2\text{O}_2 \)
D \( \text{C}_2\text{H}_4\text{O} \)

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

Q# 9/
10 Lead(II) nitrate can be decomposed as shown.

\( \text{xPb(NO}_3\text{)}_2 \rightarrow y\text{PbO} + z\text{NO}_2 + \text{O}_2 \)

Which numbers \( x \), \( y \), and \( z \) balance the equation?

\[
\begin{array}{ccc|c}
  x & y & z &  \\
  A & 2 & 2 & 2 \\
  B & 2 & 2 & 4 \\
  C & 2 & 4 & 4 \\
  D & 4 & 4 & 2 \\
\end{array}
\]

Q# 10/
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# 11/
11 The diagram shows a molecule of vinyl chloride (used to make PVC).

\[
\text{key:} \quad \bullet \text{a carbon atom} \quad \bigcirc \text{a chlorine atom} \quad \text{a hydrogen atom}
\]

What is the formula of vinyl chloride?
A \( \text{CH}_2\text{Cl} \)  B \( \text{CH}_3\text{Cl}_2 \)  C \( \text{C}_2\text{H}_2\text{Cl}_2 \)  D \( \text{C}_2\text{H}_4\text{Cl} \)
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 C₂H₅OH  B C₃H₅O  C C₂H₅OH  D C₂H₂

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, \( M \), of this acid.

Which line is correct?

<table>
<thead>
<tr>
<th>number of atoms</th>
<th>( M )</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>MgCl₂</td>
<td>S₂Cl₂</td>
</tr>
<tr>
<td>B</td>
<td>MgCl₂</td>
<td>SCl₂</td>
</tr>
<tr>
<td>C</td>
<td>MgCl₂</td>
<td>S₂Cl₁</td>
</tr>
<tr>
<td>D</td>
<td>MgCl₂</td>
<td>SCl₂</td>
</tr>
</tbody>
</table>

10 A gas has the molecular formula NOCl.

Which diagram could show molecules of the pure gas NOCl?

A  B

Q# 15/ 10 For which compound is the formula correct?

<table>
<thead>
<tr>
<th>compound</th>
<th>formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>A  ammonia</td>
<td>NH₃</td>
</tr>
<tr>
<td>B  carbon monoxide</td>
<td>CO₂</td>
</tr>
<tr>
<td>C  iron(III) oxide</td>
<td>Fe₂O₃</td>
</tr>
<tr>
<td>D  zinc hydroxide</td>
<td>Zn(OH)₂</td>
</tr>
</tbody>
</table>
5.15 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  ethane  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  $\text{O}^{2-}$  $\text{Cr}^{3+}$  $\text{Ba}^{2+}$  $\text{SO}_4^{2-}$

compounds

(i) chromium(III) sulfate ........................................................................................................... [2]

(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.

5.16 Extension Mind Map for Topic 4.1 Chemical equations

(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>CuCO$_3$</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(NO$_3$)$_2$</td>
<td>2.11</td>
<td>1.68</td>
<td></td>
</tr>
<tr>
<td>Cu and O$_2$</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.

........................................................................................................................................... [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.

........................................................................................................................................... [2]
5.17 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?

5.18 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>Measure</th>
<th>Symbol</th>
<th>Current (2005 formal definition)</th>
<th>Historical origin &amp; justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metre</td>
<td>length</td>
<td>m</td>
<td>The metre is the length of the path travelled by light in vacuum during a time interval of 1/299792458 of a second.</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>
</tr>
<tr>
<td>Kilogram</td>
<td>mass</td>
<td>kg</td>
<td>The kilogram is the unit of mass; it is equal to the mass of the international prototype of the kilogram.</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 x 60 x 60 of the day.</td>
</tr>
<tr>
<td>Second</td>
<td>time</td>
<td>s</td>
<td>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.</td>
<td>The original definition referred to the time interval of 1/273.16 of the temperature of the triple point of water.</td>
</tr>
<tr>
<td>Ampere</td>
<td>electric current</td>
<td>A</td>
<td>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 x 10^-7 newton per metre of length.</td>
<td>The original definition referred to the force between two parallel conductors carrying identical currents.</td>
</tr>
<tr>
<td>Kelvin</td>
<td>thermodynamic temperature</td>
<td>K</td>
<td>The kelvin, unit of thermodynamic temperature, is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water.</td>
<td>The kelvin was defined electrochemically as the temperature at which 11.8 milligrams of silver were deposited from a solution of silver nitrate.</td>
</tr>
</tbody>
</table>

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?
### End of Topic 7.4 Goals Checklist

For each topic, you ought to try to do as many of the following things as possible to get the most out of your time, the resources available to you, and your enjoyment of the topic. Tick each goal off as you complete it. Growth is difficult and uncomfortable, but you should choose to do these things, not because they are easy, but because challenge is something we are willing to accept, something we are unwilling to postpone, and something which we intend to win!

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Aspect</th>
<th>What you should have done</th>
<th>Yes/No</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ask your teacher 1 question, about anything, once a week</td>
<td>Yes/No</td>
<td>FUNDAMENTAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Try to answer one question asked by your teacher at least once a week</td>
<td>Yes/No</td>
<td>ESSENTIAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ask your teacher one question about something to do with science every lesson</td>
<td>Yes/No</td>
<td>EXTENSION</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Completed set of class notes</td>
<td>Yes/No</td>
<td>FUNDAMENTAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Attempted</td>
<td>Yes/No</td>
<td>ESSENTIAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Completed</td>
<td>Yes/No</td>
<td>EXTENSION</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Attempted the Mind Map for this topic</td>
<td>Yes/No</td>
<td>EXTENSION</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Attempted more than 25% of the questions and those questions you have completed have been marked</td>
<td>Yes/No</td>
<td>FUNDAMENTAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Attempted more than 25% of the questions and those questions you have completed have been marked</td>
<td>Yes/No</td>
<td>ESSENTIAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Attempted the Mind Map for this topic</td>
<td>Yes/No</td>
<td>EXCEPTIONAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Completed and marked all questions here</td>
<td>Yes/No</td>
<td>SMASHING!!!</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Completed 2 assessed activities, either in class or as homework</td>
<td>Yes/No</td>
<td>ESSENTIAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 80% on average</td>
<td>Yes/No</td>
<td>EXTENSION</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Worked on at least 25% of the exam questions in this workbook</td>
<td>Yes/No</td>
<td>FUNDAMENTAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Scored over 90%</td>
<td>Yes/No</td>
<td>EXTENSION</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Scored over 95%</td>
<td>Yes/No</td>
<td>EXCEPTIONAL</td>
<td></td>
</tr>
</tbody>
</table>

### Exceptional Activity

- **Creation of a worksheet about the SI system**
  - The creation of a worksheet about the International System of Units (SI) to help students understand and apply the fundamental units of measurement.

### Exceptional Reflection

- **Why do you think the SI units exist? Do any countries not use this system? Who gets to decide on these standards?**
  - Exploration of the historical and contemporary context of the SI system and the role of international organizations in its standardization.

### Exceptional Activity

- **Create a short 2-3 minute presentation about any part of an SI unit you find most interesting.**
  - A creative and engaging activity to deepen understanding and retention of SI units.

---

For an alternate version of the kilogram, which was not adopted, can be found by finding out about the world's roundest object: [https://www.smashingscience.org](https://www.smashingscience.org) & for China [www.SmashingScience.cn](http://www.SmashingScience.cn).
### Aspect

<table>
<thead>
<tr>
<th>Reading</th>
<th>Reflection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spend more than 1 hour a week reading a book <strong>you enjoy</strong> (in any language) about anything.</td>
<td>You completed this goal setting table</td>
</tr>
<tr>
<td>Spend more than 3 hours a week reading a book <strong>you enjoy</strong> (in any language) about anything.</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>
</tr>
<tr>
<td>Spend more than 5 hours a week reading a book <strong>you enjoy</strong> (in any language) about anything.</td>
<td>You have given an answer for every question in the Review and Reflection section at the end of this topic</td>
</tr>
<tr>
<td>Spend at least one hour a week reading a book <strong>you enjoy</strong> in English about anything.</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>
</tr>
<tr>
<td>Spend more than 3 hours a week reading a book <strong>you enjoy</strong> in English about anything.</td>
<td></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

---

### 6.3 ESSENTIAL Glossary for Keywords for this topic

<table>
<thead>
<tr>
<th>English</th>
<th>Chinese</th>
</tr>
</thead>
<tbody>
<tr>
<td>oxidation state a number given to show whether an element has been oxidised or reduced; the oxidation state of an ion is simply the change 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>oxidation 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>氧化化具有三个定义：(i) 转化涉及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>oxidising agent 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>redox reaction 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，一种物质在氧化还原反应中还原另一种物质</td>
</tr>
<tr>
<td>reduction 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>
6.4 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 0-0 single bond, a peroxy, or 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. \( \text{SO}_2 \), \( \text{SO}_3 \), \( \text{SO}_4^{2-} \), \( \text{SO}_4^{3-} \)
   b. \( \text{ClO}_2 \), \( \text{ClO}_3^- \), \( \text{ClO}_4^- \), \( \text{ClO}_5^- \), \( \text{ClO}_6^- \)
   c. \( \text{N}_2\text{O}_5 \), \( \text{NO}_2^- \), \( \text{NO}_2 \), \( \text{N}_2\text{O}_3 \), \( \text{NO}_3^- \), \( \text{NO}_5^- \)

2. Determine the oxidation number of the sulfur atom:
   a. \( \text{H}_2\text{S} \)  
   b. \( \text{S} \)  
   c. \( \text{H}_2\text{SO}_3 \)  
   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. \( \text{H}_3\text{PO}_4 \)  
   b. \( \text{H}_2\text{PO}_4 \)  
   c. \( \text{H}_2\text{PO}_3^- \)  
   d. \( \text{H}_3\text{PO}_4^+ \)  
   e. \( \text{H}_2\text{PO}_4^- \)  
   f. \( \text{H}_2\text{PO}_3^+ \)

4. Give oxidation numbers for the underlined atoms in these molecules and ions:
   a. \( \text{Cs}_2\text{O} \)  
   b. \( \text{PtCl}_4^- \)  
   c. \( \text{Cu}_2 \)  
   d. \( \text{SnF}_2 \)  
   e. \( \text{Al}_2\text{O}_3 \)
   f. \( \text{ClF}_3 \)  
   g. \( \text{H}_2\text{AsO}_3 \)  
   h. \( \text{SbF}_6^- \)  
   i. \( \text{TiO}_2 \)  
   j. \( \text{P}_4 \)  
   k. \( \text{Mo}_2\text{O}_5^- \)  

6.4.1 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 and ions:
   a. \( \text{SO}_2 \), \( \text{SO}_3 \), \( \text{SO}_4^2- \), \( \text{SO}_4^3- \)
   b. \( \text{ClO}_2 \), \( \text{ClO}_3^- \), \( \text{ClO}_4^- \), \( \text{ClO}_5^- \), \( \text{ClO}_6^- \)
   c. \( \text{N}_2\text{O}_5 \), \( \text{NO}_2^- \), \( \text{NO}_2 \), \( \text{N}_2\text{O}_3 \), \( \text{NO}_3^- \), \( \text{NO}_5^- \)

2. Determine the oxidation number of the sulfur atom:
   a. \( \text{H}_2\text{S} \)  
   b. \( \text{S} \)  
   c. \( \text{H}_2\text{SO}_3 \)  
   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. \( \text{H}_3\text{PO}_4 \)  
   b. \( \text{H}_2\text{PO}_4 \)  
   c. \( \text{H}_2\text{PO}_3^- \)  
   d. \( \text{H}_3\text{PO}_4^+ \)  
   e. \( \text{H}_2\text{PO}_4^- \)  
   f. \( \text{H}_2\text{PO}_3^+ \)

4. Give oxidation numbers for the underlined atoms in these molecules and ions:
   a. \( \text{Cs}_2\text{O} \)  
   b. \( \text{PtCl}_4^- \)  
   c. \( \text{Cu}_2 \)  
   d. \( \text{SnF}_2 \)  
   e. \( \text{Al}_2\text{O}_3 \)  
   f. \( \text{ClF}_3 \)  
   g. \( \text{H}_2\text{AsO}_3 \)  
   h. \( \text{SbF}_6^- \)  
   i. \( \text{TiO}_2 \)  
   j. \( \text{P}_4 \)  
   k. \( \text{Mo}_2\text{O}_5^- \)
6.5 ESSENTIAL Classroom Active Learning Task 2 Assigning Oxidation States

1. Assign oxidation numbers to each of the atoms in the following compounds:

- \( \text{Na}_2\text{CrO}_4 \quad \text{Na} = \quad \text{O} = \quad \text{Cr} = \)
- \( \text{K}_2\text{Cr}_2\text{O}_7 \quad \text{K} = \quad \text{O} = \quad \text{Cr} = \)
- \( \text{CO}_2 \quad \text{O} = \quad \text{C} = \)
- \( \text{CH}_4 \quad \text{H} = \quad \text{C} = \)
- \( \text{HClO}_4 \quad \text{O} = \quad \text{H} = \quad \text{Cl} = \)
- \( \text{MnO}_2 \quad \text{O} = \quad \text{Mn} = \)
- \( \text{SO}_3^{2-} \quad \text{O} = \quad \text{S} = \)
- \( \text{SF}_4 \quad \text{F} = \quad \text{S} = \)

   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>Nitrogen</td>
<td>(\text{NH}_3)</td>
<td></td>
</tr>
<tr>
<td>Nitrite</td>
<td>(\text{NO}_2^-)</td>
<td></td>
</tr>
<tr>
<td>Dinitrogen oxide</td>
<td>(\text{N}_2\text{O}_5)</td>
<td></td>
</tr>
<tr>
<td>Nitro oxide</td>
<td>(\text{NO}_2)</td>
<td></td>
</tr>
<tr>
<td>Hydroxylamine</td>
<td>(\text{NH}_2\text{OH})</td>
<td></td>
</tr>
<tr>
<td>Nitrogen oxide</td>
<td>(\text{N}_2\text{H}_4)</td>
<td></td>
</tr>
</tbody>
</table>

6.6 ESSENTIAL Classroom Active Learning Task 3 Oxidising and Reducing Agents

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.

\[ \text{N} \text{ (in N}_2) = \quad \text{N} \text{ (in NH}_3) = \]

\[ \text{H} \text{ (in H}_2) = \quad \text{H} \text{ (in NH}_3) = \]

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.

- \(4 \text{Fe} + 3 \text{O}_2 \rightarrow 2 \text{Fe}_3\text{O}_4\)

  - oxidizing agent
  - reducing agent
c. $\text{NH}_4\text{NO}_3 \rightarrow \text{N}_2 + 2 \text{H}_2\text{O}$  
oxidizing agent  
reducing agent

d. $\text{P}_4 + 10 \text{Cl}_2 \rightarrow 4 \text{PCl}_5$  
change in oxidation number  
oxidizing agent  
reducing agent

e. $2 \text{Cr}^{3+} + \text{H}_2\text{O} + 6 \text{ClO}_3^- \rightarrow \text{Cr}_2\text{O}_7^{2-} + 6\text{ClO}_2 + 2 \text{H}^+$  
change in oxidation number  
oxidizing agent  
reducing agent

6.7 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.

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 (H$_2$O)  
   $$\_\_\_\text{MnO}_4^- \rightarrow \_\_\_\text{Mn}^{2+}$$

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.

   $$2 \text{ Br}^- \rightarrow \text{Br}_2 + 2e^-$$

   $$6e^- + 8\text{H}^+ + 3\text{MnO}_4^- \rightarrow 3\text{Mn}^{2+} + 4\text{H}_2\text{O}$$

   multiply this half-reaction by ______
   multiply this half-reaction by ______

   $$\_\_\_\text{Br}^- \rightarrow \_\_\_\text{Br}_2 + \_\_\_e^-$$

   $$\_\_\_e^- + 8\_\_\_\text{H}^+ + 3\_\_\_\text{MnO}_4^- \rightarrow \_\_\_\text{Mn}^{2+} + \_\_\_\text{H}_2\text{O}$$

   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?
6.7.1 ESSENTIAL Classroom Active Learning Task 2,3 & 4 Mark Scheme

Worksheet 20 – Oxidation Reduced in Reactions

Oxidation number rule:

Elements have an oxidation number of 0. Hydrogen has an oxidation number of +1 and oxygen has an oxidation number of –2. Group 1 has a lower oxidation number than Group 2, etc.

Nitrogen forms nitrous oxide (N₂O), while nitrogen forms nitric oxide (NO).

Sulfur: –2, except when it forms NC₃S₃. 

Finally, balance hydrogen by adding protons (H⁺).

This half-reaction is producing/consuming electrons. It 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.

6.8 ESSENTIAL EXAM QUESTIONS Paper 3/4 48marks

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

Q# 2/IGCSE Chemistry/2012/s/Paper 31/

3 (a) The reactions between metals and acids are redox reactions.

Zn + 2H⁺ → Zn²⁺ + H₂

(i) Which change in the above reaction is oxidation, Zn to Zn²⁺ or 2H⁺ to H₂? Give a reason for your choice.

(ii) Which reactant in the above reaction is the oxidising agent? Give a reason for your choice.

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.

\[ 2V^{3+} + Zn \rightarrow 2V^{2+} + Zn^{2+} \]  \[1\]

(ii) Which change in the following equation is oxidation? Explain your choice.

\[ V^{2+} + Fe^{3+} \rightarrow V^{3+} + Fe^{2+} \]

\[2\]

Q# 3/ GCSE 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.

\[3\]

(ii) Which substance in the first equation is the reductant (reducing agent)?

\[1\]

Q# 4/ GCSE 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.

F\(_{2}\) changes into \[ \]  \[1\]

Q# 5/ GCSE Chemistry/2010/w/Paper 31/Q6

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>Na</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/ GCSE 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/ GCSE 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
The following apparatus was used to measure the rate of the reaction between zinc and iodine.

![Diagram of reaction setup]

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.

(ii) Write an ionic equation for the reaction between zinc atoms and silver(I) ions.

Q# 9/ iGCSE Chemistry/2004/s/Paper 3/ Q2
(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.

\[ \text{SiO}_2 + \text{C} \rightarrow \text{Si} + \text{CO} \]

(ii) Explain why the silicon(IV) oxide is said to be reduced.

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.

\[ \text{Zn(s)} + \text{Pb}^{2+}(aq) \rightarrow \text{Zn}^{2+}(aq) + \text{Pb(s)} \]

Which change is reduction? Explain your answer.

Q# 11/ iGCSE Chemistry/2002/w/Paper 3/ Q2
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?

(ii) After Group(IV) the oxidation states are negative and decrease across the period. Explain why.

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.

\[ \text{Cl}_2 + \ldots \text{Br}^- \rightarrow \ldots + \ldots \]

(ii) Explain using the idea of electron transfer why the bromide ion is oxidised by chlorine.

The bromide ion is oxidised because

Chlorine is the oxidising agent because

(iii) Name a reagent that can be oxidised by bromine molecules.

Q# 13/ iGCSE Chemistry/2001/w/Paper 3/ Q/GCSE Chemistry/2011 (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.
6.8.1 Mark Scheme iGC Chem 7.4 EQ Paper 3/4

**Q# 1** / 6.8.1 iGCSE Chemistry/2015/s/Paper 3/1

(a) (i) 2Zn(s) \(\rightarrow\) 2Zn\(^{2+}\)
   - because electron loss

(b) (ii) 2Fe\(^{3+}\) \(\rightarrow\) 2Fe
   - increase in oxidation number / electron loss

**Q# 2** / 6.8.1 iGCSE Chemistry/2012/s/Paper 3/1/Q4

(c) (i) \(V^{5+}\) is oxidant
   - because oxidation number increases for \(V^+\)

(ii) \(V^{2+}\) to \(V^{5+}\)
   - increase in oxidation number / electron loss

**Q# 3** / 6.8.1 iGCSE Chemistry/2011/w/Paper 31 / Q5

(b) (i) Fe to Fe\(^{2+}\)
   - because oxidation is electron loss / increase in oxidation number
   - need both points

(ii) Fe
   - oxidation number decreases

**Q# 4** / 6.8.1 iGCSE Chemistry/2010/w/Paper 31

(iv) reduction because electron gain
   - / because oxidation number decreases
   - need both points

(v) Fe\(^{3+}\)
   - oxidation number decreases

**Q# 5** / 6.8.1 iGCSE Chemistry/2010/w/Paper 31/Q6

(a) (i) does not form compounds / does not accept and does not lose electrons / has full outer shell / it is a Noble Gas / it is in Group 0 / 8
   - number of outer electrons increases

(ii) small number of outer electrons / lose electrons / gain electrons then positive / negative
   - number of outer electrons increases

**Q# 6** / 6.8.1 iGCSE Chemistry/2009/w/Paper 3 / Q6

(ii) T loses electrons (to form iodine molecules)
   - must be in terms of electron transfer
   - oxidation number decreases

(iii) they (electrons) are accepted by ozone
   - or it is an electron acceptor

**Q# 7** / 6.8.1 iGCSE Chemistry/2007/w/Paper 3 / Q3 (b)

(iii) reducing or reduction or reductant
   - lost electrons or gained or donated electrons or transferred (to bromine)
   - reduced
   - gained or accepted electrons

**Q# 8** / 6.8.1 iGCSE Chemistry/2005/s/Paper 3 / Q3

(a) 2Zn + I\(_2\) \(\rightarrow\) 2Zn\(^{2+}\) + 2I\(^-\)
   - For having either reactants or products correct ONLY

**Q# 9** / 6.8.1 iGCSE Chemistry/2004/s/Paper 3 / Q3

(c) (i) correctly balanced

(ii) lost oxygen
   - or decrease in oxidation number
   - NOT accepts electrons unless valid explanation

**Q# 10** / 6.8.1 iGCSE Chemistry/2003/w/Paper 3 / Q3

(c) (i) one involving lead – change 2
   - cond because electrons are gained
   - oxidation number less

(ii) correct equation
   - Zn + 2Ag\(^+\) \(\rightarrow\) 2Ag + Zn\(^{2+}\)
   - not balanced ONLY

**Q# 11** / 6.8.1 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 electron
   - NOT just different groups or valencies

(ii) gain electrons
   - number of electrons to be gained is less across period
   - or number of outer electrons increases

**Q# 12** / 6.8.1 iGCSE Chemistry/2002/s/Paper 3/

4 (a) (i) halogen

(i) iodine and oratine

(b) (i) Cl\(_2\) + 2Br\(^-\) \(\rightarrow\) 2Cl\(^-\) + Br\(_2\)
   - not balanced ONLY

(ii) because it has lost electron(s)
   - (Must be electron transfer)

Not conserved because it took electrons from the bromide
   - or chloride gained electrons
   - or because chloride was reduced

(iii) iodide or metals or iron(II) etc
   - not iodine accept iodine ions or alkene

**Q# 13** / 6.8.1 iGCSE Chemistry/2001/w/Paper 3 / Q/GCSE Chemistry/2011 (a)

(iii) reduction
   - COND electron gain or decrease in oxidation number

   [1]
6.9 ESSENTIAL EXAM QUESTIONS Paper 2 18 marks

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 thermit 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\(^{3+}\) 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.

\[ 2\text{FeCl}_2(\text{aq}) + \text{Cl}_2(g) \rightarrow 2\text{FeCl}_3(\text{aq}) \]

Which statements about this reaction are correct?

1. Fe\(^{3+}\) ions are reduced to Fe\(^{2+}\) ions.
2. Chlorine acts as a reducing agent.
3. Fe\(^{3+}\) ions each lose an electron.
4. Cl\(_2\) molecules are reduced to 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/
16 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>half-equation</th>
<th>type of reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>A  Ag → Ag⁺ + e⁻</td>
<td>oxidation</td>
</tr>
<tr>
<td>B  Ag → Ag⁺ + e⁻</td>
<td>reduction</td>
</tr>
<tr>
<td>C  Ag⁺ + e⁻ → Ag</td>
<td>oxidation</td>
</tr>
<tr>
<td>D  Ag⁺ + e⁻ → Ag</td>
<td>reduction</td>
</tr>
</tbody>
</table>

**Q# 9** / GCSE 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** / GCSE 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>oxidising agent</th>
<th>reducing agent</th>
</tr>
</thead>
<tbody>
<tr>
<td>A  H₂</td>
<td>CuO</td>
</tr>
<tr>
<td>B  CuO</td>
<td>H₂</td>
</tr>
<tr>
<td>C  H₂O</td>
<td>Cu</td>
</tr>
<tr>
<td>D  Cu</td>
<td>H₂O</td>
</tr>
</tbody>
</table>

**Q# 11** / GCSE Chemistry/2017/w/Paper 21/

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** / GCSE 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** / GCSE 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** / GCSE Chemistry/2016/w/Paper 21/

17 Four ionic half-equations are shown.

1  \[ \text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu(s)} \]
2  \[ 2\text{I}^-(\text{aq}) \rightarrow \text{I}_2(\text{aq}) + 2\text{e}^- \]
3  \[ \text{Fe}^{2+}(\text{aq}) \rightarrow \text{Fe}^{3+}(\text{aq}) + \text{e}^- \]
4  \[ \text{Cl}_2(g) + 2\text{e}^- \rightarrow 2\text{Cl}^- (\text{aq}) \]
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.
6.10  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>

6.11  FUNDAMENTAL Assessed Activity 2 Paper 1 17 marks

<table>
<thead>
<tr>
<th>Q# 1/ iGCSE Chemistry/2012/w/Paper 11/</th>
<th>Q# 2/ iGCSE Chemistry/2012/s/Paper 22/</th>
<th>Q# 3/ iGCSE Chemistry/2012/w/Paper 22/</th>
<th>Q# 4/ iGCSE Chemistry/2012/s/Paper 23/</th>
<th>Q# 5/ iGCSE Chemistry/2012/s/Paper 22/</th>
<th>Q# 6/ iGCSE Chemistry/2012/s/Paper 21/</th>
<th>Q# 7/ iGCSE Chemistry/2012/m/Paper 22/</th>
<th>Q# 8/ iGCSE Chemistry/2012/w/Paper 23/</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 Which change is an oxidation?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A FeO to Fe₂O₃</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B Fe₂O₃ to FeO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C H₂O₂ to H₂O</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D H₂O₂ to H₂</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 This element vanadium. V. forms several oxides. In which change is oxidation taking place?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A VO₂ → V₂O₃</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B V₂O₃ → VO₂</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C V₂O₃ → VO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D V₂O₃ → V₃O₅</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q# 3/
10 The red colour in some pottery glazes may be formed as a result of the reactions shown.

\[
\text{CuCO}_3 \xrightarrow{\text{heat}} \text{CuO} + \text{CO}_2 \\
\text{CuO} + \text{SnO} \rightarrow \text{Cu} + \text{SnO}_2
\]

These equations show that .......1....... is oxidised and .......2....... 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.

\[
\text{iron oxide + carbon monoxide } \rightarrow \text{iron + carbon dioxide}
\]

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.

\[
\text{N}_2 + \text{O}_2 \rightarrow 2\text{NO} \\
2\text{NO} + \text{O}_2 \rightarrow 2\text{NO}_2 \\
\text{NO} + \text{O}_2 \rightarrow \text{NO}_2 + \text{O}_3
\]
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).

\[
\text{K}_2\text{Cr}_2\text{O}_7 + 2\text{KOH} \rightarrow 2\text{KCrO}_4 + \text{H}_2\text{O}
\]

As a result of adding an excess of aqueous potassium hydroxide to aqueous potassium dichromate(VI), what happens to the oxidation state of the chromium and the pH of the reaction mixture?

<table>
<thead>
<tr>
<th>oxidation state of chromium</th>
<th>pH of the mixture</th>
</tr>
</thead>
<tbody>
<tr>
<td>A decreases</td>
<td>decreases</td>
</tr>
<tr>
<td>B decreases</td>
<td>increases</td>
</tr>
<tr>
<td>C stays the same</td>
<td>decreases</td>
</tr>
<tr>
<td>D stays the same</td>
<td>increases</td>
</tr>
</tbody>
</table>

Q# 10/
16 Which equation shows an oxidation reaction?

A \( \text{C} + \text{O}_2 \rightarrow \text{CO}_2 \)
B \( \text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2 \)
C \( 2\text{H}_2\text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{O}_2 \)
D \( \text{N}_2\text{O}_4 \rightarrow 2\text{NO}_2 \)
Q#11/
15 Which process does not involve either oxidation or reduction?
A burning methane in the air
B extracting iron from haematite
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 \( \text{CuO} + \text{C} \rightarrow 2\text{Cu} + \text{CO} \)
B \( 2\text{CuO} + \text{O}_2 \rightarrow 4\text{CuO} \)
C \( 2\text{Cu} + \text{O}_2 \rightarrow 2\text{CuO} \)
D \( \text{CuO} + \text{CO} \rightarrow \text{Cu} + \text{CO}_2 \)

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>oxidised</td>
<td>carbon dioxide</td>
</tr>
<tr>
<td>oxidised</td>
<td>carbon monoxide</td>
</tr>
<tr>
<td>reduced</td>
<td>carbon dioxide</td>
</tr>
<tr>
<td>reduced</td>
<td>carbon monoxide</td>
</tr>
</tbody>
</table>

Q#15/
17 The equation shows what happens when hydrated copper(II) sulphate is heated.

\[ \text{CuSO}_4 \cdot 5\text{H}_2\text{O(s)} \rightarrow \text{CuSO}_4(\text{s}) + 5\text{H}_2\text{O(g)} \]

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.

Q#16/
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>oxidised</td>
<td>oxidised</td>
</tr>
<tr>
<td>oxidised</td>
<td>reduced</td>
</tr>
<tr>
<td>reduced</td>
<td>oxidised</td>
</tr>
<tr>
<td>reduced</td>
<td>reduced</td>
</tr>
</tbody>
</table>

6.12 Extension Assessed Activity 3 T7.4 P4 13marks
Q#1/
(i) The chemical process taking place on the surface of the object is

\[ \text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu(s)} \]

Explain whether this process is oxidation or reduction.

(ii) [1]

Q#2/
(d) When a sample of steel is added to dilute hydrochloric acid, an aqueous solution of iron(II) chloride, \( \text{FeCl}_2 \), is formed.

When a sample of rust is added to dilute hydrochloric acid, an aqueous solution of iron(III) chloride, \( \text{FeCl}_3 \), 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>potassium iodide solution</th>
<th>iron(II) chloride solution</th>
<th>iron(III) chloride solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>no change</td>
<td>solution turns from colourless to brown</td>
<td></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]

(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.

\[ 4OH^- \rightarrow O_2 + 2H_2O + 4e^- \]

Explain why this reaction is oxidation.

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

(ii) Write the ionic half-equation for the formation of copper at the cathode.

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

Q#5/
4 Copper(II) sulfate solution was electrolysed using the apparatus shown.

![Diagram of electrolysis apparatus]

(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.

\[ 4OH^- \rightarrow O_2 + 2H_2O + 4e^- \]

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]
6.14 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 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?
6.15 Exceptional Additional Activities, Further Reading and Exploring Beyond the Syllabus

6.16 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/igcse-chem-additional-resources](https://www.smashingsciencecn.org/igcse-chem-additional-resources)


7 Topic 5 Electrochemistry

7.1 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 one question about something you do not understand in science once a week</td>
<td>ESSENTIAL</td>
<td></td>
</tr>
<tr>
<td>Notes and follow up notes</td>
<td>Complete set of class note</td>
<td>FUNDAMENTAL</td>
<td></td>
</tr>
<tr>
<td>Cornell Notetaking Attempted</td>
<td>Cornell Notetaking Completed</td>
<td>ESSENTIAL</td>
<td></td>
</tr>
<tr>
<td>Cornell Notetaking Completed to an exemplary standard</td>
<td>Attempted the Mind Map for this topic</td>
<td>EXCEPTIONAL</td>
<td></td>
</tr>
<tr>
<td>Read ahead before the topic has been started</td>
<td>Completed the Mind Map for this topic</td>
<td>EXTENSION</td>
<td></td>
</tr>
<tr>
<td>Textbook</td>
<td>Completed the questions at the end of each 2 page spread in your exercise book</td>
<td>EXTENSION</td>
<td></td>
</tr>
<tr>
<td>Highlighted key ideas and translate new words</td>
<td>Added to your class notes ideas and important information from the textbook that you learnt</td>
<td>EXTENSION</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>FUNDAMENTAL</td>
<td></td>
</tr>
<tr>
<td>Attempted more than 25% of the questions and those questions you have completed you have marked in a different colour pen</td>
<td>ESSENTIAL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Completed and marked all questions here</td>
<td>EXTENSION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Used the resources available online to answer additional questions not found in this workbook on the current topic.</td>
<td>EXCEPTIONAL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assessed Activities</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>ESSENTIAL</td>
<td></td>
</tr>
<tr>
<td>Complete the word list activity using the word list at the front of each topic as little as possible</td>
<td>FUNDAMENTAL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complete 2 assessed activities, either in class or as homework</td>
<td>ESSENTIAL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complete 2 assessed activities and scored over 70% on average</td>
<td>ESSENTIAL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complete 2 assessed activities and scored over 80% on average</td>
<td>EXTENSION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complete 2 assessed activities and scored over 90% on average</td>
<td>EXCEPTIONAL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>End of Topic Test</td>
<td>Scored 10% higher than your current average</td>
<td>ESSENTIAL</td>
<td></td>
</tr>
<tr>
<td>Scored 15% or more than your previous end of topic average</td>
<td>EXCEPTIONAL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scored over 90%</td>
<td>EXTENSION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scored over 95%</td>
<td>SMASHING!!!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading</td>
<td>Scored 10% higher than your current average</td>
<td>ESSENTIAL</td>
<td></td>
</tr>
<tr>
<td>Spend more than 1 hour a week reading a book <em>you enjoy</em> (in any language) about anything.</td>
<td>ESSENTIAL</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### 7.2 Topic 5 Syllabus

#### 5 Electricity and chemistry

**5.1 Electricity and chemistry**

<table>
<thead>
<tr>
<th>Core</th>
<th>Supplement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Define electrolysis as the breakdown of an ionic compound, molten or in aqueous solution, by the passage of electricity.</td>
<td>Describe the reasons for the use of copper and (steel-cored) aluminium in cables, and why plastics and ceramics are used as insulators.</td>
</tr>
<tr>
<td>Describe the electrode products and the observations made during the electrolysis of:</td>
<td>- the movement of electrons in the metallic conductor</td>
</tr>
<tr>
<td>- molten lead(II) bromide</td>
<td>- the removal or addition of electrons from the external circuit at the electrodes</td>
</tr>
<tr>
<td>- concentrated hydrochloric acid</td>
<td>- the movement of ions in the electrolyte</td>
</tr>
<tr>
<td>- concentrated aqueous sodium chloride</td>
<td>- Describe the production of electrical energy from simple cells, i.e. two electrodes in an electrolyte. (This should be linked with the reactivity series in section 10.2 and redox in section 7.4.)</td>
</tr>
<tr>
<td>- dilute sulfuric acid between inert electrodes (platinum or carbon)</td>
<td>- Describe, in outline, the manufacture of:</td>
</tr>
<tr>
<td>- 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).</td>
<td>- aluminium from pure aluminium oxide in molten cryolite (refer to section 10.3)</td>
</tr>
<tr>
<td>- Predict the products of the electrolysis of a specified binary compound in the molten state</td>
<td>- chlorine, hydrogen and sodium hydroxide from concentrated aqueous sodium chloride (Starting materials and essential conditions should be given but not technical details or diagrams.)</td>
</tr>
<tr>
<td>- Outline the uses of electroplating</td>
<td></td>
</tr>
</tbody>
</table>

**Reflection**

- You completed this goal setting table
- 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
- You have given an answer for every question in the Review and Reflection section at the end of this topic
- You have given good and thoughtful answers for every question in the Review and Reflection section at the end of this topic

---

**7.3 ESSENTIAL Glossary for Keywords for this topic**

<table>
<thead>
<tr>
<th>English</th>
<th>Chinese</th>
</tr>
</thead>
<tbody>
<tr>
<td>anion</td>
<td>负离子 - 在电解中会被吸引到阳极</td>
</tr>
</tbody>
</table>
| anode | 电极在任何类型的电极中 - 使电极极化 - 阳极中 - 它为正电极。
| brine | 盐水在水平的氯化钠溶液 |
| cathode | 使任何类型的发生还原 (电子增益) 的电池中的电极极性 - 在电解中它是负极 |
| cation | 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！ |
| electrochemical cell | 电化学电池一种将化学能转化为电能的电池 - 通过将两种活性不同的金属通过电解质连接制成， |
| electrolyte | 选择一种电池组 - 转换电池组 - 电极之间的发电过程 |
| electroplating | 电镀 - 一种通过电池组 - 将电池组栅极与电池组极的电极 (阳极和阴极) 组成的电池 - 电池组中的正负离子被分离并放电 |
| electrolysis | 电极 | 电极电流进入或离开电池或电解池的位置 |
| electrolytic cell | 电极电流进入或离开电池或电解池的位置 |
| electrolyte | 电极电流进入或离开电池或电解池的位置 |
| electrolyte | 电极电流进入或离开电池或电解池的位置 |
| electrolyte | 电极电流进入或离开电池或电解池的位置 |

---

### 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>When one element is pushed out of its compound by a more reactive element</td>
</tr>
<tr>
<td>Oxidation</td>
<td>Substance that is broken up when electricity is passed through it - usually a liquid</td>
</tr>
<tr>
<td>Cathode</td>
<td>The percentage of the reagents that end up in the desired products of a reaction</td>
</tr>
<tr>
<td>Anode</td>
<td>Removing oxygen from, or adding electrons to, a substance</td>
</tr>
<tr>
<td>Electrify</td>
<td>Negative electrode</td>
</tr>
<tr>
<td>Displacement</td>
<td>A conductor made of a metal or graphite used in electrolysis</td>
</tr>
<tr>
<td>Atom economy</td>
<td>Conventional Flow Notation</td>
</tr>
</tbody>
</table>

**Extension activity**

Assume that the substance being electrolyzed is used (i) to provide the information above about electron flow notation to label the electrodes with the flow notation that is happening at each pole.

**Exceptional activity**

Why is the electron flow notation different from the conventional flow notation?

### Electrolytic Cell for Electrolysps

**Galvanic or Voltaic Cell**

- **Electrolysis**
- **Concentration**
- **Displacement**
- **Electrode**
- **Electrolyte**
- **Electron**
- **Electrolysis**
- **Oxidation**
- **Reduction**

**Extension Classroom Active Learning Task 2**

Display a Venn Diagram comparing and contrasting what these two processes have in common and how are they different in each other.
7.6  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 C₄H₆?
   1. -6  2. -3  3. +3  4. +6
3. Given the reaction: Mg + CuSO₄ → MgSO₄ + Cu, which equation represents the oxidation that takes place?
   1. Mg²⁺ + 2e⁻ → Mg  2. Mg → Mg²⁺ + 2e⁻
4. In the following reaction: Fe + Zn²⁺ → Fe²⁺ + Zn
   A. Fe is reduced and Zn²⁺ is the oxidizing agent
   B. Fe is reduced and Zn is the reducing agent
   C. Fe is oxidized and Zn²⁺ is the oxidizing agent
   D. Fe is oxidized and Zn is the reducing agent
5. In which species does oxygen have an oxidation number of -1?
6. 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
7. Given the equations A, B, C, and D, which two equations represent redox reactions?
   A. AgNO₃ + NaCl → AgCl + NaNO₃
   B. Cu + H₂O → HClO + HCl
   C. CuO + CO → CO₂ + Cu
   D. NaOH + HCl → NaCl + H₂O

8. Given the unbalanced equation: ___NO₃⁻ + 4H⁺ + ___Ag → ___Ag²⁺ + ___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:

```
<table>
<thead>
<tr>
<th>Pb(s)</th>
<th>Cu(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 M</td>
<td>1.0 M</td>
</tr>
<tr>
<td>Pb²⁺(aq)</td>
<td>Cu²⁺(aq)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Switch</td>
<td>Voltmeter</td>
</tr>
</tbody>
</table>
```

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. Cu²⁺ only  
   2. Pb²⁺ only  
   3. Both Cu²⁺ and Pb²⁺  
   4. Neither Cu²⁺ nor Pb²⁺
16. In the following reaction, how many total electrons are transferred between chlorine and oxygen?
   2 ClO₃⁻ → Cl₂ + 2O₂
   1. 1  2. 2  3. 3  4. 4
17. In the following reaction what is the reducing agent?
   Mg + 2HNO₃ → Mg(NO₃)₂ + H₂

Answer the next four questions from the reaction below:
Given the unbalanced reaction:

```
   Au²⁺(aq) + I⁻(aq) → Au(s) + I₂(s)
```

21. Write the reduction half reaction

```
   Au²⁺ + e⁻ → Au(s)
```

22. Write the oxidation half reaction

```
   I⁻ + ½O₂ + H⁺ → I₂ + H₂O
```

23. Write the balanced reaction

```
   Au²⁺ + 2I⁻ + 2H⁺ → Au(s) + I₂(s) + H₂O
```

24. How many total electrons are transferred when the reaction is balanced

```
   2 Au²⁺ + 2I⁻ + 2H⁺ → 2 Au(s) + I₂(s) + H₂O
```

---


The diagram below represents an electrochemical cell for the reaction:
\[ \text{Mg(s)} + \text{Zn(NO}_3\text{)}(aq) \rightarrow \text{Mg(NO}_3\text{)}(aq) + \text{Zn(s)} \]

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 on 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 across each electrode.  
C. In what two ways does this differ from the other type of cell you have studied?

32. D. requires power, requires electrical energy; the cathode and anode are all in same cell compartment; does have a salt bridge.
Q# 1
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
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. iron and copper
C. magnesium and zinc
D. magnesium and iron

Q# 3
The diagram shows a method used to copper-plate a pan with copper(I) sulfate solution. Which apparatus could be used to electroplate an iron nail with copper?
A. apparatus A
B. apparatus B
C. apparatus C
D. apparatus D
12 The diagram shows 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>

10 Which reactions could take place at the anode during electrolysis?

1. $4\text{OH}^- (\text{aq}) \rightarrow 2\text{H}_2\text{O}(l) + \text{O}_2(g) + 4\text{e}^-$
2. $2\text{Cl}^- (\text{aq}) \rightarrow \text{Cl}_2(g) + 2\text{e}^-$
3. $\text{Cu}^{2+} (\text{aq}) + 2\text{e}^- \rightarrow \text{Cu}(s)$
4. $2\text{I}^- (\text{aq}) + 2\text{e}^- \rightarrow \text{I}_2(g)$

A 1 and 2  
B 1 and 4  
C 2 and 4  
D 3 and 4

12 The diagram shows a simple cell.

Which equation represents the reaction at the cathode?

A  $\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$
B  $2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$
C  $4\text{OH}^- \rightarrow \text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^-$
D  $2\text{O}^{2-} \rightarrow \text{O}_2 + 4\text{e}^-$

12 The diagram shows a simple cell.

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>

10 The diagram shows the electrolysis of molten zinc chloride, $\text{ZnCl}_2$.

Which statement is correct?

A Oxidation occurs at electrode X and the equation is: $2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$.  
B Oxidation occurs at electrode Y and the equation is: $\text{Zn}^{2+} + 2\text{e}^- \rightarrow \text{Zn}$.  
C Reduction occurs at electrode X and the equation is: $\text{Zn}^{2+} + 2\text{e}^- \rightarrow \text{Zn}$.  
D Reduction occurs at electrode Y and the equation is: $2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$. 


Which statement about the process occurring when the cell is in operation is correct?

A  Cu²⁺ ions are formed in solution.
B  Electrons travel through the solution.
C  The reaction Zn → Zn²⁺ + 2e⁻ occurs.
D  The zinc electrode increases in mass.

Q#7 / GCE 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.

7.8 ESSENTIAL EXAM QUESTIONS T5 Paper 3/4 100 marks

Q#1 / GCE 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.

Q#2 / GCE 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.

Q# 7 / GCE Chemistry/2016/m/Paper 22/

(i) What is a cell?
Q# 3/IGCSE Chemistry/2011/w/Paper 31/ Q3
(ii) Which electrode will be oxidised and become smaller? Explain your choice.
[3]

(iii) What measurements would you need to 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# 5/IGCSE Chemistry/2010/w/Paper 31/ Q3
This equation is needed for the question that follows:

(vi) 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)

(ii) Draw an arrow on the diagram to show the direction of the electron flow.
[1]

(i) Complete the sentence.
A cell will change ........................................ energy into electrical energy.
[1]

Q# 7/IGCSE Chemistry/2010/w/Paper 31/ Q7c
(ii) 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.
[2]

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.
Q# 9/ IGCSE Chemistry/2009/w/Paper 3/Q3

(iii) In the left hand beaker, the colour changes from brown to colourless. Complete the equation for the reaction.

\[ \text{Br}_2 \quad \rightarrow \quad \text{...} \]

Q# 10/ IGCSE Chemistry/2009/s/Paper 3/Q1

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>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>
<tr>
<td>potassium formed</td>
<td>iodine formed</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q# 11/ IGCSE Chemistry/2008/w/Paper 3/Q1

5 The electrolysis of concentrated aqueous sodium chloride produces three commercial, 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).

\[ \text{...} + \text{...} \rightarrow \text{H}_2 \] [1]

(ii) Complete the ionic equation for the reaction at the positive electrode (anode).

\[ \text{...} - \rightarrow \text{Cl}_2 \] [1]

(iii) Explain why the solution changes from sodium chloride to sodium hydroxide.

\[ \text{...} \rightarrow \text{...} \] [1]
Q# 12/ IGCSE Chemistry/2008/w/Paper 3/

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

(b) Write an ionic equation for the reaction at the positive electrode (anode).

Q# 13/ IGCSE Chemistry/2007/w/Paper 3

(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: \( \text{Zn}^{2+} (aq) \quad \text{SO}_4^{2-} (aq) \quad \text{H}^+ (aq) \quad \text{OH} (aq) \)

(i) Zinc forms at the negative electrode (cathode). Write the equation for this reaction.

(ii) Write the equation for the reaction at the positive electrode (anode).

(iii) The electrolyte changes from aqueous zinc sulphate to

Q# 14/ IGCSE Chemistry/2007/w/Paper 3/ 

6 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 ( \text{kJ/mol} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>methanol</td>
<td>( \text{CH}_3\text{OH} )</td>
<td>-730</td>
</tr>
<tr>
<td>ethanol</td>
<td>( \text{CH}_3\text{CH}_2\text{OH} )</td>
<td>-1370</td>
</tr>
<tr>
<td>propan-1-ol</td>
<td>( \text{CH}_3\text{CH}_2\text{CH}_2\text{OH} )</td>
<td>-2020</td>
</tr>
<tr>
<td>butan-1-ol</td>
<td>( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{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.

\( \text{C}_2\text{H}_4\text{OH} + \quad \text{________} + \quad \text{O}_2 \rightarrow \quad \text{________} + \quad \text{________} \)
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.

(ii) Write an ionic equation for the reaction at the negative electrode.

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.

```
<table>
<thead>
<tr>
<th>voltage</th>
<th>zinc electrode</th>
<th>iron electrode</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>becomes thinner</td>
<td></td>
</tr>
<tr>
<td></td>
<td>bubbles of hydrogen form</td>
<td></td>
</tr>
</tbody>
</table>
```

Which substance in this cell is the reductant and which ion is the oxidant?

reductant

oxidant

(ii) How could the voltage of this cell be increased?

The heat of combustion of butan-1-ol = \( \text{kJ/mol} \) [3]

<table>
<thead>
<tr>
<th>Heat of combustion/ kJ/mol</th>
<th>Number of carbon atoms per molecule</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2800</td>
<td>1</td>
</tr>
<tr>
<td>-2600</td>
<td>2</td>
</tr>
<tr>
<td>-2400</td>
<td>3</td>
</tr>
<tr>
<td>-2200</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Heat of combustion/ kJ/mol</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2800</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-2600</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-2400</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-2200</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
(d) Cells can be set up with inert electrodes and the electrolyte as oxidant and reductant.

![Diagram of a cell with electrodes and electrolyte](image)

The potassium manganate(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.

(ii) Write an ionic equation for the reaction in the right hand beaker.

---

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).

(ii) A colourless gas was given off at the positive electrode (anode) and the solution changes from blue to colourless. Explain these observations.

---

Q# 19/IGCSE Chemistry/2003/s/Paper 3/Q5

(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.

(ii) Explain why the colour of the solution does not change.

(iii) What is the large scale use of this electrolysis?

---

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.

(i) The electrolysis of molten strontium chloride produces strontium metal and chlorine. Write ionic equations for the reactions at the electrodes.

- Negative electrode (cathode)
- Positive electrode (anode)

(iii) One of the products of the electrolysis of concentrated aqueous strontium chloride is chlorine. Name the other two.

---

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.

\[
\text{La}^{3+} + \text{...} \rightarrow \text{...}
\]

(ii) Name the three products formed by the electrolysis of aqueous caesium bromide.
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 charge that occurs at the electrodes.

(i) cathode (pure copper) ..............................................

(ii) anode (impure copper) ..............................................

(iii) Write an ionic equation for the reaction at the cathode.

(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 ..............................................

Q# 22/ iGCSE Chemistry/2002/s/Paper 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.

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?

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.

(ii) How could the voltage of the cell be increased?

(f) A different type of cell is drawn below.

(i) The pH of the solution increases. Give the name of the ion formed.

(ii) Complete the equation that represents the formation of this ion.

\[ \text{O}_2 + \text{H}_2\text{O} \rightarrow \text{...........} \]
7.9 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 [1]

(iii) \( 2H^+ + 2e^- \rightarrow H_\text{g} \)
species (1) balancing (1) [2]

Q# 2/IGCSE Chemistry/2012/s/Paper 31/

(a) (i) device which changes chemical energy into electrical energy; [1]

OR
produces a voltage / potential difference / electricity; [1]

due to difference in reactivity of two metals; [1]

OR
produces a voltage / potential difference / electricity; [1]

by redox reactions; [1]

(ii) negative / electrode B / right electrode; [1]

accept: amode because it is the electrode which supplies electrons to external circuit

loses ions / iron ions / \( Fe^{2+} \) or \( Fe^{3+} \); [1]

electrons move from this electrode; [1]

(iii) change of mass of electrodes / mass of rust formed; [1]

time / mention of stop watch / regular intervals; [1]

(iv) to make it a better conductor; [1]

Q# 3/IGCSE Chemistry/2011/w/Paper 31/ Q3

(ii) aluminium low density / light [1]

aluminium is a good conductor [1]

strength / prevent sagging / allows greater separation of pylons / core made of steel because it is strong [1]

Q# 4/IGCSE Chemistry/2011/s/Paper 31/ Q2 (a)

(ii) cell [1]

accept battery

not generator

Q# 5/IGCSE Chemistry/2010/w/Paper 31/ Q3

(vi) any correct discussion of the reactivity of the halogens e.g. the more reactive the halogen the higher the voltage not better conductor [1]

Q# 6/IGCSE Chemistry/2010/w/Paper 31/ Q5 (b)

(iii) electrolysis [1]

aqueous sodium chloride

Q# 7/IGCSE Chemistry/2010/w/Paper 31/ Q2

(c) (i) tin(IV) oxide + carbon \( \rightarrow \) tin + carbon dioxide [1]

not carbon monoxide as a reductant

accept carbon monoxide as a product

not tin(IV)

accept correct symbol equation

(ii) water [1]

carbon dioxide

(iii) correct labels for (purs) copper cathode

impure copper anode [1]

electrolyte copper(II) sulfate / any soluble copper(II) salt / \( CuSO_4 \) or \( CuCl_2 \)

if labels on electrodes reversed [1]

(iv) wires / pipes / jewellery / nails / roofing / ammunition / coins / cookware / catalyst / sculptor [1]

Q# 8/IGCSE Chemistry/2010/w/Paper 31/

3 (i) chemical [1]

(ii) from right to left [1]

not through salt bridge

(iii) \( Br_2 + 2e^- \rightarrow 2Br^- \)

\( 2Br^- \) as product [1]

Q# 9/IGCSE Chemistry/2009/w/Paper 3/ Q3

(c) (i) zinc atoms change into ions, (the zinc dissolves) [1]

copper(II) ions change into atoms, (becomes plated with copper) [1]

(ii) ions [1]

electrons [1]

Q# 10/IGCSE Chemistry/2009/w/Paper 31/

2 molten potassium iodide \textit{NOT} aqueous [1]

hydrogen [1]

oxygen [1]

water uses up or solution becomes more concentrated or sodium chloride remains NOT no change [1]

If products are given as hydrogen, chlorine and sodium hydroxide then 2/3

copper [1]

oxygen (and water) [1]

sulfuric acid [1]

accept hydrogen sulfate [1]

aqueous or dilute or concentrated potassium bromide

accept correct formulae [1]

[Total: 8]

Q# 11/IGCSE Chemistry/2008/w/Paper 31/

5 (a) (i) \( 2H^+ + 2e^- \rightarrow H_2 \) [1]

(ii) \( 2Cl^- \rightarrow Cl_2 \) or \( 2Cl^- \rightarrow Cl_2 + 2e^- \) [1]

(iii) \( Na^+ \) and \( OH^- \) are left

OR \( Cl^- \) removed \( OH^- \) left

NR 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. Q(a) Pure copper
   ACCEPT any (soluble) copper salt or Cu²⁺
   if both names and formulae given, both have to be correct
   (b) Cu²⁺ + 2e⁻ → Cu⁰
   for having Cu → Cu²⁺ [1] ONLY

Q# 13/ iGCSE Chemistry/2007/w/Paper 3/ Q4
(c) (i) Zn²⁺ + 2e⁻ → Zn
(ii) 4OH⁻ → O₂ + 2H₂O
or 4OH⁻ → O₂ + 2H₂O + 4e⁻
or 2H₂O = 4H⁺ + O₂ + 4e⁻
or 2H₂O = 4H⁺ + O₂
   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)
   (ii) exothermic
   (iii) C₂H₅OH + 3O₂ = 2CO₂ + 3H₂O
   For CO₂ + H₂O ONLY [1]
   (iv) plotting points correctly
   straight line
   between -2940 and -2700kJ/mol
   NOTE minus sign needed

Q# 15/ iGCSE Chemistry/2006/w/Paper 3/ Q6
(b) (i) impure copper/blister copper/brass or copper etc
   (pure) copper
   copper sulphate or nitrate or chloride or contains Cu²⁺aq
   (ii) Cu²⁺ + 2e⁻ → Cu

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
   (iii) sacrificial protection or stop iron/steel rusting
   or galvanising
   (d) (i) pink or purple
   to colourless or decolourised
   NOT red NOT clear
   (ii) 2⁻ + 2e⁻ = I²⁻
   unbalanced ONLY [1]

Q# 17/ iGCSE Chemistry/2005/s/Paper 3/ Q5(c)
(ii) Sr²⁺ + 2e⁻ → Sr
2Ca²⁻ + 2e⁻ → Ca₂⁺
or 2e⁻ → Cl₂ + 2e⁻
(iii) hydrogen [1] and strontium hydroxide [1]

Q# 18/ iGCSE Chemistry/2004/s/Paper 3/ Q5
(b) (i) Cu²⁺ + 2e⁻ → Cu
   (ii) gas is oxygen
   (copper(II) sulphate) changes to sulphuric acid
   or copper ions removed from solution
   (c) (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/w/Paper 3/ Q5
(b) (i) La³⁺ + 3e⁻ → La
   (ii) hydrogen [1]
   bromine NOT Bromide
   cesium hydroxide [1]
   ignore any comments about electrodes

Q# 20/ iGCSE Chemistry/2003/s/Paper 3/ QiGCSE Chemistry/2001
(e) anode tin
   cathode iron or steel
   tin salt or tin ions as electrolyte
   NOT oxide or hydroxide or carbonate

Q# 21/ iGCSE Chemistry/2002/w/Paper 3/ Q4
(b) (i) copper deposited OR mass increases
   (ii) copper goes into solution OR mass decreases
   (iii) Cu²⁺ + 2e⁻ → Cu
   (iv) oxygen
   sulphuric acid accept hydrogen sulphate
   (c) (i) cells produce electricity or exothermic OR change
   chemical energy into electrical energy
   electrolysis uses it OR endothermic OR change
   electrical energy into chemical energy

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>brine</td>
<td></td>
</tr>
<tr>
<td>cathode</td>
<td></td>
</tr>
<tr>
<td>cation</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>

7.10 ESSENTIAL Assessed Activity 2 Multiple Choice T5 16marks

Q# 22/ IGCSE Chemistry/2000/w/Paper 3/ Q3
(c) (steam) and alkane:
heat or catalyst or details of chemistry – forms carbon monoxide/dioxide and (hydrogen) [1]
OR electrolysis [1]
OR carbon/coke [1]
heat or details of chemistry – forms carbon monoxide/dioxide and (hydrogen) [1]

Q# 23/ IGCSE Chemistry/2000/w/Paper 3/ Q4
(i) electrolysis
(ii) hydroxide [1]
(i) Zn - 2e → Zn²⁺ [1]
OR cathode
(ii) O₂ + 2H₂O + 4e → 4OH⁻ [2]
[unbalanced] only [1]
O₂ + 2H₂O + 2e → 2OH⁻(OH)₂ [2]

7.11 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# 22/ IGCSE Chemistry/2000/w/Paper 3/ Q4
(i) Electrolytic cell
(ii) Electroplating

7.11 ESSENTIAL Assessed Activity 2 Multiple Choice T5 16marks
Q# 1
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Which statement describes what happens at the positive electrode?
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D. Oxygen gas is produced if the electrode is made from copper.

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OR electrolysis [1]
OR carbon/coke [1]
heat or details of chemistry – forms carbon monoxide/dioxide and (hydrogen) [1]

Q# 23/ IGCSE Chemistry/2000/w/Paper 3/ Q4
(i) electrolysis
(ii) hydroxide [1]
(i) Zn - 2e → Zn²⁺ [1]
OR cathode
(ii) O₂ + 2H₂O + 4e → 4OH⁻ [2]
[unbalanced] only [1]
O₂ + 2H₂O + 2e → 2OH⁻(OH)₂ [2]

7.11 ESSENTIAL Assessed Activity 2 Multiple Choice T5 16marks
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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# 22/ IGCSE Chemistry/2000/w/Paper 3/ Q3
(c) (steam) and alkane:
heat or catalyst or details of chemistry – forms carbon monoxide/dioxide and (hydrogen) [1]
OR electrolysis [1]
OR carbon/coke [1]
heat or details of chemistry – forms carbon monoxide/dioxide and (hydrogen) [1]

Q# 23/ IGCSE Chemistry/2000/w/Paper 3/ Q4
(i) electrolysis
(ii) hydroxide [1]
(i) Zn - 2e → Zn²⁺ [1]
OR cathode
(ii) O₂ + 2H₂O + 4e → 4OH⁻ [2]
[unbalanced] only [1]
O₂ + 2H₂O + 2e → 2OH⁻(OH)₂ [2]

7.11 ESSENTIAL Assessed Activity 2 Multiple Choice T5 16marks
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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# 22/ IGCSE Chemistry/2000/w/Paper 3/ Q3
(c) (steam) and alkane:
heat or catalyst or details of chemistry – forms carbon monoxide/dioxide and (hydrogen) [1]
OR electrolysis [1]
OR carbon/coke [1]
heat or details of chemistry – forms carbon monoxide/dioxide and (hydrogen) [1]

Q# 23/ IGCSE Chemistry/2000/w/Paper 3/ Q4
(i) electrolysis
(ii) hydroxide [1]
(i) Zn - 2e → Zn²⁺ [1]
OR cathode
(ii) O₂ + 2H₂O + 4e → 4OH⁻ [2]
[unbalanced] only [1]
O₂ + 2H₂O + 2e → 2OH⁻(OH)₂ [2]

7.11 ESSENTIAL Assessed Activity 2 Multiple Choice T5 16marks
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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#3/  
10 Aqueous copper(II) sulfate is electrolysed using carbon electrodes.

What is the product at each electrode?

<table>
<thead>
<tr>
<th>Options</th>
<th>Positive Electrode</th>
<th>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>Options</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.

What is the product at each electrode?

A Oxide 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></th>
<th>Positive Electrode</th>
<th>Negative Electrode</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$2H^+ + 2e^- \rightarrow H_2$</td>
<td>$4OH^- \rightarrow 2H_2O + O_2 + 4e^-$</td>
</tr>
<tr>
<td>B</td>
<td>$2H^+ + 2e^- \rightarrow H_2$</td>
<td>$4OH^- + 4H^+ \rightarrow 2H_2O$</td>
</tr>
<tr>
<td>C</td>
<td>$4OH^- \rightarrow 2H_2O + O_2 + 4e^-$</td>
<td>$2H^+ + 2e^- \rightarrow H_2$</td>
</tr>
<tr>
<td>D</td>
<td>$4OH^- + 4H^+ \rightarrow 2H_2O$</td>
<td>$2H^+ + 2e^- \rightarrow H_2$</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></th>
<th>Anode</th>
<th>Cathode</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Cu $\rightarrow$ Cu$^{2+} + 2e^-$</td>
<td>Cu$^{2+} + 2e^- \rightarrow$ Cu</td>
</tr>
<tr>
<td>B</td>
<td>Cu$^{2+} + 2e^- \rightarrow$ Cu</td>
<td>Cu$^{2+} + 2e^- \rightarrow$ Cu</td>
</tr>
<tr>
<td>C</td>
<td>$4OH^- \rightarrow 2H_2O + O_2 + 4e^-$</td>
<td>Cu$^{2+} + 2e^- \rightarrow$ Cu</td>
</tr>
<tr>
<td>D</td>
<td>$4OH^- \rightarrow 2H_2O + O_2 + 4e^-$</td>
<td>$2H^+ + 2e^- \rightarrow H_2$</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

Q# 9/
10 Which metal combination produces the highest voltage reading in the cells shown?

A

B

C

D

Q# 10/
10 The reactivity series for a number of different metals is shown.

<table>
<thead>
<tr>
<th></th>
<th>most reactive</th>
<th>least reactive</th>
</tr>
</thead>
<tbody>
<tr>
<td>magnesium</td>
<td>zinc</td>
<td>iron</td>
</tr>
</tbody>
</table>

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

7.12 EXTENSION Assessed Activity 3 T5 Longer answer questions 21 marks

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, chloride and sodium hydroxide.

(i) Explain how these three products are formed. Give ionic equations for the reactions at the electrodes.  

\[ \text{Na}^+ + \text{Cl}^- \rightarrow \text{NaCl} \]  

\[ \text{H}^+ + 2\text{H}_2\text{O} \rightarrow \text{H}_2 + 2\text{OH}^- \]

\[ \text{OH}^- \rightarrow \text{O}_2 + 2\text{H}_2\text{O} \]

\[ \text{Al} + \text{OH}^- \rightarrow \text{Al}^3+ + 3\text{H}_2\text{O} \]  

(ii) If the solution of the electrolyte is stirred, chlorine reacts with sodium hydroxide to form sodium chlorate(\text{V}) and sodium hydroxide solution. Write an equation for this reaction.  

\[ \text{Cl}_2 + 2\text{NaOH} \rightarrow \text{NaClO}_3 + \text{NaCl} + \text{H}_2\text{O} \]  

Q# 2/  
7 Aluminium is obtained from purified alumina, Al\(_2\)O\(_3\), by electrolysis.  

(b) Describe the extraction of aluminium from alumina. Include the electrolyte, the electrodes and the reactions at the electrodes.  

\[ \text{Al}_2\text{O}_3 \rightarrow 2\text{Al} + \text{O}_2 \]  

\[ \text{Al} + \text{OH}^- \rightarrow \text{Al}^3+ + 3\text{H}_2\text{O} \]

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 yellow compound formed.  

\[ \text{Cl}_2 + \text{Na}^+ + \text{Cl}^- \rightarrow \text{NaClO}_3 + \text{NaCl} + \text{H}_2\text{O} \]  

\[ \text{Cl}_2 + \text{OH}^- \rightarrow \text{Cl}^- + \text{ClO}^- + \text{H}_2\text{O} \]

\[ \text{Cl}_2 + 2\text{OH}^- \rightarrow \text{ClO}_3^- + \text{Cl}^- + \text{H}_2\text{O} \]  

\[ \text{Cl}_2 + \text{OH}^- \rightarrow \text{Cl}^- + \text{ClO}_3^- + \text{H}_2\text{O} \]
7.13 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 to 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?
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 warp 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

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### 8.1 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 important information from the textbook you learnt</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Attempted the Mind Map for this topic</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Completed 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>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>Asessed Activities</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>Yes/No</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>Yes/No</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>Yes/No</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>Yes/No</td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Spend more than 3 hours a week reading a book you enjoy in English about anything.</td>
<td>Yes/No</td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Spend at least one hour a week reading a book you enjoy in English about anything.</td>
<td>Yes/No</td>
<td>EXCEPTIONAL</td>
</tr>
</tbody>
</table>

**Reflection**

- You have completed this goal setting table.
- 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.
- You have given an answer for every question in the Review and Reflection section at the end of this topic.
- You have given good and thoughtful answers for every question in the Review and Reflection section at the end of this topic.

---

### 8.3 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></td>
<td>bond energy the energy required to break a particular type of covalent bond</td>
<td>键能</td>
</tr>
<tr>
<td></td>
<td>burning a combustion reaction which produces a flame</td>
<td>燃烧</td>
</tr>
<tr>
<td></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</td>
</tr>
<tr>
<td></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</td>
</tr>
<tr>
<td></td>
<td>combustion a chemical reaction in which a substance reacts with oxygen – the reaction is exothermic;</td>
<td>燃烧</td>
</tr>
<tr>
<td></td>
<td>endothermic change a process or chemical reaction which takes in heat from the surroundings; ΔH has a positive value</td>
<td>吸热变化</td>
</tr>
<tr>
<td></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>放热变化</td>
</tr>
<tr>
<td></td>
<td>fuel a substance that can be used as a source of energy, usually by burning (combustion)</td>
<td>燃料</td>
</tr>
<tr>
<td></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</td>
</tr>
<tr>
<td></td>
<td>fuel cells are electrolytic cells capable of providing a continuous supply of electricity without recharging</td>
<td>燃料电池</td>
</tr>
<tr>
<td></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</td>
</tr>
<tr>
<td></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</td>
</tr>
<tr>
<td></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</td>
</tr>
</tbody>
</table>

---

8.4 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$^3$ 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>25</td>
<td>20</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

**Experiment 2**
- The polystyrene cup was amplied 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>25</td>
<td>20</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
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<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.

(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.

(ii) From your graph, deduce the time taken for the temperature of the solution in Experiment 2 to change by 6 °C from the initial temperature. Show clearly on the grid how you worked out your answer.
(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 …………………………………………………………………………………………………………………………………………… [4]

improvement 1 ……………………………………………………………………………………………………………………………………………

source of error 2 ……………………………………………………………………………………………………………………………………………

improvement 2 ……………………………………………………………………………………………………………………………………………

(h) When carrying out the experiments, what would be a disadvantage of taking the temperature readings only every 30 seconds?

……………………………………………………………………………………………… [1]

8.5 ESSNETIAL Classroom Active Learning Tasks 2: Endothermic or Exothermic?

Circle or highlight if these processes are either endothermic or exothermic. The first has already been done for you.
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.

8.6 ESSENTIAL EXAM QUESTIONS Topic 6 Paper 2 31 marks Mark Scheme
Q 1/ IGCSE Chemistry/2018/m/Paper 21/
12 10g 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.

\[ \text{H}_2(g) + \text{Cl}_2(g) \rightarrow 2\text{HCl}(g) \]

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/J</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.

\[ 2H_2(g) + O_2(g) \rightarrow 2H_2O(g) \]

What is the energy change for the reaction?

A  -3208 kJ/mol
B  -908 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.

\[ CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O \]

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

Q# 4/IGCSE Chemistry/2017/s/Paper 23/

11 The compound hydrazine is used as a rocket fuel. It has the structural formula shown.

One of the reactions of hydrazine is shown. This reaction is exothermic.

\[ N_2H_4 \rightarrow N_2 + 2H_2 \]

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  -338 kJ/mol  B  -97 kJ/mol  C  +97 kJ/mol  D  +338 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  \[ C_2H_6OH + 3O_2 \rightarrow 2CO_2 + 3H_2O \]
2  \[ C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O \]
3  \[ CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O \]

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.

\[ \text{H}_2(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow 2\text{HCl}(\text{g}) \]

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.

\[ \text{H}_2(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow 2\text{HCl}(\text{g}) \]

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 \(-134\text{ kJ/mol}\)  
C \(+184\text{ kJ/mol}\)  
D \(+240\text{ kJ/mol}\)

Q#7/IGCSE Chemistry/2017/s/Paper 21/

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 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.

\[ \text{H}_2\text{C}–\text{H} + \text{Cl}–\text{Cl} \rightarrow \text{CH}_2\text{Cl}–\text{CH}_3 + \text{HCl} \]

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 $-1420$ kJ/mol  
B $-120$ kJ/mol  
C $+120$ kJ/mol  
D $+1420$ 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.

$N_2 + 3H_2 \rightarrow 2NH_3$

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 $-4593$ kJ/mol  
B $-1083$ kJ/mol  
C $-959$ kJ/mol  
D $-87$ 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>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>
</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>
</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>
</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>
</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

13 The energy level diagram for a reaction is shown.

Which row is correct?

<table>
<thead>
<tr>
<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>–</td>
</tr>
<tr>
<td>B</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>C</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>D</td>
<td>+</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>Initial temperature /°C</th>
<th>Final temperature /°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>20</td>
</tr>
<tr>
<td>B</td>
<td>20</td>
</tr>
<tr>
<td>C</td>
<td>25</td>
</tr>
<tr>
<td>D</td>
<td>25</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 is correct?

<table>
<thead>
<tr>
<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>exothermic</td>
<td>$-$</td>
</tr>
<tr>
<td>B</td>
<td>endothermic</td>
<td>$+$</td>
</tr>
<tr>
<td>C</td>
<td>endothermic</td>
<td>$-$</td>
</tr>
<tr>
<td>D</td>
<td>exothermic</td>
<td>$+$</td>
</tr>
</tbody>
</table>

Q# 13/ IGCSE Chemistry/2016/s/Paper 22/
13 The energy level diagram for the combustion of methane is shown.

Which row gives the equation and energy change for this reaction?

<table>
<thead>
<tr>
<th>equation</th>
<th>energy change in kJ/mol</th>
</tr>
</thead>
<tbody>
<tr>
<td>A $\text{CH}_4(g) + 2\text{O}_2(g) \rightarrow \text{CO}_2(g) + 2\text{H}_2\text{O}(g)$</td>
<td>$+891$</td>
</tr>
<tr>
<td>B $\text{CH}_4(g) + 2\text{O}_2(g) \rightarrow \text{CO}_2(g) + 2\text{H}_2\text{O}(g)$</td>
<td>$-891$</td>
</tr>
<tr>
<td>C $\text{CH}_4(g) + 2\text{O}_2(g) \rightarrow \text{CO}_2(g) + 2\text{H}_2\text{O}(g)$</td>
<td>$+891$</td>
</tr>
<tr>
<td>D $\text{CH}_4(g) + 2\text{O}_2(g) \rightarrow \text{CO}_2(g) + 2\text{H}_2\text{O}(g)$</td>
<td>$-891$</td>
</tr>
</tbody>
</table>
13 Which row describes an endothermic reaction?

<table>
<thead>
<tr>
<th></th>
<th>energy needed to break bonds/\text{kJ}</th>
<th>energy released by forming bonds/\text{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>

8.6.1 ESSENTIAL EXAM QUESTIONS Topic 6 Paper 2 31marks Mark Scheme

12 Hydrogen burns exothermically in oxygen.

The equation for the reaction is:

\[ \text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O} \]

The table shows the bond energies involved.

<table>
<thead>
<tr>
<th>Bond</th>
<th>Bond energy in \text{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 giver out during the reaction?

A. \(-3226 \text{kJ/mol}\)
B. \(-884 \text{kJ/mol}\)
C. \(-486 \text{kJ/mol}\)
D. \(-412 \text{kJ/mol}\)

15 Which substance could not be used as a fuel to heat water in a boiler?

A. ethanol
B. hydrogen
C. methane
D. oxygen
ESSENTIAL EXAM QUESTIONS T6 Paper 3/4 29 marks

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.

\[ \text{H—H} + \text{Cl—Cl} \rightarrow \text{H—Cl} + \text{H—Cl} \]

Bond energies in kJ/mol

<table>
<thead>
<tr>
<th>Bond</th>
<th>Energy in 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

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

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

Q# 2/IGCSE Chemistry/2011/s/Paper 31/ Q5

(d) 20.0 cm\(^3\) of aqueous sodium hydroxide, 2.00 mol/dm\(^3\), was placed in a beaker. The temperature of the alkali was measured and 1.0 cm\(^3\) portions of hydrochloric acid were added. After each addition, the temperature of the mixture was measured. Typical results are shown on the graph.

18.0 cm\(^3\) volume of acid added

\[ \text{NaOH(aq)} + \text{HCl(aq)} \rightarrow \text{NaCl(aq)} + \text{H}_2\text{O(l)} \]

(i) Explain why the temperature increases rapidly at first then stops increasing.
.................................................................................................................................................. [2]

(ii) Suggest why the temperature drops after the addition of 18.0 cm\(^3\) of acid.
.................................................................................................................................................. [1]

Q# 3/IGCSE Chemistry/2009/s/Paper 31/ Q7

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>Cl—Cl</td>
<td>+242</td>
</tr>
<tr>
<td>H—Cl</td>
<td>+431</td>
</tr>
</tbody>
</table>

Use the above data to show that the following reaction is exothermic.

\[ \text{H—H} + \text{Cl—Cl} \rightarrow \text{2H—Cl} \]
.................................................................................................................................................. [4]

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

.................................................................................................................................................. [5]
Q# 4/IGCSE Chemistry/2006/s/Paper 3/

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.

(ii) Explain, using the idea of bonds forming and breaking, why this reaction is exothermic, that is it produces heat energy.

Q# 5/IGCSE Chemistry/2005/w/Paper 3/ Q7

7 In 1909, Haber discovered the 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

(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>exothermic</td>
</tr>
<tr>
<td>3 moles of broken</td>
<td>+1308</td>
<td>exothermic</td>
</tr>
<tr>
<td>6 moles of N−H formed</td>
<td>-2328</td>
<td>exothermic</td>
</tr>
</tbody>
</table>

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?

(ii) The engine will run on a small pack of jet fuel. What other chemical is needed to burn this fuel?

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.

8.7.1 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

(c) bonds broken energy
    C-H   +412
    C=O   +242
    total energy +654

   bonds formed energy
    C-O   -338
    H=O   -431
    total energy -769
    energy change -115
    negative sign indicates exothermic
8.8 ESSENTIAL EXAM QUESTIONS Topic 6 Paper 6 75 marks

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.

**Q6** /GCSE Chemistry/2018/s/Paper 6/Q2

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>30</td>
<td>25</td>
</tr>
<tr>
<td>5.0</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>10.0</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>15.0</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>20.0</td>
<td>30</td>
<td>20</td>
</tr>
</tbody>
</table>

---

**Q7** /GCSE Chemistry/2003/s/Paper 3/Q5

1. **(a)**

(i) portable

(ii) oxygen or air

**Q8** /GCSE 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
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></td>
<td>20</td>
</tr>
<tr>
<td>5.0</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>10.0</td>
<td></td>
<td>35</td>
</tr>
<tr>
<td>15.0</td>
<td></td>
<td>40</td>
</tr>
<tr>
<td>20.0</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>25.0</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>30.0</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>35.0</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>40.0</td>
<td></td>
<td>30</td>
</tr>
</tbody>
</table>

(b) Plot the results for Experiment 1 on the grid and draw two intersecting straight line graphs.
Q# 3/IGCSE Chemistry/2018/J/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.
- 3g 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 4g of solid C.
- The procedure was repeated using 6g 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="image1" alt="Temperature Diagram" /></td>
<td>20</td>
<td><img src="image2" alt="Temperature Diagram" /></td>
<td>15</td>
<td>+5</td>
</tr>
<tr>
<td>4</td>
<td><img src="image3" alt="Temperature Diagram" /></td>
<td>20</td>
<td><img src="image4" alt="Temperature Diagram" /></td>
<td>15</td>
<td>+5</td>
</tr>
</tbody>
</table>

(g) (i) In Experiment 2, why was the burette rinsed with distilled water?

(ii) Why was the burette then rinsed with acid S?

(h) Describe one source of error in Experiment 2. Suggest an improvement to reduce this source of error.

- source of error: .................................................................................................................... [1]
- improvement: ............................................................................................................................ [2]

[Total: 17]

(e) (i) Use your graph to estimate the volume of acid S which must be added to neutralise 50 cm$^2$ of aqueous sodium hydroxide.

Show clearly on the grid how you worked out your answer.

(ii) Suggest how the volume in (e)(i) would differ if the experiment were repeated using 25 cm$^2$ instead of 50 cm$^2$ of aqueous sodium hydroxide.

Explain your answer.

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

(f) What type of energy change occurs when acid S reacts with aqueous sodium hydroxide?

- ................................................................................................................................................ [1]
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>30</td>
<td>25</td>
<td>30</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>30</td>
<td>25</td>
<td>30</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>30</td>
<td>30</td>
<td>25</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>30</td>
<td>35</td>
<td>30</td>
<td>30</td>
<td>20</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]
8.8.1 ESSENTIAL EXAM QUESTIONS Topic 6 Paper 6 75marks Mark Scheme

**Q# 2**/iGCSE Chemistry/2018/s/Paper 63/Q2

<table>
<thead>
<tr>
<th>(a)</th>
<th>all temperature boxes completed correctly:</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>21, 23, 25, 27, 29, 31, 33, 35, 37, 39</td>
<td></td>
</tr>
</tbody>
</table>

(b) | all points plotted correctly (cf a half a small square) | 1 |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>best fit intersecting straight line graphs</td>
<td></td>
</tr>
</tbody>
</table>

(c) | temperature boxes completed correctly: | 2 |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>21, 23, 25, 27, 29, 31, 33, 35, 37, 39</td>
<td></td>
</tr>
</tbody>
</table>

(d) | all points plotted correctly | 1 |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>best fit intersecting straight line graphs</td>
<td></td>
</tr>
</tbody>
</table>

(e) | value from graph where lines cross: 12 cm³ | 1 |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>shown clearly at intersection</td>
<td></td>
</tr>
</tbody>
</table>

(f) | half volume of liquid | 1 |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>less than half twice the volume of sodium hydroxide present</td>
<td></td>
</tr>
</tbody>
</table>

(g) | exothermic/heat given out | 1 |

(h) | to remove traces of acid/clean/remove impurities | 1 |

(i) | to remove traces of water | 1 |

(j) | source of error | 1 |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>using a measuring cylinder or heat losses</td>
<td></td>
</tr>
</tbody>
</table>

(k) | improvement | 1 |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>use a pipette</td>
<td></td>
</tr>
</tbody>
</table>

**Q# 3**/iGCSE Chemistry/2018/s/Paper 62/Q2

<table>
<thead>
<tr>
<th>(a)</th>
<th>final temperatures at 21°C</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>final temperatures at 17, 15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>temperature changes -3, -4, -6</td>
<td></td>
</tr>
</tbody>
</table>

(b) | final temperatures at 22, 21, 20°C | 1 |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>final temperatures at 26, 24, 22°C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>temperature changes 14, 12, 10</td>
<td></td>
</tr>
</tbody>
</table>

(c) | points plotted correctly (cf a half a small square) | 2 |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>best fit straight line graphs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>labels D (upper) and C (lower) or least 2.2 and 1.</td>
<td></td>
</tr>
</tbody>
</table>

(d) | value from graph, -8°C | 1 |
|----|------------------------|---|

(e) | exothermic | 1 |

(f) | room temperature / 21°C | 1 |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>heat lost to surroundings</td>
<td></td>
</tr>
</tbody>
</table>

(g) | half as much | 2 |

(h) | change in apparatus or method e.g. use a bobbin or use insulation/lead | 1 |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>explanation e.g. as more accurate/predictable, than a potentiometer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>reduce heat losses</td>
<td></td>
</tr>
</tbody>
</table>

(i) | repeat experiments | 1 |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>compare/average</td>
<td></td>
</tr>
</tbody>
</table>

**Q# 4**/iGCSE Chemistry/2017/w/Paper 63/

<table>
<thead>
<tr>
<th>(a)</th>
<th>temperature boxes completed: 33, 35, 37, 39, 41, 43, 45, 47, 49, 51</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>
</tbody>
</table>

(b) | temperature boxes completed correctly: 22, 24, 26, 28, 30, 32, 34, 36, 38, 40 | 2 |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></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>
</tbody>
</table>

(c) | all points plotted | 1 |

(d) | two smooth line graphs (join line graph correct = [1]) | 1 |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>both graphs appropriately labelled</td>
<td></td>
</tr>
</tbody>
</table>

(e) | value from graph | 1 |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>shown clearly</td>
<td></td>
</tr>
</tbody>
</table>

(f) | value from graph | 1 |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>shown clearly</td>
<td></td>
</tr>
</tbody>
</table>

(g) | room temperature / 22°C | 1 |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>reaction has finished, all the solid has dissolved</td>
<td></td>
</tr>
</tbody>
</table>

(h) | source of error | 4 |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>heat losses</td>
<td></td>
</tr>
</tbody>
</table>

(i) | improvement |   |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>use a lid/lag the apparatus</td>
<td></td>
</tr>
</tbody>
</table>

(j) | source of error |   |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>use a stopcock/hose</td>
<td></td>
</tr>
</tbody>
</table>

(k) | improvement |   |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>use a stopcock/hose</td>
<td></td>
</tr>
<tr>
<td></td>
<td>use wax/paraffin on the stopcock</td>
<td></td>
</tr>
<tr>
<td></td>
<td>this solid absorbs water from the air</td>
<td></td>
</tr>
<tr>
<td></td>
<td>store in a sealed container/airtight container/depot isolated</td>
<td></td>
</tr>
<tr>
<td></td>
<td>only done once</td>
<td></td>
</tr>
<tr>
<td></td>
<td>repeat and average</td>
<td></td>
</tr>
<tr>
<td></td>
<td>different masses of solids used/masses of solids not measured</td>
<td></td>
</tr>
</tbody>
</table>

(l) | use same mass of solid/weight the solids |   |

(m) | lower data less data/less data the graph not as good/not enough readings whilst the solid is reaching | 1 |
### 8.9 FUNDAMENTAL Assessed Activity 1 Keyword Test

<table>
<thead>
<tr>
<th>Topic</th>
<th>English</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>998</td>
<td>exothermic change</td>
<td>a process or chemical reaction in which heat energy is produced and released to the surroundings; ΔH has a negative value</td>
</tr>
<tr>
<td>842</td>
<td>activation energy</td>
<td>[E_A] 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>
</tr>
<tr>
<td>776</td>
<td>burning</td>
<td>burning is a combustion reaction which produces a flame</td>
</tr>
<tr>
<td>700</td>
<td>combustion</td>
<td>a chemical reaction in which a substance reacts with oxygen – the reaction is exothermic; the reaction is exothermic;</td>
</tr>
<tr>
<td>664</td>
<td>fuel cells</td>
<td>fuel cells are electrolytic cells capable of providing a continuous supply of electricity without recharging</td>
</tr>
<tr>
<td>642</td>
<td>kinetic (particle) theory</td>
<td>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>
</tr>
<tr>
<td>621</td>
<td>fuel cell</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>
</tr>
<tr>
<td>592</td>
<td>collision theory</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>
</tr>
<tr>
<td>530</td>
<td>endothermic change</td>
<td>a process or chemical reaction which takes in heat from the surroundings; ΔH has a positive value</td>
</tr>
<tr>
<td>434</td>
<td>bond energy</td>
<td>bond energy the energy required to break a particular type of covalent bond</td>
</tr>
<tr>
<td>307</td>
<td>catalyst</td>
<td>catalyst a substance which increases the rate of a chemical reaction but itself remains unchanged at the end of the reaction</td>
</tr>
<tr>
<td>183</td>
<td>heat of combustion</td>
<td>heat of combustion</td>
</tr>
<tr>
<td>133</td>
<td>heat of reaction</td>
<td>heat of reaction</td>
</tr>
</tbody>
</table>

### 8.10 ESSENTIAL Assessed Activity 2 Topic 6 Paper 2 14 marks

**Q# 1/**

12 Ethene burns in oxygen to form carbon dioxide and water vapour.

\[
\text{H}_2\text{C} = \text{C} + 3\text{O} = \text{O} \rightarrow 2\text{H}_2\text{O} + 2\text{H}_2\text{O} \]

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>O=C</td>
<td>+905</td>
</tr>
<tr>
<td>O-H</td>
<td>+460</td>
</tr>
</tbody>
</table>

What is the energy change for the reaction?

A \(-2959\) kJ/mol  
B \(-2313\) kJ/mol  
C \(-1319\) kJ/mol  
D \(-399\) kJ/mol

**Q# 2/**

12 Hydrogen peroxide, \(\text{H}_2\text{O} = \text{O} = \text{H}\), decomposes to form water and oxygen.

\[2\text{H}_2\text{O}_2(g) \rightarrow 2\text{H}_2\text{O}(g) + \text{O}_2(g)\]

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 \(-346\) kJ/mol  
B \(-196\) kJ/mol  
C \(+196\) kJ/mol  
D \(+346\) kJ/mol
Q# 3/

12 Methane burns in an excess of oxygen. The equation is shown.

\[ \text{CH}_4(g) + 2\text{O}_2(g) \rightarrow \text{CO}_2(g) + 2\text{H}_2\text{O}(g) \]

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>C=O</td>
<td>+498</td>
</tr>
</tbody>
</table>

What is the energy change for the reaction?

A. +818 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. +502 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?

A. C
B. D
C. A
D. B

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 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=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 -500 kJ/mol  B -124 kJ/mol  C +486 kJ/mol  D +5496 kJ/mol

Q#7/

13 The equation for the complete combustion of methane is shown.

\[ \text{CH}_4(g) + 2\text{O}_2(g) \rightarrow \text{CO}_2(g) + 2\text{H}_2\text{O}(g) \]

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>+466</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#6/

12 Which diagram is a correctly labelled energy level diagram for an endothermic reaction?

A  

B  

A endothermic  B endothermic  C exothermic  D exothermic

<table>
<thead>
<tr>
<th>type of energy change</th>
<th>explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A endothermic</td>
<td>less energy is released making bonds than is absorbed to break bonds</td>
</tr>
<tr>
<td>B endothermic</td>
<td>more energy is released making bonds than is absorbed to break bonds</td>
</tr>
<tr>
<td>C exothermic</td>
<td>less energy is released making bonds than is absorbed to break bonds</td>
</tr>
<tr>
<td>D 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 +203 kJ/mol  B +103 kJ/mol  C -103 kJ/mol  D -263 kJ/mol

8.11 Essential Assessed Activity 3 Topic 6 Paper 6 19 marks

Q#1/2

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, 5 g 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>
</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>
</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>
</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.

(ii) Compare the rates of reaction in Experiments 1 and 3. Explain why the rates of reaction are different.

(g) Predict the temperature of the mixture in Experiment 2 after 2 hours. Explain your answer.

(h) When doing the experiments, what would be the advantage of taking the temperature readings every 15 seconds?

(i) Explain why a copper can should not be used in place of the polystyrene cup in these experiments.

[Total: 19]
8.12  EXCEPTIONAL Assessed Activity 4 T6 13marks

10. Bond enthalpies and average bond enthalpies at 298 K

<table>
<thead>
<tr>
<th>Bond</th>
<th>$\Delta H / \text{kJ mol}^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>H–H</td>
<td>436</td>
</tr>
<tr>
<td>C–C</td>
<td>347</td>
</tr>
<tr>
<td>C≡C</td>
<td>612</td>
</tr>
<tr>
<td>N–N</td>
<td>838</td>
</tr>
<tr>
<td>Si–Si</td>
<td>565</td>
</tr>
<tr>
<td>C–Si</td>
<td>226</td>
</tr>
<tr>
<td>Si–N</td>
<td>158</td>
</tr>
<tr>
<td>N–N</td>
<td>410</td>
</tr>
<tr>
<td>N≡N</td>
<td>945</td>
</tr>
<tr>
<td>P–P</td>
<td>158</td>
</tr>
<tr>
<td>O–O</td>
<td>144</td>
</tr>
<tr>
<td>O=O</td>
<td>458</td>
</tr>
<tr>
<td>S–S</td>
<td>266</td>
</tr>
<tr>
<td>F–F</td>
<td>138</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bond</th>
<th>$\Delta H / \text{kJ mol}^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>C–H</td>
<td>413</td>
</tr>
<tr>
<td>Si–H</td>
<td>318</td>
</tr>
<tr>
<td>N–H</td>
<td>391</td>
</tr>
<tr>
<td>P–H</td>
<td>321</td>
</tr>
<tr>
<td>O–H</td>
<td>464</td>
</tr>
<tr>
<td>S–H</td>
<td>364</td>
</tr>
<tr>
<td>F–H</td>
<td>568</td>
</tr>
<tr>
<td>Cl–H</td>
<td>432</td>
</tr>
<tr>
<td>Br–H</td>
<td>366</td>
</tr>
<tr>
<td>I–H</td>
<td>298</td>
</tr>
<tr>
<td>C–O</td>
<td>358</td>
</tr>
<tr>
<td>C–O</td>
<td>746</td>
</tr>
<tr>
<td>C–N</td>
<td>286</td>
</tr>
</tbody>
</table>

11. One important property of a rocket fuel mixture is the large volume of gaseous products formed which provide thrust. Hydrazine, $\text{N}_2\text{H}_4$, is often used as a rocket fuel. The combustion of hydrazine is represented by the equation below.

$$\text{N}_2\text{H}_4(g) + \text{O}_2(g) \rightarrow \text{N}_2(g) + 2\text{H}_2\text{O}(g) \quad \Delta H^\circ = -585 \text{ kJ mol}^{-1}$$

Hydrazine:

(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.

(c) 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. $\text{HCl}(g) \rightarrow \text{H}^+(g) + \text{Cl}^-(g)$
   B. $\text{HCl}(g) \rightarrow \text{H}(g) + \text{Cl}(g)$
   C. $\text{HCl}(g) \rightarrow \frac{1}{2} \text{H}_2(g) + \frac{1}{2} \text{Cl}_2(g)$
   D. $2\text{HCl}(g) \rightarrow \text{H}_2(g) + \text{Cl}_2(g)$

14. Which process represents the C–Cl bond enthalpy in tetrachloromethane?
   A. $\text{CCl}_4(g) \rightarrow \text{C}(g) + 4\text{Cl}(g)$
   B. $\text{CCl}_4(g) \rightarrow \text{CCl}_3(g) + \text{Cl}(g)$
   C. $\text{CCl}_4(l) \rightarrow \text{C}(g) + 4\text{Cl}(g)$
   D. $\text{CCl}_4(l) \rightarrow \text{C}(s) + 2\text{Cl}_2(g)$

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.

16. When some solid barium hydroxide and solid ammonium thiosulfate were reacted together, the temperature of the surroundings was observed to decrease from 15 $^\circ$C to $–4$ $^\circ$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.
8.13 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 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?

8.14 Exceptional Additional Activities, Further Reading and Exploring Beyond the Syllabus

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?
**EXCEPTIONAL EXAM QUESTIONS T6 From IB SL 31 marks**

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 to answer these questions, but most A* level students probably wouldn't be able to answer them all.

### 10. Bond enthalpies and average bond enthalpies at 298 K

<table>
<thead>
<tr>
<th>Bond</th>
<th>( \Delta H ) / kJ mol(^{-1} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>H–H</td>
<td>436</td>
</tr>
<tr>
<td>C–C</td>
<td>347</td>
</tr>
<tr>
<td>C–C</td>
<td>612</td>
</tr>
<tr>
<td>C–C</td>
<td>838</td>
</tr>
<tr>
<td>C=C (benzene)</td>
<td>555</td>
</tr>
<tr>
<td>Si–Si</td>
<td>226</td>
</tr>
<tr>
<td>N–N</td>
<td>158</td>
</tr>
<tr>
<td>N–N</td>
<td>410</td>
</tr>
<tr>
<td>N2N</td>
<td>945</td>
</tr>
<tr>
<td>P–P</td>
<td>158</td>
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<td>O–O</td>
<td>144</td>
</tr>
<tr>
<td>O=O</td>
<td>458</td>
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<td>S–S</td>
<td>266</td>
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<td>F–F</td>
<td>158</td>
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<tr>
<td>Cl–Cl</td>
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<td>Br–Br</td>
<td>192</td>
</tr>
<tr>
<td>I–I</td>
<td>151</td>
</tr>
</tbody>
</table>

### 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. \( \text{HBr}(g) \rightarrow \text{H}(g) + \text{Br}(g) \)
- B. \( \text{HBr}(g) \rightarrow \text{H}(g) + \text{Br}(l) \)
- C. \( \text{HBr}(g) \rightarrow \text{H}(g) + \frac{1}{2} \text{Br}_2(1) \)
- D. \( \text{HBr}(g) \rightarrow \text{H}(g) + \frac{1}{2} \text{Br}_2(g) \)

(Total 1 mark)

### 5. Which is correct about energy changes during bond breaking and bond formation?
- A. Bond breaking is endothermic and requires energy.
- B. Bond breaking is exothermic and releases energy.
- C. Bond making is endothermic and requires energy.
- D. Bond making is exothermic and releases energy.

(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?
- A. endothermic and \( \Delta H \) positive
- B. exothermic and \( \Delta H \) negative

(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.

(Total 1 mark)
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.

(Total 1 mark)

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.

\[ \text{C}_4\text{H}_8(g) + 6\text{O}_2(g) \rightarrow 4\text{CO}_2(g) + 4\text{H}_2\text{O}(g) \]

(c) 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.

\[ \text{C}_4\text{H}_8(g) + 6\text{O}_2(g) \rightarrow 4\text{CO}_2(g) + 4\text{H}_2\text{O}(g) \]

(3 marks)

10. Two students were asked to use information from the Data Booklet to calculate a value for the enthalpy of hydrogenation of ethene to form ethane.

\[ \text{C}_2\text{H}_4(g) + \text{H}_2(g) \rightarrow \text{C}_2\text{H}_6(g) \]

John used the average bond enthalpies from Table 10. Marit used the values of enthalpies of combustion from Table 12.

(a) Calculate the value for the enthalpy of hydrogenation of ethene obtained using the average bond enthalpies given in Table 10.

(2 marks)

(b) John then decided to determine the enthalpy of hydrogenation of cyclohexene to produce cyclohexane.

\[ \text{C}_6\text{H}_{10}(l) + \text{H}_2(g) \rightarrow \text{C}_6\text{H}_{12}(l) \]

(i) Use the average bond enthalpies to deduce a value for the enthalpy of hydrogenation of cyclohexene.

(1 mark)

(8.16.1) EXCEPTIONAL EXAM QUESTIONS T6 From IB SL 31 marks 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);

(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.

\[ \Delta H = (612 + 436) - (347 + 826) = 1048 - 1173 = -125 \text{ (kJ mol}^{-1}\text{)}; \]

Award \[2\] for correct final answer.

If old Data Booklet values then allow:

\[ \Delta H = 1048 - 1172 = -124 \text{ (kJ mol}^{-1}\text{)} \]

2. Award \[1\] for +125.

(iii) 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

\[ (6 \times 12) + (2 \times 348) + (8 \times 412) + (6 \times 496) / 7580 \text{ (kJ mol}^{-1}\text{)}; \]

Bonds made

\[ (8 \times 743) + (8 \times 463) / 9648 \text{ (kJ mol}^{-1}\text{)}; \]

\[ \Delta H = -2068 \text{ (kJ mol}^{-1}\text{)}; \]

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 \(\Delta H\).

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);

\[ \Delta H = (1048 - 1173) / (2700 - 2825) = -125 \text{ kJ mol}^{-1}; \]

2

(d) (i) –125 kJ mol\(^{-1}\);
## 9.1 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 others, 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>FUNDAMENTAL</td>
<td></td>
</tr>
<tr>
<td>Notes and follow up notes</td>
<td>Complete set of class notes</td>
<td>ESSENTIAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Attempted</td>
<td>ESSENTIAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Completed</td>
<td>EXTENSION</td>
<td></td>
</tr>
<tr>
<td>Textbook</td>
<td>Read ahead before the topic has been started</td>
<td>EXTENSION</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Highlighted key ideas and translate new words</td>
<td>FUNDAMENTAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Completed the Mind Map for this topic</td>
<td>ESSENTIAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Added to your class notes ideas and important information from the textbook that you learnt</td>
<td>EXTENSION</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>FUNDAMENTAL</td>
<td></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>ESSENTIAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Completed and marked all questions here</td>
<td>EXTENSION</td>
<td></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>EXCEPTIONAL</td>
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</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>EXCEPTIONAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ask your teacher about an exam question that they cannot answer</td>
<td>EXCEPTIONALLY SMASHING!!!</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>FUNDAMENTAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Completed 2 assessed activities, either in class or as homework</td>
<td>ESSENTIAL</td>
<td></td>
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<tr>
<td></td>
<td>Completed 2 assessed activities and scored over 70% on average</td>
<td>ESSENTIAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Completed 2 assessed activities and scored over 80% on average</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 90% on average</td>
<td>ESSENTIAL</td>
<td></td>
</tr>
<tr>
<td></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>
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<td></td>
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<td></td>
<td>Scored 90% or more than your current average</td>
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<td>Scored 5% or more than your previous end of topic average</td>
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<td></td>
<td>Scored over 90%</td>
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<tr>
<td></td>
<td>Scored over 95%</td>
<td>SMASHING!!!</td>
<td></td>
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</tbody>
</table>

## 9.2 Topic 7.1 and 7.2 Syllabus

### 7.1 Physical and chemical changes

- Identify physical and chemical changes, and understand the differences between them

### 7.2 Rate (speed) of reaction

- 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

- 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.)
- Discuss 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.)
- Discuss 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
<table>
<thead>
<tr>
<th>English</th>
<th>Chinese</th>
</tr>
</thead>
<tbody>
<tr>
<td>enzymes</td>
<td>酶/酶分子</td>
</tr>
<tr>
<td>protein molecules that act as biological catalysts</td>
<td>作为生物催化剂的蛋白质分子</td>
</tr>
</tbody>
</table>

**Glossary for Keywords for Topic 7.1 & 7.2**

**Enzymes**
protein molecules that act as biological catalysts.

**Photochemical Reaction**
a chemical reaction that occurs when light, usually of a particular wavelength, falls on the reactants.

**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.

**Denature**
If an enzyme is placed in an extreme environment, e.g. too acidic or alkali, too hot or is physically damaged by motion (like shaking) will no longer be able to function. Usually this change is permanent.

**Reaction Rate**
a measure of how fast a reaction takes place in a reaction.

**Speed of Reaction**
a less accurate name for reaction rate.

---

**Extension Keywords**

**Reaction from Paper 6 3.6 marks**

1. **Q# 1**
   - A measuring cylinder was used to add 10 cm³ of solution S and 10 cm³ of sodium thiosulfate solution to a conical flask. 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 mixture. The final temperature of the mixture was measured and recorded.
   - The conical flask was emptied and rinsed with distilled water.

2. **Q# 2**
   - A measuring cylinder was used to add 10 cm³ of solution S and 10 cm³ of sodium thiosulfate solution to a conical flask. 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 mixture. The final temperature of the mixture was measured and recorded.
   - The conical flask was emptied and rinsed with distilled water.
(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></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>31</td>
<td>29</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>41</td>
<td>37</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>51</td>
<td>45</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(b) Plot the results for Experiments 1–4 on the grid. Draw a smooth line graph.

- [Graph Image]

(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 ................................................................................................................

............................................................................................................................................................ [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]

Q12 /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)

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.

<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></td>
<td>-87</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>-87</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>-87</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>-87</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>-87</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>-87</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>-87</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>-87</td>
<td>0</td>
</tr>
</tbody>
</table>

[3]
(b) Plot the results on the grid. Draw a smooth line graph.

(e) (i) Why does the mass of the conical flask and its contents decrease?

(ii) Suggest the purpose of the cotton wool.

(iii) Why does the graph level off? Explain your answer.

(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.

Makr Scheme For Drawing Graphs Active Learning Exercise

Q# 1/ iGCSE Chemistry/2018/w/Paper 63/Q2

Q#2/ iGCSE Chemistry/2018/w/Paper 61/Q2

(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.
9.6 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

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]

Q# 2/IGCSE Chemistry/2018/w/Paper 42/Q4

(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. [3]

Q# 3/IGCSE Chemistry/2018/w/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.

Q# 4/ IGCSE Chemistry/2017/w/Paper 41/

7 Copper(II) oxide reacts with dilute hydrochloric acid.

\[ \text{CuO(s) } + \text{2HCl(aq)} \rightarrow \text{CuCl}_2(aq) + \text{H}_2\text{O(l)} \]

6.00 g of copper(II) oxide were added to 50.0 cm\(^3\) of 1.00 mol/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# 5/ IGCSE Chemistry/2017/s/Paper 41/

8 Magnesium carbonate reacts with dilute hydrochloric acid.

\[ \text{MgCO}_3(s) + \text{2HCl(aq)} \rightarrow \text{MgCl}_2(aq) + \text{H}_2\text{O(l)} + \text{CO}_2(g) \]

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 30 seconds.
(a) The results obtained are shown on the graph.

![Graph showing total volume of gas collected against time (s).]

(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.

(b) A piece of magnesium ribbon was cleaned. The experiment was repeated using this clean magnesium ribbon instead of magnesium carbonate.

\[
\text{Mg}(s) + 2\text{HCl}(aq) \rightarrow \text{MgCl}_2(aq) + \text{H}_2(g)
\]

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.

\[
\text{Na}_2\text{S}_2\text{O}_3(aq) + 2\text{HCl}(aq) \rightarrow \text{S}(s) + 2\text{NaCl}(aq) + \text{H}_2\text{O}(l) + \text{SO}_2(g)
\]

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>10</td>
<td>10</td>
<td>40</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.

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/

(a) M1 volume of gas
M2 time

(b) M1 rate decreases / reaction rate slower
M2 concentration of acid decreases
M3 fewer collisions per unit time

Q# 2/IGCSE Chemistry/2018/w/Paper 42/

(c) M1 Time taken is less
M2 (particles) have more energy
M3 (particles) move faster
M4 More collisions (of particles) occur per second / per unit time
M5 More of the particles / collisions have energy greater than activation energy
M6 More (of the) particles / collisions have sufficient energy to react
M7 A greater percentage / proportion / fraction of collisions (of particles) are successful

Q# 3/IGCSE Chemistry/2018/s/Paper 43/

(a) (i) M1 (particles) have more energy / (particles) move faster
M2 more collisions per second / greater collision rate
M3 more of the colliding molecules have sufficient energy (activation energy) to react

Q# 4/IGCSE Chemistry/2017/w/Paper 41/

(a) M1 more particles of acid in a given volume / dm³ / cm³
M2 more collisions per second / unit time / greater collision rate

Q# 5/IGCSE Chemistry/2017/s/Paper 41/

(a) M1 curve starts from (G,0) and has a lower gradient than the original curve
M2 because dips have a lower surface area

(b) M1 curve starts from (G,0) and has a lower gradient than the original curve
M2 because dips have a lower surface area
9.7 ESSENTIAL EXAM QUESTIONS Paper 2 Topic 7.1 & 7.2 12marks

Q8  / IGCSE Chemistry/2016/w/Paper 41/

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

Q14  / IGCSE Chemistry/2018/w/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 collisions with sufficient energy to react</td>
<td>more collisions per second and more collisions with sufficient energy to react</td>
</tr>
<tr>
<td>C</td>
<td>more collisions per second only</td>
<td>more collisions per second and more collisions with sufficient energy to react</td>
</tr>
<tr>
<td>D</td>
<td>more collisions per second and more collisions with sufficient energy to react</td>
<td>more collisions per second and more collisions with sufficient energy to react</td>
</tr>
</tbody>
</table>

Q7  / IGCSE Chemistry/2016/w/Paper 41/

1. More particles per unit volume/particles are closer together.
2. The rate of collisions/there are more collisions per unit time.

Q14  / IGCSE Chemistry/2018/w/Paper 22/

14 The rate of reaction between magnesium ribbon and 2 mol/dm² 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?

<table>
<thead>
<tr>
<th></th>
<th>1 mol/dm² hydrochloric acid at 25°C</th>
<th>2 mol/dm² hydrochloric acid at 10°C</th>
<th>2 mol/dm² hydrochloric acid at 20°C</th>
<th>3 mol/dm² hydrochloric acid at 25°C</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# 6/ GCSE Chemistry/2017/s/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/ GCSE 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/ GCSE 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/ GCSE 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/ GCSE 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/ GCSE Chemistry/2017/w/Paper 21/
14 When sulfur is heated it undergoes a ...... change as it melts.

Further heating causes the sulfur to undergo a ...... 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>
9.8 ESSENTIAL QUESTIONS Paper 3/4 T7.1 & 7.2 139 marks

Q# 1/ IGCSE Chemistry/2015/5/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.

![Diagram of paper sections covered with silver bromide]

Predict the appearance of the different sections of the paper after exposure to the light and the removal of the card. Explain your predictions.

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

(ii) Name the substance which is responsible for the colour in green plants and is essential for photosynthesis.
............................................................................................................................................................................................ [1]

Q# 2/ IGCSE Chemistry/2015/s/Paper 31/
3 (a) The reactions between metals and acids are redox reactions.

\[ \text{Zn} + 2\text{H}^+ \rightarrow \text{Zn}^{2+} + \text{H}_2 \]
Q3/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.

40 cm$^3$ 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.

(a) (i) How do the rates at times $t_1$, $t_2$ and $t_3$ differ?

(ii) Explain the trend in reaction rate that you described in (a)(i).

(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.

(ii) Explain the shape of this graph.

(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.

---

Q4/IGCSE Chemistry/2013/w/Paper 31/
4 20.0 g of small lumps of calcium carbonate and 40 cm$^3$ of hydrochloric acid, concentration 2.0 mol/dm$^3$, 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.
CaCO₃(s) + 2HCl(aq) → CaCl₂(aq) + H₂O(l) + CO₂(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.

(ii) Label the graph F where the reaction rate is the fastest, S where it is slowing down and O where the rate is zero.

(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.

(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 cm³ of hydrochloric acid, concentration 1.0 mol/dm³, had been used.

(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 cm³ of hydrochloric acid, concentration 2.0 mol/dm³, were used.

(ii) The reaction rate would be faster if the experiment was carried out at a higher temperature.

Q# 5 / 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>
<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.

(ii) How would you know when the reaction had stopped?

(c) (i) Explain why the reaction in experiment 1 is faster than the reaction in experiment 2.

(ii) Explain in terms of collisions between reacting particles why experiment 4 is slower than experiment 1.
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.

\[ \text{CC(g)} + \text{Cl}_2(g) \rightarrow \text{COCl}_2(g) \]

(i) Explain the phrase photochemical reaction.

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

(ii) Give another example of a photochemical reaction and explain why it is important either to the environment or in industry.

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

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.

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

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.

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

(ii) Reactions involving enzymes do not follow the above pattern. The following graph shows how the speed of such a reaction varies with temperature.

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

(b) An organic compound decomposes to give off nitrogen.

\[ \text{C}_4\text{H}_6\text{NCl(aq)} \rightarrow \text{C}_2\text{H}_2\text{Cl}(l) + \text{N}_2(g) \]

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.

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

(i) The reaction is catalysed by copper. Sketch the graph for the catalysed reaction on the diagram above.

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

(ii) How does the speed of this reaction vary with time?

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

(iii) Why does the speed of reaction vary with time?

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

Q# 9/IGCSE Chemistry/2011/w/Paper 31/
5 The rate of the reaction between iron and aqueous bromine can be investigated using the apparatus shown below.

........................................................................................................................................... [2]
Q# 10/ iGCSE Chemistry/2010/s/Paper 31/ Q4

(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.

\[ \text{mass of iron} \]
\[ \text{time (iron was in solution of bromine)} \]

(i) Suggest an explanation for the shape of the graph.

(ii) Predict the shape of the graph if a similar piece of iron with a much rougher surface had been used. Explain your answer.

(iii) Describe how you could find out if the rate of this reaction depended on the speed of stirring.

Q# 11/ iGCSE Chemistry/2008/s/Paper 31/ Q6

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} black
Q12/ GCSE Chemistry/2007/Je/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.

CaCO₃(s) + 2HCl(aq) → CaCl₂(aq) + CO₂(g) + H₂O(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>

(b) Explain the results.

(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

![Graph](image-url)
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.

(b) Reaction rate increases when concentration or temperature is increased. Using the idea of reacting particles, explain why:

(i) increasing concentration increases reaction rate, [2]

(ii) 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]
Q# 14/ iGCSE Chemistry/2005/s/Paper 3/

2 The following apparatus was used to measure the rate of the reaction between zinc and iodine.

![Apparatus Diagram]

- 100 cm³ of aqueous iodine, 0.1 mol/dm³ at 25 °C
- mixture stirred by magnetic stirrer

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.

![Graphs]

(i) Which reagent iodine or zinc was in excess? Give a reason for your choice.

(ii) Describe how the shape of graph 1 would change if 100 cm³ of 0.05 mol/dm³ iodine had been used.

(iii) On graph 2, sketch the shape if the reaction had been carried out using 100 cm³ of 0.1 mol/dm³ iodine at 35 °C instead of at 25 °C.

Q# 15/ iGCSE Chemistry/2004/w/Paper 3/ QGCSE Chemistry/201

(d) The rate of photosynthesis of pond weed can be measured using the following experiment.

![Photosynthesis Apparatus]

(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.

![Reaction Apparatus]

- nitrogen gas
- solution of organic compound
The results of this experiment are shown on the graph below.

The graph shows the relationship between the volume of nitrogen and time. As time increases, the volume of nitrogen also increases.

Q# 17/ IGCSE Chemistry/2003/w/Paper 3/

9.8.1 ESSENTIAL EXAM QUESTIONS Paper 3/4 T7.1 & T7.2 139 marks

(i) Complete the table (assume the rate is proportional to both the acid concentration and the number of pieces of calcium carbonate).

<table>
<thead>
<tr>
<th>Concentration of acid/m\text{mol/L}</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>80</td>
<td>...</td>
<td>160</td>
<td></td>
</tr>
</tbody>
</table>

(ii) Explain why the reaction rate would increase if the temperature was increased.

(iii) Explain why the rate of this reaction increases if the piece of carbonate is crushed to a powder.

(iv) Fine powders mixed with air can explode violently. Name an industrial process where there is a risk of this type of explosion.

(b) Sodium chloride(l) 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:

\[ 2\text{NaCl(aq)} \rightarrow 2\text{NaCl(aq)} + \text{O}_2(g) \]

(i) Describe how the rate of this reaction could be measured.

(ii) How could you show that this reaction is photochemical?
Q# 2/IGCSE Chemistry/2015/s/Paper 31/

3(iii) zinc displaces copper or zinc more reactive than copper;

\[ \text{Zn} + \text{Cu}^{2+} \rightarrow \text{Zn}^{2+} + \text{Cu} \]

OR \[ \text{Zn} + \text{Cu}^{2+} \rightarrow \text{Zn}^{2+} + \text{Cu} \]

A copper less reactive than zinc;

Electrolysis with copper ions or with Cu^{2+} or with copper dichromate;

Electrolysis with copper

[1] H^+ ions are reduced

[2] A multistep process

A less time to complete the reaction; same amount of gas in less time/ faster motion/ more gas in the same time period

[1] A same volume of hydrogen produced. At room temperature

[1] A no extra gas is made

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

6 (a) (i) rate at t₂ less than at t₁ or the rate decreases (1)

\[ \text{rate at t₂ } \text{ zero/reaction stopped} \]

[1] (ii) rate at t₂ less than at t₁ because concentration of hydrogen peroxide is less at t₂ or concentration of hydrogen peroxide is decreasing. (1)

\[ \text{rate at t₂ } \text{ zero/reaction stopped because} \]

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

equiv for M₁ for a shallower curve because of slower rate.

[2]

(c) filter (and rinse/wash) (1)

dry manganese (IV) oxide (1)

weigh/measure mass manganese(IV) oxide after reaction (1)

the mass should be 0.1 g or un Changed. (1)

Q# 4/IGCSE Chemistry/2013/w/Paper 31/

4 (a) (i) (mass at m₀) (mass at t = 5)

note: must have mass at t = 5 not final mass

(ii) fastest at origin

slowing down between origin and flat section gradient = 0

where gradient = 0

three of above in the approximately 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]
Q8/ 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;  

Q9/ 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;  
final 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 

Q10/ iGCSE Chemistry/2010/s/Paper 3/  
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 add)  
any two  
not concentration / light / catalyst / pressure 

Q11/ iGCSE Chemistry/2008/s/Paper 3/  
6 (a) (i) (fine powder) large surface area  
high / fast 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 

Q12/ iGCSE Chemistry/2007/w/Paper 3/  
7 (a) (i) lower concentration  
ACCEPT without reference to experiment 2  
but higher concentration must be referred to expk 1  
COND fewer collisions or lower rate of collision 

(ii) powdered so large / larger surface area  
COND so more collisions or higher rate of collision 

(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) four / origin  
greatest decreases until ≠ 0  
therefore has to be a curve 

Q13/ iGCSE Chemistry/2006/s/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  
oxyn  
(ii) chlorophyll [2]
Q# 14/ iGCSE Chemistry/2005/w/Paper 3/ Q2

(c) (i) zinc and a reason
Do not mark consent 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 extinguished
Must have glowing or equivalent idea
OR any similar description that includes the two points glowing and needles.

(ii) measure volume or count bubbles
time
NOT units

(iii) rate slows down
Because the reaction is photochemical or rate depends on intensity of light
or light loss bright or less light falling on plant or light provides energy or photosynthesis etc.

Q# 16/ iGCSE Chemistry/2004/w/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/ Q2

2 (a) (i) 40 [1]
80 or 40 [1]
1 [1]

(ii) particles have more energy or moving faster
or collide more frequently
collide with more energy

(iii) greater surface area

(iv) flour mills or coal mines or metal powders
fireworks or gunpowder

(b) (i) collect and measure volume of oxygen
or mass or count bubbles

(ii) measure rate in different light levels and comment
accept if dark so reaction

2. 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. 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 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></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>7</td>
<td></td>
<td></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.

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

[Total: 18]

Q# 2/IGCSE Chemistry/2018/s/Paper 61/Q2

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 cm³ of aqueous sodium thiosulfate into a 250 cm³ conical flask. The conical flask was placed on a printed sheet of paper.
- 10 cm³ 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 cm³ of aqueous sodium thiosulfate into a conical flask, followed by 10 cm³ of distilled water. The conical flask was placed on the printed sheet of paper.
- 10 cm³ 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 cm³ of aqueous sodium thiosulfate and 15 cm³ of distilled water.

Experiment 4

- Experiment 2 was repeated but using 30 cm³ of aqueous sodium thiosulfate and 20 cm³ of distilled water.

Experiment 5

- Experiment 2 was repeated but using 10 cm³ of aqueous sodium thiosulfate and 40 cm³ 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></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>35</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td></td>
<td></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.
(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.

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

........................................................................................................................................... [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 cm³ conical flask instead of a 250 cm³ 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.

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

[Total: 16]

Q# 3/IGCSE Chemistry/2017/w/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 carried out using the apparatus shown.

![Diagram of apparatus](image)

**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>
<td>30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>42</td>
<td>40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>54</td>
<td>52</td>
<td></td>
<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.

(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.
Q#4/IGCSE Chemistry/2017/Paper 63/Q2

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>Experiment 1</th>
<th>Volume of gas (cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>40</td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>60</td>
<td></td>
<td>21</td>
</tr>
<tr>
<td>80</td>
<td></td>
<td>27</td>
</tr>
<tr>
<td>100</td>
<td></td>
<td>33</td>
</tr>
<tr>
<td>120</td>
<td></td>
<td>39</td>
</tr>
<tr>
<td>140</td>
<td></td>
<td>45</td>
</tr>
<tr>
<td>160</td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>180</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]
Q#5/IGCSE Chemistry/2017/s/Paper 62/Q2

2 A student investigated the reaction between aqueous potassium permanganate(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>
</tr>
</thead>
<tbody>
<tr>
<td>initial burette reading/cm³</td>
</tr>
<tr>
<td>difference/cm³</td>
</tr>
</tbody>
</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>initial reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>final reading</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>final burette reading/cm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>initial burette reading/cm³</td>
</tr>
<tr>
<td>difference/cm³</td>
</tr>
</tbody>
</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 ...........................................................................................................................................[2]

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

(f) Give one advantage and one disadvantage of using a measuring cylinder instead of a 25 cm³ pipette for solution B.

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

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

(g) How would the results be improved by taking repeated measurements?

...........................................................................................................................................[1]
Q# 6/IGCSE Chemistry/2017/w/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 iodate 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>37</th>
</tr>
</thead>
<tbody>
<tr>
<td>initial burette reading/cm³</td>
<td>39</td>
</tr>
<tr>
<td>difference/cm³</td>
<td></td>
</tr>
</tbody>
</table>

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>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>initial burette reading/cm³</td>
<td>21</td>
</tr>
<tr>
<td>difference/cm³</td>
<td></td>
</tr>
</tbody>
</table>

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 cm³ 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 25 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></td>
<td>30</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>120</td>
<td></td>
<td></td>
</tr>
<tr>
<td>140</td>
<td></td>
<td></td>
</tr>
<tr>
<td>160</td>
<td></td>
<td></td>
</tr>
<tr>
<td>180</td>
<td></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?

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

(ii) Suggest a possible reason for this anomalous result.

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

(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.

........................................... cm³ [2]
Q7 8/1GCSE Chemistry/2016/s/Paper 62/Q2

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, 8 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.

(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.

................................................................................................................................. [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]
<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 Image" /></td>
<td><img src="image" alt="Time Image" /></td>
</tr>
<tr>
<td>1.0</td>
<td><img src="image" alt="Timer Image" /></td>
<td><img src="image" alt="Time Image" /></td>
</tr>
<tr>
<td>1.5</td>
<td><img src="image" alt="Timer Image" /></td>
<td><img src="image" alt="Time Image" /></td>
</tr>
<tr>
<td>2.0</td>
<td><img src="image" alt="Timer Image" /></td>
<td><img src="image" alt="Time Image" /></td>
</tr>
<tr>
<td>2.5</td>
<td><img src="image" alt="Timer Image" /></td>
<td><img src="image" alt="Time Image" /></td>
</tr>
<tr>
<td>3.0</td>
<td><img src="image" alt="Timer Image" /></td>
<td><img src="image" alt="Time Image" /></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 40 cm³ 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.

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

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

(f) Explain one disadvantage of using a beaker instead of a conical flask.

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

Q9/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\(^2\) of distilled water and 40 cm\(^2\) 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="image1" alt="Stop-clock 1" /></td>
<td>15</td>
<td>17</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td><img src="image2" alt="Stop-clock 2" /></td>
<td>26</td>
<td>28</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td><img src="image3" alt="Stop-clock 3" /></td>
<td>40</td>
<td>42</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td><img src="image4" alt="Stop-clock 4" /></td>
<td>51</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?

(ii) Explain why the rate of reaction was greatest in this experiment.

(e) (i) Suggest and explain the effect on the results of using a burette to measure the volume of solution J.

(ii) Suggest and explain one other improvement to these experiments.

9.9.1 ESSENTIAL EXAM QUESTIONS Paper 6 Topic 7.1 and 7.2 151marks Mark Scheme

Q# 1/ GCSE Chemistry/2018/aw/Paper 62/Q2

2(a) Table of results for experiments 1–6

<table>
<thead>
<tr>
<th>Time compared</th>
<th>29, 30, 31, 32, 33, 34</th>
</tr>
</thead>
<tbody>
<tr>
<td>in seconds</td>
<td></td>
</tr>
</tbody>
</table>

2(b) All points plotted correctly 3

2(c) Smooth line graph 3

2(d) Value from graph 3

2(e) Indication on graph 3

2(f) Unit 3

2(g)(i) Experiment 1 3

2(g)(ii) More particles (if solution L present per unit volume) 3

more frequent collisions / particles collide more often / higher collision rate 3

2(g)(iii) More accurate 3

2(g)(iv) Too slow / too slow addition of solution J takes longer to add 3

Measuring time taken less accurate / results more accurate 3

2(g)(v) Reagent and average / compare results 3
### 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></td>
</tr>
<tr>
<td>7</td>
<td>photochemical reaction</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>denature</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>photosynthesis</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>reaction rate</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>speed of reaction</td>
<td></td>
</tr>
</tbody>
</table>

**Q# 7/IGCE Chemistry/2016/w/Paper 62/**

| Q# 7(a) | table of results; volume losses completed correctly; (20, 44, 64, 68, 105, 126) | 2 |
| Q# 7(b) | all points correctly plotted; smooth line graph | 2 |
| Q# 7(c) | point at 66 ± 2 cm²; fourth point/measurement | 1 |
| Q# 7(d) | measured measuring cylinder; read too early | 1 |
| Q# 7(e) | value from graph (56–70); shown clearly | 1 |
| Q# 7(f) | the experimenter has finished; all the acid has reacted | 1 |
| Q# 7(g) | value from graph or table (57–74) cm² | 1 |
| Q# 7(h) | 132.2 ± 0.08 cm² | 1 |

**Q# 7(g)**

- sharper curve to same level | 1 |
- air is displaced (when the acid is added) | 1 |

**Q# 7(h)**

- improvement, explanation
  - use a burette/graduated pipette/gas syringe
  - improve accuracy
  - use cotton thread to hold a test-tube (containing the acid) in the flask to avoid collision
  - repeat the experiment; take average/more frequent readings

**Q# 8/IGCE Chemistry/2016/s/Paper 62/**

| Q# 8(a) | all 6 times completed correctly (2 marks); (22, 43, 64, 88, 105, 126) | 2 |
| Q# 8(b) | 5 times completed correctly (1 mark); in seconds | 1 |

- Q# 8(b)
  - appropriate scale for plots/increasing at 20s per large square; plot is a linear scale
  - all 5 points plotted correctly 1 half a small square (2 marks); 2 points plotted correctly 1 half a small square (1 mark); trend straight/line graph | 1 |
| Q# 8(c) | value from graph 1 half a small square (typically 107–170); solvent is; extrapolation | 1 |
| Q# 8(d) | sketch line below original line and diverging | 1 |

- Q# 8(d)
  - as an indicator | 1 |
| Q# 8(e) | more accurate | 1 |
| Q# 8(f) | solution slow to run out of pipette; difficult to know when to start times/reaction does not start at once/ inaccurate time measurement curves | 1 |

- Q# 8(f)
  - difficulty in waiting/ mixing/ shaking | 1 |

**Q# 9/IGCE Chemistry/2016/m/Paper 62/**

| Q# 9(a) | In each column: 4 correct + 1; 3 correct + 1; 2 correct + 1; 1 correct + 1; average temperature losses completed correctly; 16, 27, 41, 50; times completed in seconds correctly: 123, 98, 27, 18; | 4 |
| Q# 9(b) | all points plotted correctly | 4 |
| Q# 9(c) | value from graph: 12–13s; extrapolation | 2 |

- Q# 9(c)
  - experiment 4 | 2 |
| Q# 9(d) | any 2 from: highest temperatures; most energy; most changes/evolutions; more accurate; than a measuring cylinder | 2 |
| Q# 9(e) | insulation/ use a lid, to reduce heat losses; OR; repeat; average results; OR: measure water/methanol; absorb energy using a burette/ use a 2dp stopwatch/digital thermometer; reference to accuracy | 2 |

- Q# 9(e)
  - insulation/ use a lid, to reduce heat losses; OR; repeat; average results; OR: measure water/methanol; absorb energy using a burette/ use a 2dp stopwatch/digital thermometer; reference to accuracy | 2 |
9.11 ESSENTIAL Assessed Activity 2 Topic 7.1 & 7.2 Paper 2 15 marks

Q# 1/
14 Copper(II) carbonate reacts with dilute sulfuric acid.

\[ \text{CuCO}_2\text{(s)} + \text{H}_2\text{SO}_4\text{(aq)} \rightarrow \text{CuSO}_4\text{(aq)} + \text{CO}_2\text{(g)} + \text{H}_2\text{O(l)} \]

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 reaction 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 experiment](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?

![Graph A](image)  
![Graph B](image)

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.

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 0.1 g of magnesium ribbon. The acid in experiment 1 was less concentrated than in experiment 2.

Which graph shows the results of the experiments?
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?

Which words correctly complete gaps 1 and 2?

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.

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.

Q#17 The diagram shows an energy level diagram for a reaction. Increasing the temperature increases the rate of reaction. A reason for this is that the ...2.......

Which two statements correctly complete gaps 1 and 2?

A. endothermic activation energy decreases
B. endothermic collision rate increases
C. exothermic activation energy decreases
D. exothermic collision rate increases

9.12 Extension Assessed Activity 3 Paper 3/4 17marks

(c) Aqueous hydrogen peroxide decomposes to form water and oxygen.

\[ 2\text{H}_2\text{O}_2(\text{aq}) \rightarrow 2\text{H}_2\text{O}(\ell) + \text{O}_2(\text{g}) \]

This reaction is catalysed by manganese(IV) oxide.

The following experiments were carried out to investigate the rate of this reaction. A 0.1g 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.
Q# 19/
(d) The graph shows how the rate of the exothermic reaction between aluminium and hydrochloric acid varies with time.

(i) How does the rate of reaction vary with time? Explain why the rate varies.

(ii) The following experiment was carried out at the same temperature.
0.1 g of manganese(IV) oxide and 20 cm³ of 0.4 M hydrogen peroxide
Sketch the curve for this experiment on the same grid.

(iii) How would the shape of the graph differ if only half the mass of catalyst had been used in these experiments?

Q# 20/
(a) 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.

Q# 21/
(v) Give another example of a reaction that is influenced by light. Describe one important application of this reaction.

reaction

application
9.13 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?
9.15 EXCEPTIONAL Additional Activities, Further Reading and Exploring Beyond the Syllabus

Possible ideas for a presentation

For extremely unreactive elements check out this information:
- [https://13c35962-4d0-484-9028-2c640705-4a5a.13c35962-4d0-484-9028-2c640705-4a5a.filesusr.com/ugd/d26cc6_e152e10a08314c70b4eaeeef061c9e5d.docx?index=true](https://13c35962-4d0-484-9028-2c640705-4a5a.13c35962-4d0-484-9028-2c640705-4a5a.filesusr.com/ugd/d26cc6_e152e10a08314c70b4eaeeef061c9e5d.docx?index=true)

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 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’s good to find out where your academic career might take you one day!
- [https://13c35962-4d0-484-9028-2c640705-4a5a.13c35962-4d0-484-9028-2c640705-4a5a.filesusr.com/ugd/d26cc6_a8071c3248a647e0aee64d250493929.docx?index=true](https://13c35962-4d0-484-9028-2c640705-4a5a.13c35962-4d0-484-9028-2c640705-4a5a.filesusr.com/ugd/d26cc6_a8071c3248a647e0aee64d250493929.docx?index=true)

9.16 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:

![Enzyme Structure](https://13c35962-4d0-484-9028-2c640705-4a5a.13c35962-4d0-484-9028-2c640705-4a5a.filesusr.com/ugd/d26cc6_09d1ac89ec85489bbc6d57fb6a437c9d.docx?index=true)

Enzymes in general: [https://13c35962-4d0-484-9028-2c640705-4a5a.13c35962-4d0-484-9028-2c640705-4a5a.filesusr.com/ugd/d26cc6_302ada967ced4f779b628443088894.pdf?index=true](https://13c35962-4d0-484-9028-2c640705-4a5a.13c35962-4d0-484-9028-2c640705-4a5a.filesusr.com/ugd/d26cc6_302ada967ced4f779b628443088894.pdf?index=true)

How much faster enzymes speed up a reaction: [https://13c35962-4d0-484-9028-2c640705-4a5a.13c35962-4d0-484-9028-2c640705-4a5a.filesusr.com/ugd/d26cc6_e152e10a08314c70b4eaeeef061c9e5d.docx?index=true](https://13c35962-4d0-484-9028-2c640705-4a5a.13c35962-4d0-484-9028-2c640705-4a5a.filesusr.com/ugd/d26cc6_e152e10a08314c70b4eaeeef061c9e5d.docx?index=true)

Artificial enzymes: [https://13c35962-4d0-484-9028-2c640705-4a5a.13c35962-4d0-484-9028-2c640705-4a5a.filesusr.com/ugd/d26cc6_09d1ac89ec85489bbc6d57fb6a437c9d.docx?index=true](https://13c35962-4d0-484-9028-2c640705-4a5a.13c35962-4d0-484-9028-2c640705-4a5a.filesusr.com/ugd/d26cc6_09d1ac89ec85489bbc6d57fb6a437c9d.docx?index=true)

This website provides free academic articles about the biosciences, check it out!
- [https://13c35962-4d0-484-9028-2c640705-4a5a.13c35962-4d0-484-9028-2c640705-4a5a.filesusr.com/ugd/d26cc6_e152e10a08314c70b4eaeeef061c9e5d.docx?index=true](https://13c35962-4d0-484-9028-2c640705-4a5a.13c35962-4d0-484-9028-2c640705-4a5a.filesusr.com/ugd/d26cc6_e152e10a08314c70b4eaeeef061c9e5d.docx?index=true)

10 Topics 7.3 Reversible Reactions, 11.3 Nitrogen & Fertilisers & 12 Sulfur (Equilibria)

10.1 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 in order 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><strong>Interacted with your teacher</strong></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><strong>Notes and follow up notes</strong></td>
<td>Complete set of class note</td>
<td></td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Cornell Note-taking Attempted</td>
<td></td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Cornell Note-taking Completed</td>
<td></td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Cornell Note-taking 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><strong>Textbook</strong></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 translated 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><strong>Past Exam Questions</strong></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 marled 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>EXCEPTICALLY SMASHING!!!</td>
</tr>
<tr>
<td><strong>Assessed Activities</strong></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>EXTENSION</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><strong>End of Topic Test</strong></td>
<td>Revisited 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>
10.2 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) sulphate 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), manganese(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 oxidised potassium permanganate(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.

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 hydrogen and nitrogen, i.e. hydrocarbons or steam and air.

12 Sulfur

12.1 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.

10.3 ESSENTIAL Glossary for Keywords for this topic

**English**

- **dynamic (chemical) equilibrium** 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.

- **equilibrium** a less precise name for dynamic equilibrium.

- **reversible reaction** a chemical reaction which can go either forwards or backwards, depending on the conditions.

- **acid rain** this has been made more acidic than normal by the presence of dissolved pollutants such as sulfur dioxide (SO₂) and nitrogen oxides (NOₓ).

- **artificial fertiliser** 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.

- **carbon cycle** the system by which carbon and its compounds in the air, oceans and rocks are interchanged.

- **Haber process** the industrial manufacture of ammonia by the reaction of nitrogen with hydrogen in the presence of an iron catalyst.

- **nitrogen cycle** the system by which nitrogen and its compounds, both in the air and in the soil, are interchanged.

- **Contact process** the industrial manufacture of sulfuric acid using the raw materials sulfur and air.

**中文**

- **动态（化学）平衡**两个化学反应，一个反应的逆反应，同时发生，在相同的时间内，反应物和产物的浓度保持恒定，因为正反应的速率与逆反应的速率相同。

- **平衡**动态平衡的更不精确的名称。

- **可逆反应**一个化学反应可以向前或向后进行的化学反应。

- **酸雨**由于溶解的污染物（例如二氧化硫（SO₂）和氮氧化物（NOₓ））的存在，使酸度比正常情况下更高。

- **人工肥料**一种添加到土壤中以增加氮、磷和钾等元素含量的物质（NPK肥料）：这可使农作物更健康地生长并产生更高的产量。

- **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。

- **哈伯过程**工业制造氨的反应，氢气在铁催化剂的存在下。

- **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。

- **接触过程**工业制造硫酸的方法，使用原材料硫酸和空气。
10.4 ESSENTIAL Classroom Active Learning Tasks 1 The Haber Process

Write a number next to each of these statement to indicate the order that is needed to make ammonia in the Haber Process:

- Steam is reacted with methane to make hydrogen.
- The gases are passed over an iron catalyst.
- The gases are heated to 450°C.
- Hydrogen is mixed with nitrogen, obtained from air.
- The gases are compressed to 200 atmospheres.
- Ammonia gas is produced, then cooled to a liquid.
- Liquid ammonia is pumped off to be sold.
- Unreacted nitrogen and hydrogen are recycled.

Q6. The flow chart below shows the main stages in the production of ammonium nitrate.

(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?

(i) 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.

10.5 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.
10.7 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?

(b) What happens to the rate of reaction as the reaction proceeds? Explain your answer.

(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.

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.

Q#3  IGCSE Chemistry/2018/w/Paper 41/Q5
(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.

(ii) State and explain the effect of increasing the temperature on the rate of the reverse reaction.

Q#4  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.

(b) The chemical equation shows the equilibrium between dinitrogen tetroxide (N₂O₄, a colourless gas) and nitrogen dioxide (NO₂, a brown gas).

\[ \text{N}_2\text{O}_4(g) \rightleftharpoons 2\text{NO}_2(g) \]

colourless \quad brown

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.

Q# 6/ IGCSE Chemistry/2017/w/Paper 42/

5 Some chemical reactions are reversible.

(a) Aqueous potassium chromate(VI), K₂CrO₄, is a yellow solution.

Aqueous potassium dichromate(VI), K₂Cr₂O₇, is an orange solution.

The two compounds interconvert when the pH of the solution changes.

\[ 2\text{K}_2\text{CrO}_4 \rightleftharpoons \text{K}_2\text{Cr}_2\text{O}_7 + \text{K}_2\text{SO}_4 + \text{H}_2\text{O} \]

yellow \quad orange

Solution 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 Y.

- Explain, in terms of the position of the equilibrium, what you would see if sodium hydroxide were added to solution Y.

Q# 7/ IGCSE Chemistry/2017/w/Paper 41/Q5

(c) Nitrogen dioxide, NO₂, exists in equilibrium with dinitrogen tetroxide, N₂O₄.

Nitrogen dioxide is brown and dinitrogen tetroxide is colourless.

\[ 2\text{NO}_2(g) \rightleftharpoons \text{N}_2\text{O}_4(g) \]

brown \quad 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.

(i) 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.

\[ \text{CuO(s)} + 2\text{HCl(aq)} \rightarrow \text{CuCl}_2(aq) + \text{H}_2\text{O(l)} \]

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.

(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/

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.

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 30 seconds.

- bung
- conical flask
- inverted measuring cylinder
- magnesium carbonate pieces
- dilute hydrochloric acid
- water
- trough
(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.

(b) A piece of magnesium ribbon was cleaned. The experiment was repeated using this clean magnesium ribbon instead of magnesium carbonate.

\[ \text{Mg}(s) + 2\text{HCl(aq)} \rightarrow \text{MgCl}_2(\text{aq}) + \text{H}_2(g) \]

This reaction is exothermic. The rate of the reaction gradually increased over the first 2 minutes. Explain why the rate of the reaction increased.

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.

\[ \text{Na}_2\text{S}_2\text{O}_3(\text{aq}) + 2\text{HCl(aq)} \rightarrow \text{S}(s) + 2\text{NaCl(aq)} + \text{H}_2\text{O(l)} + \text{SO}_2(g) \]

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.

The reaction rate increases with increasing concentration because there are more reactant molecules available to collide and form products.

(c) The student repeated experiment 1 at a higher temperature.

Use collision theory to explain why the rate of reaction would increase.

As the temperature increases, the kinetic energy of the molecules increases, leading to more effective collisions and thus a faster reaction rate.

(b) Ammonia is also made when ammonium carbonate decomposes.

\[
\text{(NH}_4\text{)}_2\text{CO}_3(s) \rightarrow 2\text{NH}_3(g) + \text{H}_2\text{O}(g) + \text{CO}_2(g)
\]

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.

(i) What is meant by the term equilibrium for a reversible reaction?

Equilibrium refers to the state where the forward and reverse reactions occur at equal rates, resulting in a constant composition of the system.

(iii) State and explain the effect of increasing the pressure on the yield of ammonia in this reaction.

Increasing the pressure shifts the equilibrium to the right, favoring the formation of ammonia, thus increasing its yield.

Q# 13/ IGCSE Chemistry/2016/m/Paper 41/ 4

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.

The Haber Process involves the following reaction:

\[
\text{N}_2(g) + 3\text{H}_2(g) \rightleftharpoons 2\text{NH}_3(g)
\]

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.

Increasing the pressure and temperature shifts the equilibrium to the right, promoting the production of sulfur trioxide.
Q# 15/ IGCSE Chemistry/2016/s/Paper 41/
5 Sulfuric acid is produced by the Contact process. The steps of the Contact process are shown.

\[
\begin{align*}
& \text{starting} \quad \text{step 1} \quad \text{sulfur} \quad \text{dioxide} \quad \text{step 2} \quad \text{sulfur} \quad \text{trioxide} \quad \text{step 3} \quad \text{oleum} \quad \text{step 4} \quad \text{sulfuric} \quad \text{acid} \\
& (b) Describe step 2, giving reaction conditions and a chemical equation. Reference to reaction rate and yield is not required.
\end{align*}
\]

**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>5(a)</th>
<th>M1 volume of gas</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M2 time</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5(b)</th>
<th>M1 rate decreases/reaction gets slower</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M2 concentration of acid decreases</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M3 fewer collisions per unit time</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5(c)</th>
<th>M1 particles have more kinetic energy</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M2 particles move faster</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M3 more collisions per unit time</td>
<td></td>
</tr>
<tr>
<td></td>
<td>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>
<td></td>
</tr>
<tr>
<td></td>
<td>OR 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>OR 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>4(c)</th>
<th>M1 Time taken is less</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M2 (particles) have more energy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M3 (particles) move faster</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M4 More collisions (of particles) occur per second per unit time</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M5 More of the particles/collisions have energy greater than activation energy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OR More of the particles/collisions have sufficient energy to react</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OR 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>S6(a)</th>
<th>M1 Faster and</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M2 More particles per unit volume</td>
<td></td>
</tr>
<tr>
<td></td>
<td>and/or greater collision rate</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S6(b)</th>
<th>Reaction faster and (particles) have more energy or (particles) move faster</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M2 More collisions per second / unit time or greater collision rate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M4 More of the particles/collisions have energy greater than the activation energy/more particles/collisions have sufficient energy to react or a greater percentage/proportion/fraction of collisions are successful</td>
<td></td>
</tr>
</tbody>
</table>

Q# 4/ IGCSE Chemistry/2018/w/Paper 43/

<table>
<thead>
<tr>
<th>S7(a)</th>
<th>M1 All reactants are in their pure state</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M2 Reaction is exothermic (increased temperature)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M3 Equilibrium shifts in the direction of the products</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S7(b)</th>
<th>M1 Lower concentration (less reactant)</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M2 More collisions per second / unit time or greater collision rate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M3 More of the particles/collisions have energy greater than the activation energy/more particles/collisions have sufficient energy to react or a greater percentage/proportion/fraction of collisions are successful</td>
<td></td>
</tr>
</tbody>
</table>

Q# 5/ IGCSE Chemistry/2018/w/Paper 41/

<table>
<thead>
<tr>
<th>S8(a)</th>
<th>M1 Faster (particles) have more energy or (particles) move faster</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M2 More collisions per second / unit time or greater collision rate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M4 More of the particles/collisions have energy greater than the activation energy/more particles/collisions have sufficient energy to react or a greater percentage/proportion/fraction of collisions are successful</td>
<td></td>
</tr>
</tbody>
</table>

Q# 6/ IGCSE Chemistry/2017/w/Paper 42/

<table>
<thead>
<tr>
<th>S9(a)</th>
<th>M1 Equilibrium moves to the right-hand side</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M2 reactions are exothermic (increased temperature)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M3 Equilibrium shifts in the direction of the products</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S9(b)</th>
<th>M1 Lower concentration (less reactant)</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M2 More collisions per second / unit time or greater collision rate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M3 More of the particles/collisions have energy greater than the activation energy/more particles/collisions have sufficient energy to react or a greater percentage/proportion/fraction of collisions are successful</td>
<td></td>
</tr>
</tbody>
</table>

Q# 7/ IGCSE Chemistry/2017/w/Paper 41/Q5

<table>
<thead>
<tr>
<th>S10(a)</th>
<th>M1 Equilibrium moves to the right-hand side</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M2 reactions are exothermic (increased temperature)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M3 Equilibrium shifts in the direction of the products</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S10(b)</th>
<th>M1 Equilibrium moves to the right-hand side</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M2 reactions are exothermic (increased temperature)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M3 Equilibrium shifts in the direction of the products</td>
<td></td>
</tr>
</tbody>
</table>

Q# 8/ IGCSE Chemistry/2017/w/Paper 41/

<table>
<thead>
<tr>
<th>S11(a)</th>
<th>M1 Equilibrium moves to the right-hand side</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M2 reactions are exothermic (increased temperature)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M3 Equilibrium shifts in the direction of the products</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S11(b)</th>
<th>M1 Equilibrium moves to the right-hand side</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M2 reactions are exothermic (increased temperature)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M3 Equilibrium shifts in the direction of the products</td>
<td></td>
</tr>
</tbody>
</table>

Q9. IGCSE Chemistry/2017/s/Paper 41/

5(d) curve starts from (0,0) and has a lower gradient than the original curve 1
because lumps have a lower surface area

5(e) curve starts from (0,0) and has a lower gradient than the original curve 1
because lumps have a lower surface area

Q10. IGCSE Chemistry/2016/w/Paper 41/

8(a)(i) any 4 from:
- shaded down
- more collisions per second OR higher collision rate
- more collisions per second OR higher collision rate
- same volume of gas
- more collisions per second OR higher collision rate

8(a)(ii) faster reaction
- larger surface area
- more collisions per second OR higher collision rate
- increase in temperature
- increase in temperature

8(b) any 5 from:
- temperature increased
- particles have more energy
- particles have more energy
- temperature increased
- more of the collisions are successful

Q11. IGCSE Chemistry/2016/s/Paper 41/

3(d)(ii) M1 more particles per unit volume or particles are closer together; 1
M2 increases the rate of collisions (there are more collisions per unit time); 1

3(e) M1 particles gain more energy and move faster; 3
M2 increasing rate of collisions due to higher temperatures per unit time; 1
M3 increase in temperature

Q12. IGCSE Chemistry/2016/w/Paper 41/

4(a)(i) M1 forward and reverse reactions occur; 1
M3 heat energy involved in the reactions (heat is produced and/or absorbed) is important; 1
M4 rate of forward and reverse reactions equal; 1

4(a)(ii) exothermic and yield increases as temperature increases; 1

4(b)(ii) M1 yield increases as pressure increases; 1
M2 increase in pressure increases the reaction; 1
M3 so position of equilibrium moves left; 1

Q13. IGCSE Chemistry/2016/m/Paper 42/

5(a) pressure in range 150-300 atmospheres atm; 5
temperature in range 300-470 °C; 1
iron catalyst; 1
balanced equation: \( N_2 + 3H_2 \rightarrow 2NH_3 \); 1
equilibrium reversible; 1

Q14. IGCSE Chemistry/2018/w/Paper 41/

4(a)(i) M1 vanadium pentoxide or vanadium(V) oxide or \( V=O \) (catalyst); 1
M2 1-5 atmospheres atm; 1
M3 450°C units required; 1
M4 25O(g) + 25H(g) \( \rightarrow \) 50H(g); 1
M5 equilibrium/reversible reaction in equation or text; 1

Q15. IGCSE Chemistry/2016/s/Paper 41/

5(b)
- M1 vanadium pentoxide or vanadium(V) oxide or \( V=O \) (catalyst); 1
- M2 1-5 atmospheres atm; 1
- M3 450°C units required; 1
- M4 25O(g) + 25H(g) \( \rightarrow \) 50H(g); 1
- M5 equilibrium/reversible reaction in equation or text; 1

10.8 ESSENTIAL EXAM QUESTIONS Paper 2 Topic 7.3

Topic Chem 7 Q8/ IGCSE Chemistry/2016/s/Paper 23/

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:

\[ \text{CO}(g) + 2\text{H}_2(g) \rightarrow \text{CH}_3\text{OH}(g) \]

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

Topic Chem 7 Q9/ IGCSE Chemistry/2016/s/Paper 22/

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:

\[ \text{CO}(g) + 2\text{H}_2(g) \rightarrow \text{CH}_3\text{OH}(g) \]

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 decrease</td>
<td>decrease</td>
</tr>
<tr>
<td>B decrease</td>
<td>increase</td>
</tr>
<tr>
<td>C increase</td>
<td>decrease</td>
</tr>
<tr>
<td>D increase</td>
<td>increase</td>
</tr>
</tbody>
</table>
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>temperature</th>
<th>pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>A high</td>
<td>high</td>
</tr>
<tr>
<td>B high</td>
<td>low</td>
</tr>
<tr>
<td>C low</td>
<td>high</td>
</tr>
<tr>
<td>D low</td>
<td>low</td>
</tr>
</tbody>
</table>

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\textsubscript{2} and N\textsubscript{2}O\textsubscript{4} is correct?

A If the pressure is decreased the amount of N\textsubscript{2}O\textsubscript{4} increases.
B If the temperature is increased the amount of N\textsubscript{2}O\textsubscript{4} increases.
C The rates of formation and decomposition of N\textsubscript{2}O\textsubscript{4} are not the same.
D The decomposition of N\textsubscript{2}O\textsubscript{4} is an endothermic reaction.

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>hydrogen</th>
<th>nitrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>A air</td>
<td>air</td>
</tr>
<tr>
<td>B air</td>
<td>natural gas</td>
</tr>
<tr>
<td>C natural gas</td>
<td>air</td>
</tr>
<tr>
<td>D natural gas</td>
<td>natural gas</td>
</tr>
</tbody>
</table>

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>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 air</td>
<td>natural gas</td>
<td>250</td>
<td>2</td>
</tr>
<tr>
<td>B air</td>
<td>natural gas</td>
<td>250</td>
<td>200</td>
</tr>
<tr>
<td>C natural gas</td>
<td>air</td>
<td>450</td>
<td>2</td>
</tr>
<tr>
<td>D natural gas</td>
<td>air</td>
<td>450</td>
<td>200</td>
</tr>
</tbody>
</table>

31 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>nitrogen</th>
<th>hydrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>A fertilisers</td>
<td>reacting methane with steam</td>
</tr>
<tr>
<td>B fertilisers</td>
<td>the air</td>
</tr>
<tr>
<td>C the air</td>
<td>reacting methane with steam</td>
</tr>
<tr>
<td>D the air</td>
<td>the air</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.

\[ \text{N}_2(g) + 3\text{H}_2(g) \rightleftharpoons 2\text{NH}_3(g) \quad \Delta H = -92 \text{ kJ/mol} \]

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

33 Ammonia is manufactured by the Haber process, using an iron catalyst.

\[ \text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3 \]

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.
D The ammonia reacts with the catalyst.

34 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.

35 Which row gives the conditions for the Haber process?

<table>
<thead>
<tr>
<th>temperature /°C</th>
<th>pressure /atm</th>
<th>catalyst</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 200</td>
<td>2</td>
<td>V_2O_5</td>
</tr>
<tr>
<td>B 200</td>
<td>450</td>
<td>Fe</td>
</tr>
<tr>
<td>C 450</td>
<td>200</td>
<td>Fe</td>
</tr>
<tr>
<td>D 500</td>
<td>250</td>
<td>V_2O_5</td>
</tr>
</tbody>
</table>
32 Ammonia is manufactured by a reversible reaction.

\[ \text{N}_2(g) + 3\text{H}_2(g) \rightleftharpoons 2\text{NH}_3(g) \]

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>
<th>percentage yield</th>
<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>

32 Ammonia is formed by a reversible reaction.

\[ \text{N}_2(g) + 3\text{H}_2(g) \rightleftharpoons 2\text{NH}_3(g) \]

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>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>

34 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>nitrogen (N)</th>
<th>phosphorus (P)</th>
<th>potassium (K)</th>
</tr>
</thead>
<tbody>
<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:

$$2\text{SO}_2(g) + \text{O}_2(g) \rightarrow 2\text{SO}_3(g)$$

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 used</th>
<th>sulfur dioxide used</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.

33 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>temperature °C</th>
<th>pressure atm</th>
<th>catalyst</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 40</td>
<td>200</td>
<td>Fe</td>
</tr>
<tr>
<td>B 40</td>
<td>200</td>
<td>V_2O_5</td>
</tr>
<tr>
<td>C 400</td>
<td>2</td>
<td>Fe</td>
</tr>
<tr>
<td>D 400</td>
<td>2</td>
<td>V_2O_5</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>ion</th>
<th>formed from</th>
<th>process</th>
<th>catalyst</th>
</tr>
</thead>
<tbody>
<tr>
<td>A ammonium</td>
<td>ammonia</td>
<td>Contact</td>
<td>iron</td>
</tr>
<tr>
<td>B ammonium</td>
<td>ammonia</td>
<td>Haber</td>
<td>vanadium(V) oxide</td>
</tr>
<tr>
<td>C sulfate</td>
<td>sulfuric acid</td>
<td>Contact</td>
<td>vanadium(V) oxide</td>
</tr>
<tr>
<td>D 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. \( SO_2 + H_2O \rightarrow H_2SO_3 \)

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>reactants</th>
<th>catalyst</th>
</tr>
</thead>
<tbody>
<tr>
<td>A sulfur and oxygen</td>
<td>vanadium(V) oxide</td>
</tr>
<tr>
<td>B sulfur dioxide and oxygen</td>
<td>vanadium(V) oxide</td>
</tr>
<tr>
<td>C sulfur dioxide and steam</td>
<td>iron</td>
</tr>
<tr>
<td>D 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>temperature /°C</th>
<th>pressure /atmospheres</th>
<th>catalyst</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 450</td>
<td>1.5</td>
<td>iron</td>
</tr>
<tr>
<td>B 450</td>
<td>1.5</td>
<td>iron</td>
</tr>
<tr>
<td>C 450</td>
<td>200</td>
<td>vanadium(V) oxide</td>
</tr>
<tr>
<td>D 450</td>
<td>200</td>
<td>vanadium(V) oxide</td>
</tr>
</tbody>
</table>

33 The equation for an exothermic reaction in the Contact process is shown.

\[ 2SO_2(g) + O_2(g) \rightarrow 2SO_3(g) \]

Which effects do increasing the temperature and using a catalyst have on the rate of formation of sulfur trioxide, \( SO_3 \)?

<table>
<thead>
<tr>
<th>increasing the temperature</th>
<th>using a catalyst</th>
</tr>
</thead>
<tbody>
<tr>
<td>A rate decreases</td>
<td>rate decreases</td>
</tr>
<tr>
<td>B rate decreases</td>
<td>rate increases</td>
</tr>
<tr>
<td>C rate increases</td>
<td>rate decreases</td>
</tr>
<tr>
<td>D 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.

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.
4 Reversible reactions can come to equilibrium. The following are three examples of types of gaseous equilibria.

\[ A_1(g) + B_2(g) \rightleftharpoons 2AB(g) \quad \text{reaction 1} \]
\[ A_1(g) + 3B_2(g) \rightleftharpoons 2AB_3(g) \quad \text{reaction 2} \]
\[ 2AB_2(g) \rightleftharpoons 2AB(g) + B_2(g) \quad \text{reaction 3} \]

(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)
\[ \text{% product at equilibrium} \]
\[ \text{0} \quad \text{pressure} \]

(ii)
\[ \text{% product at equilibrium} \]
\[ \text{0} \quad \text{pressure} \]

(iii) % product at equilibrium
\[ \text{0} \quad \text{pressure} \]

effect on percentage of products .................................................................
reaction ...........................................................................................................
reason ...........................................................................................................
.................................................................................................................. [5]

6 Iodine reacts with chlorine to form dark brown iodine monochloride.

\[ I_2(g) + Cl_2(g) \rightarrow 2ICl \]

This reacts with more chlorine to give yellow iodine trichloride. There is an equilibrium between these iodine chlorides.

\[ 1ICl(g) + Cl_2(g) \rightleftharpoons ICl_3(s) \]

dark brown yellow

(a) Explain what is meant by equilibrium.

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

(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.

FeSO₄·7H₂O(s) → FeSO₄(s) + 7H₂O(g)
green crystals yellow powder
2FeSO₄(s) → Fe₂O₃(s) + SO₂(g) + SO₃(g)
On cooling
SO₃ + H₂O → H₂SO₄ sulfuric acid
SO₂ + H₂O → H₂SO₃ sulfurous acid

(i) How could you show that the first reaction is reversible?

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

(c) Methanol is made from carbon monoxide.

CO(g) + 2H₂(g) ⇌ CH₃OH(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 ........................................................................................................ [2]
reason ......................................................................................................... [2]

(b) Both of the following reactions are reversible.

reaction 1 N₂(g) + O₂(g) ⇌ 2NO(g)
reaction 2 2NO(g) + O₂(g) ⇌ 2NO₂(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.

\[
\text{BiCl}_3(\text{aq}) + \text{H}_2\text{O}(l) \rightleftharpoons \text{BiCl}_4(\text{s}) + 2\text{HCl}(\text{aq})
\]

(i) Explain why the rate of the forward reaction decreases with time.

(ii) Why does the rate of the backward reaction increase with time?

(iii) After some time why does the appearance of the mixture remain unchanged?

(iv) When a few drops of concentrated hydrochloric acid are added to the cloudy mixture, it changes to a colourless solution. Suggest an explanation.

(b) Carbon monoxide is used to purify nickel. Nickel reacts with carbon monoxide to form a gaseous compound.

\[
\text{Ni}(s) + 4\text{CO}(g) \rightleftharpoons \text{Ni}(_4\text{CO})_4(g)
\]

(i) What reaction condition will favour the back reaction and reform nickel metal? Explain your choice.
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

(ii) Hydrogen

(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?

- Pair A
- Pair B
- Pair C

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.

(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

\[ \text{N}_2(g) + 3\text{H}_2(g) \rightleftharpoons 2\text{NH}_3(g) \] 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>
<thead>
<tr>
<th>pressure / atmospheres</th>
<th>100</th>
<th>200</th>
<th>300</th>
<th>400</th>
</tr>
</thead>
<tbody>
<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>7</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.

(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.

\[ \% \text{ ammonia at equilibrium} \]

\[ \text{temperature} \]

(i) Explain the term equilibrium.

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

(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.

![Graph showing % ammonia at equilibrium vs pressure](image)

(ii) Explain why the graph has the shape shown.

The forward reaction is exothermic.

(a) (i) What is the catalyst for this reaction?

(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.

(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?

(ii) Only ammonia gas liquefies. Suggest an explanation for this.

(c) Urea, CO(NH₂)₂, is one of the fertilisers manufactured from ammonia. Ammonia is heated with carbon dioxide.

(i) Write an equation for the manufacture of urea.

(ii) Explain why urea on its own might not be very effective in promoting crop growth.
7 In 1908, Haber discovered that nitrogen and hydrogen would react to form ammonia. The yield of ammonia was 8%.

\[ \text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g}) \]

The forward reaction is exothermic.

(catalyst platinum

temperature 600 °C

pressure 200 atm

(a) Describe how hydrogen is obtained for the modern process.

(b) (i) What is the catalyst in the modern process?

(ii) Explain why the modern process, which uses a lower temperature, has a higher yield of 15%.

1 Ammonia contains the elements nitrogen and hydrogen. It is manufactured from these elements in the Haber process.

\[ \text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g}) \]

The forward reaction is exothermic.

(i) Name two raw materials from which hydrogen is manufactured.

(ii) The table shows how the percentage of ammonia in the equilibrium mixture varies with pressure at 600 °C.

<table>
<thead>
<tr>
<th>percentage ammonia</th>
<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>
</tr>
</tbody>
</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.

(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.

(ii) Name a nitrogen-containing fertiliser that is manufactured from sulphuric acid.

(c) Outline how hydrogen is manufactured from water.
3. The main use of sulfur dioxide is the manufacture of sulfuric acid.
   
   (a) State two other uses of sulfur dioxide.

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

   (b) One source of sulfur dioxide is burning sulfur in air.
         Describe how sulfur dioxide can be made from the ore zinc sulfide.

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

   (c) The Contact process changes sulfur dioxide into sulfur trioxide.

   \[ 2\text{SO}_2(g) + \text{O}_2(g) \rightleftharpoons 2\text{SO}_3(g) \]
         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?

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

   (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?

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

   (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.

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

\[ 2\text{SO}_2(g) + \text{O}_2(g) \rightarrow 2\text{SO}_3(g) \]

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.

(b) Sulfuric acid was first made in the Middle East by heating the mineral, green vitriol, FeSO₄·7H₂O. The gases formed were cooled.

\[
\begin{align*}
\text{FeSO}_4 \cdot 7\text{H}_2\text{O}(s) & \rightarrow \text{FeSO}_4(s) + 7\text{H}_2\text{O}(g) \\
\text{green crystals} & \rightarrow \text{yellow powder}
\end{align*}
\]

\[
\begin{align*}
2\text{FeSO}_4(s) & \rightarrow \text{Fe}_2\text{O}_3(s) + \text{SO}_2(g) + \text{SO}_3(g) \\
\text{On cooling} & \\
\text{SO}_2 + \text{H}_2\text{O} & \rightarrow \text{H}_2\text{SO}_4 \quad \text{sulfuric acid} \\
\text{SO}_3 + \text{H}_2\text{O} & \rightarrow \text{H}_2\text{SO}_4 \quad \text{sulfuric acid}
\end{align*}
\]

(ii) Sulfurous acid is a reductant. What would you see when acidified potassium manganate(VII) is added to a solution containing this acid?

(iii) Suggest an explanation why sulfuric acid in contact with air changes into sulfuric acid.
6 (a) Sulfuric acid is made by the Contact process.

\[ 2\text{SO}_2 + \text{O}_2 \rightarrow 2\text{SO}_3 \]

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?

4 (a) Zinc is extracted from zinc blende, ZnS.

(i) 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.

(ii) Give another use of sulphur dioxide.

(iii) Describe how sulphur dioxide is converted into sulphur trioxide.

(iv) Name a fertiliser made from sulphuric acid.

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(iii) Explain, mentioning both rate and percentage yield, why the temperature used in the Contact process is 450°C.

(iv) Describe how the sulphur trioxide is changed into concentrated sulphuric acid.

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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.
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.

\[ \text{percentage of sulphur trioxide} \]
\[ \text{temperature} \]

(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.

\[ 2\text{SO}_2 + \text{O}_2 \rightarrow 2\text{SO}_3 \]

(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.

\[
\text{calcium carbonate} \rightarrow \text{calcium sulphate} \quad \text{[1]}
\]

(ii) Describe how you could test the water entering the cave to show that it contained sulphate ions.

\[
\text{test} \quad \text{[2]}
\]

(iii) How could you show that the water entering the cave has a high concentration of hydrogen ions?

\[
\text{[1]}
\]

(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.

\[
\text{H}_2\text{S} \rightarrow \text{[2]}
\]

(ii) Explain why all the hydrogen sulphide should be removed from the petroleum before it is used as a fuel.
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.

\[
\begin{align*}
\text{Sulphur} & \quad \rightarrow \quad \text{Sulphur dioxide} \\
S & \quad \text{reaction 1} \quad \text{SO}_2 \\
\text{Sulphur dioxide + oxygen} & \quad \rightarrow \quad \text{Sulphur trioxide} \\
2\text{SO}_2 + \text{O}_2 & \quad \text{reaction 2} \quad 2\text{SO}_3 \\
\text{Sulphur trioxide} & \quad \rightarrow \quad \text{Oleum} \\
\text{SO}_3 & \quad \text{reaction 3} \quad \text{H}_2\text{S}_2\text{O}_7 \\
\text{Oleum + water} & \quad \rightarrow \quad \text{Sulphuric acid} \\
\text{H}_2\text{S}_2\text{O}_7 & \quad \text{reaction 4} \quad \text{H}_2\text{SO}_4
\end{align*}
\]

(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]
5 Sulphur dioxide, SO₂, and sulphur trioxide, SO₃, 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.

\[
\text{Sulphur dioxide} + \text{....} \rightarrow \text{Sulphur trioxide}
\] .................................................................[1]

(iii) What are the conditions for this reaction?
.................................................................................................................[2]

10.10.2 ESSENTIAL EXAM QUESTIONS Paper 3/4 Topic 7.3 56 marks Mark Scheme

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

\[ V_r > V_p \] .................................................................[1]

(ii) same reaction 1

\[ V_r = V_p \] .................................................................[1]

(iii) decrease reaction 3

\[ V_p > V_r \] .................................................................[1]

Accept: moles of gas / molecules of gas as an alternative to volume

6 (a) \( \text{Rates =} \) "equal concentrations do not change / macroscopic properties remain constant accept amounts do not change"

(b) endothermic

Cond favoured by high temperatures

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

(c) (i) move to left

Cond bigger volume / more moles etc do not insist on “gas”

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

(ii) less yellow solid / more brown liquid

Accept: yellow to brown / less solid more liquid / goes brown

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

Topic 7.3 Q6 IGCSE Chemistry/2009/w/Paper 3 Q6

(b) (i) add water to yellow powder or to anhydrous salt

It would go green .................................................................[1]
Topic Chem 7.3 Q# 4/ iGCSE Chemistry/2008/w/Paper 31/

5 (a) (i) (concentration) of reactants/CO and C\textsubscript{2} \textsubscript{2} increases (concentration) of product decreases/OCC\textsubscript{6}

(ii) (decrease in pressure favours e x i s t s) with more molecules or moles of side with bigger volume (of gas) NB [2] or [0]

(b) forward reaction is exothermic because it is favoured by low temperatures or cool AC E P T argument re back reaction

Topic Chem 7.3 Q# 5/ iGCSE Chemistry/2007/w/Paper 3/6 (c)

(iii) high pressure COND forward reaction volume decreases 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

Topic Chem 7.3 Q# 6/ iGCSE Chemistry/2005/w/Paper 3/Q3

(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

Topic Chem 7.3 Q# 7/ iGCSE Chemistry/2005/w/Paper 3/

(a) (i) because concentration of BiCl\textsubscript{3} decreases bismuth chloride used up ONLY [1]

(ii) products are being formed or concentration of products increases. Concentration mark given either (i) or (ii)

(iii) reaction has come to equilibrium rates equal or no change in concentration

(iv) equilibrium to left or favours backward reaction or equilibrium moves to use up hydrochloric acid BiCl\textsubscript{3} used up or BiCl\textsubscript{4} formed

Topic Chem 7.3 Q# 8/ iGCSE Chemistry/2004/w/Paper 3/

3 (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

(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 thermostil and comment re position of equilibrium.
Haber process and nitrogen chemistry 63 Marks

3 (a) (i) fractional distillation (liquid air) [1]

(ii) cracking / heat in presence of catalyst of alkane / petroleum to give an alkene and hydrogen [1]

OR: electrolysis (1) named electrolyte (1) hydrogen at cathode (1) [1]

OR: from methane (1) react water / steam (1) heat catalyst (1) only ACCEPT: water with methane or electrolysis [1]

(b) (i) the pair with both graphs correct is C [5]

NOTE: mark (b)(ii) independent of (b)(i) [5]

(ii) high pressure favours side with fewer moles / fewer volumes this is RHS / product / ammonia %NH₃ / yield increases as pressure increases [1]

the forward reaction is exothermic exothermic reactions favoured by low temperatures %NH₃ / yield decreases as temperature increases [1]

ACCEPT: reverse arguments [1]

(iii) increases reaction rate [1]

ACCEPT: reduces activation energy [1]

OR: decreases the amount of energy particles need to react [1]

OR: economic rate at lower temperature so higher yield [1]

[Total: 14]

(b) any 5a 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 give a fast enough rate note need whole concept to get this compromise temperature point [5]

6 (a) (i) air (liquid) petroleum or crude oil or alkynes 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/macrosopic properties do not change accept amounts stay the same NOT no change rate of forward and back reactions equal [1]

(ii) it increases with increase temperature or decreases with decreased temperature [1]

(c) (i) shows as increase either a line or curve (any decrease = 0) [1]

(ii) increase pressure favours the side with fewer volume or molecules or moles that is RHS or products side ignore any mention of rates [1]
Topic Chem 11.3 Q# 6/ iGCSE Chemistry/2008/s/Paper 3  

0 (a) burning wood produces carbon dioxide
less photosynthesis or trees take up carbon dioxide

Topic Chem 11.3 Q# 7/ iGCSE Chemistry/2006/w/Paper 3  

5 (a) (i) iron
(ii) advantage higher yield
explanation lower temperature favours the exothermic reaction
(heat is the forward reaction)
(b) (i) Sent over the catalyst again or used to make more ammonia
NOT just reused
(ii) It has the highest boiling point
(c) (i) CO₂ + 2NH₃ → CO(NH₂)₂ + H₂O
Not balanced [1]
(ii) Any comment based on deficiency of PK or ONLY provides Nitrogen as a nutrient
NOT soil pH

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]  
(b) (i) iron [1]  
(ii) lower temperature moves equilibrium to right because forward reaction is exothermic

Topic Chem 11.3 Q# 9/ iGCSE Chemistry/2004/s/Paper 3  

(b) (i) potassium [1]  
(ii) ammonium sulphate [1]  

Topic Chem 11.3 Q# 10/ iGCSE Chemistry/2003/s/Paper 3  

1 (a) (i) different boiling points
(ii) methane or water or petroleum or named petroleum fraction or alkane
Any TWO [2]
(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)
350 to 300 atm
Any TWO

(c) steam and alkane
best catalyst or details of chemistry – forms carbon monoxide/dioxide and (hydrogen)
[1]  
OR electrolysis
brine or acidified water
or hydrogen anodes or cathode
[1]  
OR carbon/coke
heat or details of chemistry – forms carbon monoxide/dioxide and (hydrogen)
10.10.2.1 ESSENTIAL EXAM QUESTIONS Contact Process and Sulfur Chemistry 79 Marks
Mark Scheme

Topic Chem 12 Q# 1/ iGCSE Chemistry/2014/w/Paper 3  

Page 463 of 773
3 (a) Any two from:
bleach/making wood pulp/making paper
food/fruit juice/wine preservative
fungus/sterilising/metcide [2]

(b) heating/toasting/burning (zinc sulfides)
in air/oxygen O2 on M1
[1]

(c) (i) \( \text{NO}_2 \) [1]

(ii) position of equilibrium shifts right/yield increases to save energy [1]

(iii) faster reaction/rate [1]
more collisions per second/higher collision frequency
fewer molecules/molecules (of gas) on right
so position of equilibrium shifts right/yield increases [1]

(d) (the reaction is) too violent/too exothermic or produces mist/fumes (of acid) [1]

Topic Chem 12 Q# 2/ IGCSE Chemistry/2013/w/Paper 3/ Q6

(b) (i) anhydrous cobalt chloride becomes hydrated
ACCEPT: hydrous [1]

(ii) carbon dioxide is acidic
sodium hydroxide and calcium oxide are bases / alkalis [1]

(iii) Any two of:
water, calcium carbonate and sodium carbonate
ACCEPT: sodium bicarbonate [2]


(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 [1]

(iii) reacts with oxygen in air [1]

Topic Chem 12 Q# 5/ IGCSE Chemistry/2009/w/Paper 3/

6 (a) (i) burn sulfur in air or oxygen
or heat a metal sulﬁde in air [1]

(ii) bleach for wood pulp/cloth/straw or preserve food or sterilising
or making wine or fungit or refrigerant
Accept making paper [1]

(iii) vanadium(V) oxide accept vanadium oxide or \( \text{V}_2\text{O}_3 \)
or vanadium pentoxide
oxidation state not essential but if given it has to be (V) [1]

(iv) rate too slow or rate not economic [1]

(v) reaction too violent or forms a mist [1]

Topic Chem 12 Q# 6/ IGCSE Chemistry/2008/s/Paper 3/Q/IGCSE Chemistry/201

(g) vanadium [1]

ACCEPT name or symbol

Topic Chem 12 Q# 7/ IGCSE Chemistry/2007/w/Paper 3/

4 (a) (i) bleach for wood pulp or preserving food or sterilising
or in wine making or as a refrigerant or in metalurgy or
(liquid) sulphur dioxide is used in the petroleum industry
or kill microbes etc or insecticide [1]

(ii) (react with) oxygen or air
NOT burn/burn in air/oxygen
450°C
vanadium oxide catalyst (if oxidation state given has to be correct) or platinum [1]
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 sulﬁde or magnesium sulﬁde [1]
(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

5 (a) (i) Burn sulphur in air (or oxygen)
(ii) as a bleach
(iii) kill bacterial 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

5 (a) (i) preservative or sterilising
(ii) making paper

(b) (i) making sulphuric acid or Contact Process
(ii) oxygen
(iii) vanadium oxide as catalyst (ignore oxidation state) DO NOT accept lead(ii) compounds

(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) 2H₂ to 1S
COND 8 around sulphur atom
2e per hydrogen atom
THREE correct
TWO from above [1]
IONIC structure = \( \text{[]} \)

2. (a) (i) USA or Texas or Poland or Mexico or Japan or Ethiopia
accept other sources of sulphur eg petroleum or natural gas or metal sulphides or volcanoes
NOT coal, NOT underground

(ii) Preventing food or bleaching or sterilising or disinfecting or making paper or bleaching wood pulp or wine or paper or furfuration or making paper
NOT making wood pulp

(iii) burnt toast in oxygen or air

(iv) vanadium(V) oxide or vanadium oxide or platinum
increase oxidation state of vanadium
NOT a definition of a catalyst

(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

(iv) sulphur trioxide = sulphuric acid = colour correct symbol equation acceptable

(vii) \( \text{H}_2\text{SO}_3 + \text{H}_2\text{O} = 2\text{H}_2\text{SO}_4 \)

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
<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>

10.11 FUNDAMENTAL Assessed Activity 1 Keyword Test

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 atm, 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 [1]
(iii) dissolve in (conc) sulphuric acid NOT dilute [1]
   add water or dilute [1]

Topic Chem 12 Q15/IGCSE Chemistry/2001/j/w/Paper 3/Q4
5 (a) (i) bleach [1]
(ii) kills bacteria or germs or micro organisms [1]
10.12 ESSENTIAL Assessed Activity 2 Topic 7.4, 11.3 and 12 Paper 2 15 marks

**Topic Chem 7 Q# 1/**

15 The reversible reaction between methane and steam is shown:

\[ \text{CH}_4(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{CO}(\text{g}) + \text{3H}_2(\text{g}) \]

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/**

16 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 \(\text{BiCl}_3\) reacts with water, a white precipitate of \(\text{BiOCl}\) is formed. The equation for the reaction is shown.

\[ \text{BiCl}_3(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{BiOCl}(\text{s}) + \text{2HCl}(\text{aq}) \]

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

**Topic Chem 7 Q# 4/**

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>

**Topic Chem 7 Q# 5/**

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.

**Topic Chem 7 Q# 6/**

16 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>reaction rate</th>
<th>amount of (\text{SO}_2)</th>
<th>amount of (\text{SO}_3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A increases</td>
<td>decreases</td>
<td>increases</td>
</tr>
<tr>
<td>B increases</td>
<td>increases</td>
<td>decreases</td>
</tr>
<tr>
<td>C unchanged</td>
<td>decreases</td>
<td>increases</td>
</tr>
<tr>
<td>D unchanged</td>
<td>increases</td>
<td>decreases</td>
</tr>
</tbody>
</table>
16 The formation of sulfur trioxide from sulfur dioxide is a reversible reaction.

\[2\text{SO}_2(g) + \text{O}_2(g) \leftrightarrow 2\text{SO}_3(g)\]

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

16 Methane reacts with steam to produce hydrogen and carbon monoxide.

The equation for the reaction is shown:

\[\text{CH}_4(g) + \text{H}_2\text{O}(g) \leftrightarrow 3\text{H}_2(g) + \text{CO}(g)\]

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>increase</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>

16 Hydrogen is produced when methane reacts with steam.

The equation for the reaction is shown:

\[\text{CH}_4(g) + \text{H}_2\text{O}(g) \leftrightarrow \text{CO}(g) + 3\text{H}_2(g)\]

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.

\[ \text{N}_2(g) + 3\text{H}_2(g) \rightleftharpoons 2\text{NH}_3(g) \]

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/

16 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.

\[ \text{H}_2(g) + \text{I}_2(g) \rightleftharpoons 2\text{HI}(g) \]

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 \( \text{HCl}(g) \)
B. adding more \( \text{H}_2\text{O}(g) \)
C. decreasing the pressure
D. increasing the temperature

14. 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

15. 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 \( \text{T} \) is added.

After the addition of \( \text{T} \), which substances increase in concentration?

A. \( \text{P}, \text{Q}, \text{R} \) and \( \text{S} \)
B. \( \text{P} \) and \( \text{Q} \) only
C. \( \text{P}, \text{Q} \) and \( \text{R} \) only
D. \( \text{S} \) only

10.13. ESSENTIAL Assessed Activity 3 Topic 7.3 15 marks

Chem 7.3 Q# 1/

(c) 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.

\[ \text{ICl}(l) + \text{Cl}_2(g) \rightleftharpoons 1\text{ICl}_2(s) \]

(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?

\[ \text{ICl}_3(g) + \text{Cl}_2(g) \rightleftharpoons \text{ICl}_4(s) \]

Explain your deduction.

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

Chem 7.3 Q# 2/

5 Carbonyl chloride, COCl₂, 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.

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

(ii) If the temperature is allowed to increase to above 200°C, very little carbonyl chloride is formed. Explain why.

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

(iii) Explain why a catalyst is used.

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

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.

(c) 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]

10.14 EXTENSION Mind Map For Topics 7.3 Reversible Reactions, 11.3 Nitrogen & Fertilisers & 12 Sulfur (Equilibria)
10.15 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?

10.16 Exceptional Additional Activities, Further Reading and Exploring Beyond the Syllabus

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.

What could be done to make these molecules easier to understand? Try to find as many reasons these molecules should not exist as possible and explain why in the space below.

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.
10.17 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/4026c6_9a7531099001c4ad5ab630adb8e64ac.pptx?index=true

And what kinds of things that matter in the best presentations here:
https://13c35962-6df0-4843-9028-c26407054a5a.filesusr.com/ugd/4026c6_9038cccb606643c889dc09c257e5dbb4.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/4026c6_9a7531099001c4ad5ab630adb8e64ac.pptx?index=true
To find out more, you could buy this book, which is just $5,000 US (or about 36,000RMB): maybe an interesting career?:
https://www.researchandmarkets.com/reports/4793190/global-sulfuric-acid-market-by-raw-material-by

## 11 Topic 8.1 & 8.2 Acids & Bases

### 11.1 End of Topic 8.1 & 8.2 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 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>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>
</tbody>
</table>
### 8. Acid, bases and salts

#### 8.1 The characteristic properties of acids and bases

**Acids**
- **Strong acids**: Produce a high concentration of H⁺ ions in aqueous solution. Examples include hydrochloric acid (HCl), sulfuric acid (H₂SO₄), and nitric acid (HNO₃).
- **Weak acids**: Produce a low concentration of H⁺ ions in aqueous solution. Examples include acetic acid (CH₃CO₂H) and carbonic acid (H₂CO₃).

**Bases**
- **Strong bases**: Produce a high concentration of hydroxide ions (OH⁻) in aqueous solution. Examples include sodium hydroxide (NaOH) and potassium hydroxide (KOH).
- **Weak bases**: Produce a low concentration of hydroxide ions in aqueous solution. Examples include ammonia (NH₃) and amines.

**Universal indicator**
- A solution containing a mixture of pH indicators which can be used to test the pH of a solution. It changes color depending on the pH of the solution, with different colors indicating different pH ranges.

**Neutralisation**
- A reaction in which an acid and a base are combined to form a salt and water, according to the reaction equation: 
  \[ \text{acid} + \text{base} \rightarrow \text{salt} + \text{water} \]

**Corrosive**
- An acid or base that can dissolve or ‘eat away’ at other materials, such as wood, metals, or human skin, for instance.

**Strong acids**
- Produce the highest possible concentration of H⁺ ions in aqueous solution, typically around pH 0.

**Weak acids**
- Produce a lower concentration of H⁺ ions in aqueous solution, typically around pH 1 to 7.

**Strong bases**
- Produce the highest possible concentration of hydroxide ions (OH⁻) in aqueous solution, typically around pH 14.

**Weak bases**
- Produce a lower concentration of hydroxide ions in aqueous solution, typically around pH 7 to 14.

**Neutralisation scale**
- The pH value of a solution can range from 0 to 14, with 7 being neutral, below 7 being acidic, and above 7 being basic.
11.3 ESSENTIAL Classroom Active Learning Tasks 1 Naming Acids and Bases
Name the following acids and bases:

90) NaOH
91) H₂SO₃
92) H₂S
93) H₃P
94) H₃PO₄
95) NH₃
96) HCN
97) Ca(OH)₂
98) Fe(OH)₃

Write the formulas of the following acids and bases:

99) hydrobromic acid
100) hydrofluoric acid
101) carbonic acid
102) lithiuim hydroxide
103) nitrous acid
104) cobalt (II) hydroxide
105) sulfuric acid
106) beryllium hydroxide

11.4 Extension Classroom Active Learning Tasks 1 Naming Salts
Name or write the formula for the following ionic compounds:

21) NaBr
22) Sc(OH)₃
23) V₃(SO₄)₃
24) NH₄F
25) CaCO₃
26) NiPO₄
27) Li₂SO₃
28) Zn₃P₂
29) Sr(C₂H₃O₂)₂
30) Cu₃O
31) Ag₃PO₄
32) SnS₂
33) Ti(CN)₃
34) KMnO₄
35) Pb₃N₂
36) Co₂O₃
37) CdSO₃
38) Cu(NO₂)₂
39) Fe(HCO₃)₂

Write the formulas for the following ionic compounds:

42) iron (II) phosphate
43) titanium (II) selenide
44) calcium bromide
45) gallium chloride
46) sodium hydride
47) beryllium hydroxide
48) zinc carbonate
49) manganese (VII) arsenide
50) copper (II) chloride
51) cobalt (III) chlorate
52) ammonium oxide
53) potassium hydroxide
54) lead (IV) sulfate
55) silver cyanide
56) vanadium (V) nitride
57) strontium acetate
58) molybdenum (VI) sulfate
59) platinum (II) sulfide
60) ammonium sulfate
61) sodium bromide
62) calcium acetate
63) diphosphorus pentoxide
64) titanium(IV) sulfate
65) FePO4 · iron (III) phosphate
66) potassium nitride
67) sulfur dioxide
68) copper (I) hydroxide
69) zinc nitrate
70) vanadium (III) sulfide

**Mark Scheme For Naming Acids, Bases and Salts**

Be careful, some examples have been removed because they go beyond the syllabus, so make sure you check the question number with the answer number!

**Name the following acids and bases:**

90) NaOH sodium hydroxide
91) H2SO3 sulfurous acid
92) H2S hydrogen sulfide
93) H3P phosphine
94) H3PO4 phosphoric acid
95) NH3 ammonia
96) HCN hydrocyanic acid
97) Ca(OH)2 calcium hydroxide
98) Fe(OH)2 iron (II) hydroxide

**Write the formulas of the following acids and bases:**

99) hydrobromic acid HBr
100) hydrofluoric acid HF
101) carbonic acid H2CO3
102) lithium hydroxide LiOH
103) nitrous acid HNO2
104) cobalt (II) hydroxide Co(OH)2
105) sulfuric acid H2SO4
106) beryllium hydroxide Be(OH)2

**Naming Ionic Compounds**

21) NaBr sodium bromide
22) Sc(OH)3 scandium (III) hydroxide
23) V2(SO4)3 vanadium (III) sulfate
24) NH4F ammonium fluoride
25) CaO3 calcium carbonate
26) NiPO4 nickel (III) phosphate
27) Li2S02 lithium sulfite
28) Zn2P2 zinc phosphate
29) Sr(C2H3O2)2 strontium acetate
30) Cu2O copper (I) oxide
31) Ag2PO4 silver phosphate
32) YClO2 yttrium (I) chlorate
33) SnS2 tin (IV) sulfide
34) TiCl4 titanium (IV) chloride
35) KMnO4 potassium permanganate
36) Pb2N2 lead (II) nitride
37) CoCO3 cobalt (II) carbonate
38) CdSO3 cadmium sulfite
39) Cu(NO2)2 copper (II) nitrite
40) Fe(HCO3)2 iron (II) bicarbonate

**Name the following chemical compounds:**

41) lithium acetate LiC2H3O2
42) iron (II) phosphate Fe3(PO4)2
11.5 Essential Classroom Active Learning Tasks 3 Reactions between acids and bases

**Reaction of Metal Oxides with Acids**

Metal Oxide + Acid → Salt + Water

For example,

Copper Oxide + Sulfuric Acid → Copper Sulfate + Water

1. Magnesium Oxide + Nitric Acid → ______________ + ____________
2. Silver Oxide + Hydrochloric Acid → ______________ + ____________
3. Lead Oxide + Sulfuric Acid → ______________ + ____________
4. Copper Oxide + Nitric Acid → ______________ + ____________

5. SnO + H₂SO₄ → ___________ + H₂O
6. CuO + ___________ → CuCl₂ + H₂O
7. CaO + 2HNO₃ → ___________ + H₂O

**Reaction of Acids with Metals**

Metals + Acid → Salt + Hydrogen

Complete the equations (remember hydrochloric acid makes chloride salts, sulfuric acid makes sulfate salts and nitric acid makes nitrate salts)

For example,

Calcium + Sulfuric Acid → Calcium Sulfate + Hydrogen

1. Calcium + Hydrochloric Acid → ______________ + ____________
2. Magnesium + Sulfuric Acid → ______________ + ____________

3. Lead + Nitric Acid → ______________ + ____________
4. Iron + _______________ → Iron Chloride + ____________
5. Zinc + Sulfuric Acid → _______________ + Hydrogen
6. Tin + _______________ → Tin Nitrate + Hydrogen
7. Ca + 2HCl → _______________ + H₂
8. Mg + _______________ → MgSO₄ + H₂

**Reaction of Metal Carbonates with Acids**

Metal Carbonate + Acid → Salt + Water + Carbon Dioxide

For example,

Calcium Carbonate + Nitric Acid → Calcium Nitrate + Water + Carbon Dioxide

1. Magnesium carbonate + Hydrochloric Acid → ___________ + ___________ + ______________
2. Sodium Carbonate + Nitric Acid → ___________ + ___________ + ______________
3. Calcium Carbonate + Sulfuric Acid → ___________ + ___________ + ______________
4. Potassium Carbonate + Hydrochloric Acid → ___________ + ___________ + ______________
5. Lithium Carbonate + ___________ → Lithium Sulfate + ___________ + ______________
6. CaCO₃ + H₂SO₄ → ___________ + H₂O + CO₂
7. Na₂CO₃ + ___________ → 2NaCl + H₂O + CO₂

Reactions of acids with metal oxides, metals, and carbonates Answers
Metal Oxide + Acid → Salt + Water

For example,

Copper Oxide + Sulfuric Acid → Copper Sulfate + Water
8. Magnesium Oxide + Nitric Acid → Magnesium Nitrate + Water
9. Silver Oxide + Hydrochloric Acid → Silver Chloride + Water
10. Lead Oxide + Sulfuric Acid → Lead Sulfate + Water
11. Copper Oxide + Nitric Acid → Copper Nitrate + Water
12. SnO + H₂SO₄ → SnSO₄ + H₂O
13. CuO + 2HCl → CuCl₂ + H₂O
14. CaO + 2HNO₃ → Ca(NO₃)₂ + H₂O

Reaction of Acids with Metals
Complete the equations (remember hydrochloric acid makes chloride salts, sulfuric acid makes sulfate salts and nitric acid makes nitrate salts)

Metals + Acid → Salt + Hydrogen

For example,

Lithium + Sulfuric Acid → Lithium Sulfate + Hydrogen
1. Calcium + Hydrochloric Acid → Calcium Chloride + Hydrogen
2. Magnesium + Sulfuric Acid → Magnesium Sulfate + Hydrogen
3. Lead + Nitric Acid → Lead Nitrate + Hydrogen
4. Iron + Hydrochloric Acid → Iron Chloride + Hydrogen
5. Zinc + Sulfuric Acid → Zinc Sulfate + Hydrogen
6. Tin + Nitric Acid → Tin Nitrate + Hydrogen
7. Ca + 2HCl → CaCl₂ + H₂
8. Mg + H₂SO₄ → MgSO₄ + H₂

Reaction of Metal Carbonates with Acids

Metal Carbonate + Acid → Salt + Water + Carbon Dioxide

For example,

Calcium Carbonate + Hydrochloric Acid → Calcium Chloride + Water + Carbon Dioxide
1. Magnesium carbonate + Hydrochloric Acid → Magnesium Chloride + Water + Carbon Dioxide
2. Sodium Carbonate + Nitric Acid → Sodium Nitrate + Water + Carbon Dioxide
3. Calcium Carbonate + Sulfuric Acid → Calcium Sulfate + Water + Carbon Dioxide
4. Potassium Carbonate + Hydrochloric Acid → Potassium Chloride + Water + Carbon Dioxide
5. Lithium Carbonate + Sulfuric Acid → Lithium Sulfate + Water + Carbon Dioxide
6. CaCO₃ + H₂SO₄ → CaSO₄ + H₂O + CO₂
7. Na₂CO₃ + 2HCl → 2NaCl + H₂O + CO₂

11.6 ESSENTIAL EXAM QUESTIONS Paper 3/4 111 marks Topic 8.1 & 8.2

Topic Chem 8.1 Q# 2 /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>
<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>

(ii) The acids used for experiment 1 and experiment 3 have the same concentration. Explain why experiment 3 is slower than experiment 1.

6 Ammonia is a compound which only contains the elements nitrogen and hydrogen. It is a weak base.

(a) (i) Define the term base.

(ii) Given aqueous solutions of ammonia and sodium hydroxide, both having a concentration of 0.1 mol/dm³, how could you show that ammonia is the weaker base?

(b) (i) 2Li + 2H₂ → 2LiH + H₂

(ii) zinc carbonate + hydrochloric acid → zinc chloride + carbon dioxide + water

(iii) MgO + 2H₂ → MgH₂ + H₂O
(b) Two of the reactions in (a) are acid/base and one is redox. Which one is redox? Explain your choice.

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

(b) The only difference in the two experiments was the method used to hold down the magnesium. The results are shown below.

(c) The experiment was repeated using 1.0 mol/dm$^3$ propanoic acid instead of 1.0 mol/dm$^3$ hydrochloric acid. Propanoic acid is a weak acid.

(i) How would the graph for propanoic acid differ from the graph for hydrochloric acid?

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

(ii) How would the graph for propanoic acid be the same as the graph for hydrochloric acid?

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

(c) When lactic acid is heated, acrylic acid is formed.

Lactic acid

$\text{H} - \text{C} - \text{C} - \text{COOH}$

Acrylic acid

$\text{H} \equiv \text{C} - \text{C} - \text{COOH}$

(iii) Describe a test, other than using an indicator, which would show that both chemicals contain an acid group.

Test

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

Result

........................................................................................................................................................................................ [2]
5 Methylamine, CH₃NH₂, is a weak base. Its properties are similar to those of ammonia.

(a) When methylamine is dissolved in water, the following equilibrium is set up.

$$\text{CH}_3\text{NH}_2 + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{NH}_3^+ + \text{OH}^-$$

(i) Suggest why the arrows are not the same length.

(ii) Explain why water is stated to behave as an acid and methylamine as a base.

(b) An aqueous solution of the strong base, sodium hydroxide, is pH 12. Predict the pH of an aqueous solution of methylamine which has the same concentration. Give a reason for your choice of pH.

(c) Methylamine is a weak base like ammonia.

(i) Methylamine can neutralise acids.

$$2\text{CH}_3\text{NH}_2 + \text{H}_2\text{SO}_4 \rightarrow (\text{CH}_3\text{NH}_3)_2\text{SO}_4$$

Write the equation for the reaction between methylamine and hydrochloric acid. Name the salt formed.

(ii) When aqueous methylamine is added to aqueous iron(II) sulphate, a green precipitate is formed. What would you see if iron(III) chloride solution had been used instead of iron(II) sulphate?

(iii) Suggest the name of a reagent that will displace methylamine from one of its salts, for example methylammonium sulphate.

---

5 Carbonyl chloride, COCl₂, is a colourless gas. It is made by the following reaction.

$$\text{CO(g)} + \text{Cl}_2(g) \rightleftharpoons \text{COCl}_2(g)$$

(c) Carbonyl chloride reacts with water to form two acidic compounds. Suggest which acidic compounds are formed.

1. ................................................................. [2]

2. ................................................................. [2]
(b) The following apparatus was set up to investigate the electrical conductivity of dilute acids.

Dilute sulphuric acid is a strong acid. If it was replaced by a weak acid, what two differences in the observations would you expect to make?

(c) The equation for the reaction of X with cold water is given below.

\[ 2X(s) + 2H_2O(l) \rightarrow 2XOH(aq) + H_2(g) \]

(i) Describe the test you would use to show that the gas evolved is hydrogen.

(ii) How could you show that the water contained a compound of the type XOH?

(iii) In which group of the Periodic Table does metal X belong?

(iv) The ore of X is its chloride. Suggest how metal X could be extracted from its chloride.
3 (a) Four bottles were known to contain aqueous ammonia, dilute hydrochloric acid, sodium hydroxide solution and vinegar, which is dilute ethanoic acid. The bottles had lost their labels. The pH values of the four solutions were 1, 4, 10 and 13.

Complete the table.

<table>
<thead>
<tr>
<th>solution</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>aqueous ammonia</td>
<td></td>
</tr>
<tr>
<td>dilute hydrochloric acid</td>
<td></td>
</tr>
<tr>
<td>sodium hydroxide solution</td>
<td></td>
</tr>
<tr>
<td>vinegar</td>
<td></td>
</tr>
</tbody>
</table>

(b) The following apparatus was set up to investigate the electrical conductivity of dilute acids.

![Apparatus for investigating electrical conductivity]

Dilute sulphuric acid is a strong acid. If it was replaced by a weak acid, what two differences in the observations would you expect to make?

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

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

(c) When nitric acid is added to water the following reaction occurs.

\[ \text{HNO}_3 + \text{H}_2\text{O} \rightarrow \text{NO}_3^- + \text{H}_3\text{O}^+ \]

Give the name and the formula of the particle which is transferred from nitric acid to water.

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

formula .................................................................................................................................................... [2]
Propanoic acid is a weak acid.

(i) The following equation represents its reaction with ammonia.

CH$_3$-CH$_2$-COOH + NH$_3$ → CH$_3$-CH$_2$-COO$^{-}$ + NH$_4^+$

Explain why propanoic acid behaves as an acid and ammonia as a base.

(ii) Explain the expression weak acid.

(iii) Rock phosphate (calcium phosphate) is obtained by mining. It reacts with concentrated sulphuric acid to form the fertiliser, superphosphate. Predict the formula of each of these phosphates.

<table>
<thead>
<tr>
<th>Phosphate</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>calcium phosphate</td>
<td>Ca$^{2+}$ and PO$_4^{3-}$</td>
</tr>
<tr>
<td>calcium superphosphate</td>
<td>Ca$^{2+}$ and H$_2$PO$_4^-$</td>
</tr>
</tbody>
</table>

(iv) The ionic equation for the reaction between the phosphate ion and sulphuric acid is shown below.

PO$_4^{3-}$ + 2H$_2$SO$_4$ → H$_2$PO$_4^-$ + 2HSO$_4^-$

Explain why the phosphate ion is described as acting as a base in this reaction.

In 2002, Swedish scientists found high levels of acrylamide in starchy foods that had been cooked above 120°C. Acrylamide, which is thought to be a risk to human health, has the following structure.
(ii) Given an aqueous solution, concentration 0.1 mol/dm³, how could you show that acetic acid is a weak acid.

(c) Ammonia is a base.

(i) Name a particle that an ammonia molecule can accept from an acid.

(ii) Write an equation for ammonia acting as a base.

(d) Given aqueous solutions, 0.1 mol/dm³, of sodium hydroxide and ammonia, describe how you could show that ammonia is the weaker base.

4 Bromine is one of the halogens in Group VII.
(d) Phosphorus tribromide reacts with water to form two acids.

(i) Balance the equation for this reaction.

\[ \text{PBr}_3 + \text{H}_2\text{O} \rightarrow \text{HBr} + \text{H}_3\text{PO}_4 \] [1]

(ii) Describe by giving essential details how you could show that phosphorous acid, \( \text{H}_3\text{PO}_4 \), is a weaker acid than hydrogen bromide.

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

(e) Hydrogen bromide is an acid. When it is dissolved in water the following reaction occurs.

\[ \text{HBr} + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{Br}^- \]

(i) Name the particle lost by the hydrogen bromide molecule.

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

(ii) What type of reagent is the water molecule in this reaction?

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

Topic Chem 8.2 Q# 20/ IGCSE Chemistry/2015/w/Paper 31/

6 Carbon and silicon are elements in Group IV. They both form oxides of the type \( \text{XO}_2 \).

(iii) How could you show that silicon(IV) oxide is acidic and not basic or amphoteric?

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

Topic Chem 8.2 Q# 21/ IGCSE Chemistry/2015/w/Paper 31/

2 Describe how to separate the following. In each example, give a description of the procedure used and explain why this method works.

(a) Magnesium hydroxide from a mixture of magnesium hydroxide and zinc hydroxide.

procedure ...........................................................................................................................................

explanation ...........................................................................................................................................

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

Topic Chem 8.2 Q# 22/ IGCSE Chemistry/2015/s/Paper 31/

3 (a) The reactions between metals and acids are redox reactions.

\[ \text{Zn} + 2\text{H}^+ \rightarrow \text{Zn}^{2+} + \text{H}_2 \]

(c) If the first experiment was repeated using ethanoic acid, \( \text{CH}_3\text{COOH} \), instead of hydrochloric acid, how and why would the graph be different from graph 1? 

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

Topic Chem 8.2 Q# 23/ IGCSE Chemistry/2014/s/Paper 31/Q4

(b) Across a period, the elements change from metallic to non-metallic.

(i) Describe how the type of oxide changes across this period.

........................................................................................................................................... [2]
2. An element, M, has the electron distribution $2 + 8 + 18 + 3$.
   (e) The hydroxide of M is a white powder which is insoluble in water. Describe how you could show that this hydroxide is amphoteric.

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

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

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

   Topic Chem 8.2 Q# 25/ iGCSE Chemistry/2012/w/Paper 31/ 4 Silicon(IV) oxide, SiO$_2$, and zirconium(IV) oxide, ZrO$_2$, are both non-metal oxides. They have similar physical properties but silicon(IV) oxide is acidic and zirconium(IV) oxide is amphoteric.

   (c) (i) Name a reagent that reacts with the oxides of both elements.
       ........................................................................................................................................................................... [1]

   (ii) Name a reagent that reacts with only one of the oxides.

       reagent .........................................................................................................................................................................

       oxide which reacts ................................................................................................................................................. [2]

   Topic Chem 8.2 Q# 26/ iGCSE Chemistry/2011/w/Paper 31/ 1 This question is concerned with the following oxides.

       sulfur dioxide
carbon monoxide
lithium oxide
aluminum oxide
nitrogen dioxide
strontium oxide

   (a) (i) Which of the above oxides will react with hydrochloric acid but not with aqueous sodium hydroxide?
       ........................................................................................................................................................................... [1]

   (ii) Which of the above oxides will react with aqueous sodium hydroxide but not with hydrochloric acid?
       ........................................................................................................................................................................... [1]

   (iii) Which of the above oxides will react with both hydrochloric acid and aqueous sodium hydroxide?
       ........................................................................................................................................................................... [1]

   (iv) Which of the above oxides will not react with hydrochloric acid or with aqueous sodium hydroxide?
       ........................................................................................................................................................................... [1]

   Topic Chem 8.2 Q# 27/ iGCSE Chemistry/2010/w/Paper 31/Q6

   (b) Beryllium hydroxide, a white solid, is an amphoteric hydroxide.

   (i) Name another metal which has an amphoteric hydroxide.
       ........................................................................................................................................................................... [1]

   (ii) Suggest what you would observe when an excess of aqueous sodium hydroxide is added gradually to aqueous beryllium sulfate.
       ........................................................................................................................................................................... [2]

   Topic Chem 8.2 Q# 28/ iGCSE Chemistry/2006/s/Paper 3/ Q3
(d) This question is concerned with the following oxides.

- aluminium oxide $\text{Al}_2\text{O}_3$
- calcium oxide $\text{CaO}$
- carbon dioxide $\text{CO}_2$
- carbon monoxide $\text{CO}$
- magnesium oxide $\text{MgO}$
- sulphur dioxide $\text{SO}_2$

(i) Which of the above oxides will react with hydrochloric acid but not with aqueous sodium hydroxide?

(ii) Which of the above oxides will react with aqueous sodium hydroxide but not with hydrochloric acid?

(iii) Which of the above oxides will react both with hydrochloric acid and with aqueous sodium hydroxide?

(iv) Which of the above oxides will react neither with hydrochloric acid nor with aqueous sodium hydroxide?

(c) Complete the following table by writing “reaction” or “no reaction” in the spaces provided.

<table>
<thead>
<tr>
<th>oxide</th>
<th>type of oxide</th>
<th>reaction with acid</th>
<th>reaction with alkali</th>
</tr>
</thead>
<tbody>
<tr>
<td>magnesium</td>
<td>basic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>aluminium</td>
<td>amphoteric</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[2]

(b) (i) Complete the word equation.

$manganese(II) + \text{hydrochloric acid} \rightarrow \text{oxide} + \text{acid}$

(ii) Which, if any, of these oxides will react with sodium hydroxide?

[2]
Q1. Match the following pH values to the solutions given below.

1. 3 7 10 13

The solutions all have the same concentration.

<table>
<thead>
<tr>
<th>Solution</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aqueous ammonia, weak base</td>
<td>10</td>
</tr>
<tr>
<td>Dilute hydrochloric acid, a strong acid</td>
<td>1</td>
</tr>
<tr>
<td>Aqueous sodium hydroxide, a strong base</td>
<td>13</td>
</tr>
<tr>
<td>Aqueous sodium chloride, a salt</td>
<td>7</td>
</tr>
<tr>
<td>Dilute ethanoic acid, a weak acid</td>
<td>3</td>
</tr>
</tbody>
</table>

(b) Hydrochloric acid: strong acid or ethanoic acid: weak acid

OR: hydrochloric acid: completely ionised or ethanoic acid: partially ionised
hydrochloric acid: greater concentration of more H⁺ ions than ethanoic acid.

(c) Rate of reaction with Ca, Mg, Zn, Fe

Strong (hydrochloric) acid: faster or more bubbles or dissolves faster

OR: rate of reaction with (metal) carbonate

Strong (hydrochloric) acid: faster or more bubbles or dissolves faster (only if carbonate insoluble)

OR: electrical conductivity

Strong (hydrochloric) acid: better conductor

Q2. (iii) Ethanoic acid is a weak acid or hydrochloric acid is a strong acid

Accept: stronger or weaker

Ethanoic acid: less ionised / dissociated / lower / smaller concentration of hydrogen ions [1]

Accept: less hydrogen ions and vice versa argument but not dissociation of ions

Q3. (a) (i) Proton or H⁺ acceptor

(ii) (measure) pH or (use) pH indicator

Note: can be implied need not be explicit

Sodium hydroxide has higher pH / ammonium(aq) has lower pH

This sentence would score 2 marks.

OR: Appropriate colours with pH table / appropriate numerical values

Ammonia is closer to green, blue-green, turquoise or lighter blue

Sodium hydroxide is darker blue / purple / violet

OR: Measure electrical conductivity

Can be implied need not be explicit

Ammonia (aq) is the poorer conductor / Sodium hydroxide is the better conductor

Q4. (iii) 1.33 / 1.3 / 1.3333 (mol/dm³) scores both marks not 1.34

For a correct method – Mₙ Vₙ / moles of NaOH = 0.02

With an incorrect answer only [1]

Q5. (c) Hess

Not alkali

Accepts a proton

Accepts hydrogen ion / H⁺ only [1]

Proton and H⁺ [2]

Q6. (b) Reaction 1 is redox / Li/Hi reaction

Condensation either oxidation number state / Electron transfer

Q7. (c) (i) Smaller gradient not rate is slower

(ii) Same final volume of hydrogen / same level (on graph)

Q8. (iii) Naphthol

Observation result

Suitable named metal (NOT sodium, lead, any metal below magnesium etc.)

If un-named metal [0] result can score [1]

Hydrogen evolved or bubbles / effervescence / fizzing

Insoluble metal oxide

Colour changes or dissolves

Any carbonate or bicarbonate

Gas / Carbon dioxide / bubbles / effervescence / fizzing

Sodium hydroxide or alkaline

Temperature increase or accept indicator to show neutralisation

Unspecified base scores [1] only

NOT alcohol

Q9. (b) (i) Because it accepts a proton

Accepts hydrogen ion or H⁺ ONLY [1]

Proton and H⁺ [2]

(ii) Hydrochloric acid is a strong acid

Hydrogen fluoride is a weak acid

Weaker or stronger correctly applied for [2]
Q10/ IGCSE Chemistry/2008/s/Paper 31/Q5

(iii) hydrogen chloride (aqueous) would have lower pH
OR hydrogen fluoride (aqueous) would have higher pH
If values suggested, not over 7

(c) hydrogen chloride or hydrochloric acid
carbon dioxide or carbonic acid or hydrogen carbonate

Q11/ IGCSE Chemistry/2007/w/Paper 3/

5 (a) (i) equilibrium to left or many molecules and few ions or partially ionised or reverse reaction favoured

(ii) Water donates proton
methylamine accepts a proton
NOTE if hydrogen ion then ONLY [1] provided both are correct

(b) less than 12 more than 7
smaller concentration of hydroxide ions or partially dissociated
or poor proton acceptor or poor H⁺ acceptor
NOT it is a weak base

(c) (i) CH₂NH₂ + HCl = CH₂NH₃Cl
methylammonium chloride
NOTE the equation must be as written, the equation with sulphuric acid has been given as guidance.

(ii) brown precipitate
ACCEPT orange or red/brown or brick red or brown/red

(iii) sodium hydroxide or any named strong base

Q12/ IGCSE Chemistry/2006/w/Paper 3/ Q3

(b) With strong acid bulb brighter
faster rate of bubbles
OR corresponding comments for weak acid

Q13/ IGCSE Chemistry/2006/s/Paper 3/ Q2

(c) (i) goes "pop" with burning splint
or mixed with air and ignited goes pop
NOT glowing splint

(ii) test and observable result
universal indicator goes blue
or pH paper goes blue
or high pH, accept 13, 14
or ammonium ion gives off ammonia
or with metallic cations forms a precipitate
NOT litmus
ONLY accept - neutralises acids with an observable result, e.g. becomes warm.

(iii) Group 1

(iv) electrolysis
COND molten
Q# 14/ iGCSE Chemistry/2006/s/Paper 3/
3  (a) ammonia 10
  hydrochloric acid 1
  sodium hydroxide 13
  ethanoic acid 4
  All correct [2]
  Two correct [1]
  (b) With strong acid bulb brighter [1]
  faster rate of bubbles [1]
  OR corresponding comments for weak acid [1]
  (c) proton NCT hydrogen ion [1]
  H⁺ not conditional on proton [1]
  Only way (or [2] is proton and H⁺ [1]

Q# 15/ iGCSE Chemistry/2005/s/Paper 3/Q3:
(d) (i) acid loses a proton
   base accepts a proton [2]
   OR same explanation but acid loses a hydrogen ion (1)
   and base gains hydrogen ion (1) [1]

(ii) only partially ionised or poor hydrogen ion donor or poor proton donor [1]
   NOT does not form many hydrogen ions in water or low concentration of hydrogen ions
   NOT pH [1]

Q# 16/ iGCSE Chemistry/2004/s/Paper 3/ Q2 (b)
(iii) \( \text{Ca(H}_2\text{PO}_4\text{)}_2 \) [1]

(iv) only acceptable responses are:
    accepts a proton [2]
    accepts H⁺ [1] only

Q# 17/ iGCSE Chemistry/2004/s/Paper 3/ (ii)
measure pH
   more than 1 and less than 7 or
correct colour eg orange or yellow NOT red
   NOT green [1]
   OR add magnesium or calcium carbonate
   weak acid reacts slowly

Q# 18/ iGCSE Chemistry/2003/s/Paper 3/ iGCSE Chemistry/201

Q# 19/ iGCSE Chemistry/2002/s/Paper 3/ Q4
(d) (i) balanced [1]
(ii) pH phosphorous acid has higher pH [1]
   OR electrical conductivity phosphorous acid poorer [1]
   OR reaction with named metal or carbonate hydrobromic faster [1]
   OR pH indicator correct colours [1]

(ii) proton or hydrogen ion [1]
   OR base or proton acceptor or electron pair donor [1]

Q# 20/ iGCSE Chemistry/2015/w/Paper S1/ (b)
(iii) \( \text{SO}_2 \text{ reacts with or dissolves in or neutralises an acid or acidic salt;} \) [1]
\( \text{SO}_2 \text{ does not react or dissolve in or neutralise an alkali or basic salt;} \) [1]

Q# 21/ iGCSE Chemistry/2015/w/Paper 31/ (ii)
(iii) Iodine/iodide (b amphethic b) will react or will dissolve/magnesium hydroxide does not react or does not dissolve [1]
Q# 22/ iGCSE Chemistry/2015/s/Paper 31/ Q3
Q# 23/ IGCSE Chemistry/2014/s/Paper 31/ Q4
(b) (i) Assume change is from L to R unless clearly stated:
   basic to amphoteric to acidic (2) [2]

Q# 24/ IGCSE Chemistry/2013/s/Paper 31/ Q2
(e) it would react with dissolves in a named strong acid
   it would react with dissolves in a named alkali
   it reacts with both acids and bases/alkalis = 1
   [max 2]

Q# 25/ IGCSE Chemistry/2012/w/Paper 31/ Q4
(c) (i) sodium hydroxide / any named alkali / reactive metal
   (ii) named acid; Zn(II) carbonate oxide
   (iii) sulfur dioxide / nitrogen dioxide
   (iv) carbon monoxide
   accept: correct formulæ
   [1]

Q# 26/ IGCSE Chemistry/2011/w/Paper 31/
1 (a) (i) lithium oxide / strontium oxide
   (ii) sulfur dioxide / nitrogen dioxide
   (iii) aluminium oxide
   (iv) carbon monoxide
   [1]

Q# 27/ IGCSE Chemistry/2010/w/Paper 31/ Q6
(b) (i) zinc / aluminium / lead / tin / chromium
   (ii) white precipitate
   precipitate dissolves / colourless solution forms / forms a clear solution
   soluble in excess
   [1]

Q# 28/ IGCSE Chemistry/2006/s/Paper 3/ Q3
(d) (i) CaO and MgO
   (ii) CO₂ and SO₂
   (iii) Al₂O₃
   (iv) CO
   [1]

Q# 29/ IGCSE Chemistry/2005/s/Paper 3/Q6
(c) reaction no reaction reaction
   reaction
   [1]

Q# 30/ IGCSE Chemistry/2002/w/Paper 3/ Q3 (c)
(ii) sodium
   (iii) sulphur or chlorine
   [1]

Q# 31/ IGCSE Chemistry/2002/w/Paper 3/ Q2
(b) (i) manganese chloride
   water
   (ii) manganese(II) and (IV) oxides
   [1]
### 11.7 FUNDAMENTAL Assessed Activity 1 Keyword Test

<table>
<thead>
<tr>
<th>English</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>litmus</td>
<td></td>
</tr>
<tr>
<td>amphoteric hydroxides</td>
<td></td>
</tr>
<tr>
<td>acidic oxides</td>
<td></td>
</tr>
<tr>
<td>neutralisation</td>
<td></td>
</tr>
<tr>
<td>pH scale</td>
<td></td>
</tr>
<tr>
<td>precipitation reaction</td>
<td></td>
</tr>
<tr>
<td>weak acid</td>
<td></td>
</tr>
<tr>
<td>acid</td>
<td></td>
</tr>
<tr>
<td>indicator</td>
<td></td>
</tr>
<tr>
<td>base</td>
<td></td>
</tr>
<tr>
<td>strong alkali</td>
<td></td>
</tr>
<tr>
<td>strong acid</td>
<td></td>
</tr>
<tr>
<td>weak alkali</td>
<td></td>
</tr>
<tr>
<td>corrosive</td>
<td></td>
</tr>
<tr>
<td>Universal Indicator</td>
<td></td>
</tr>
</tbody>
</table>

### 11.8 FUNDAMENTAL Assessed Activity 2 Paper 1 Topic 8.1 and 8.2 18marks

**Q# 1/14**

Three chemicals, P, Q and R, were each dissolved in water. The table shows some of the reactions of these solutions.

<table>
<thead>
<tr>
<th>solution</th>
<th>reaction when solid sodium carbonate is added</th>
<th>reaction when heated with solid ammonium chloride</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>gas evolved</td>
<td>no reaction</td>
</tr>
<tr>
<td>Q</td>
<td>no reaction</td>
<td>gas evolved</td>
</tr>
<tr>
<td>R</td>
<td>no reaction</td>
<td>no reaction</td>
</tr>
</tbody>
</table>

The pH of the three solutions was also measured.

What are the correct pH values of these solutions?

<table>
<thead>
<tr>
<th></th>
<th>P</th>
<th>Q</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>B</td>
<td>2</td>
<td>13</td>
<td>7</td>
</tr>
<tr>
<td>C</td>
<td>7</td>
<td>2</td>
<td>13</td>
</tr>
<tr>
<td>D</td>
<td>13</td>
<td>7</td>
<td>2</td>
</tr>
</tbody>
</table>
15 The oxide of element X forms a solution with pH 4.
The oxide of element Y forms a solution that turns Universal Indicator blue.
Which row correctly classifies elements X and Y?

<table>
<thead>
<tr>
<th>element X</th>
<th>element Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>A metal</td>
<td>metal</td>
</tr>
<tr>
<td>B metal</td>
<td>non-metal</td>
</tr>
<tr>
<td>C non-metal</td>
<td>metal</td>
</tr>
<tr>
<td>D non-metal</td>
<td>non-metal</td>
</tr>
</tbody>
</table>

16 Which two processes are involved in the preparation of magnesium sulfate from dilute sulfuric acid and an excess of magnesium oxide?
A neutralisation and filtration
B neutralisation and oxidation
C thermal decomposition and filtration
D thermal decomposition and oxidation

Q# 2/
32 The diagram shows two substances, X and Y, being heated together.

The Universal Indicator paper turns blue during the experiment.
What are substances X and Y?
A ammonium nitrate and hydrochloric acid
B ammonium nitrate and sodium hydroxide
C sodium carbonate and hydrochloric acid
D sodium carbonate and sodium hydroxide

Q# 3/
17 Element X forms an acidic, covalent oxide.
Which row shows how many electrons there could be in the outer shell of an atom of X?

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>B</td>
<td>✓</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>C</td>
<td>x</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>D</td>
<td>x</td>
<td>✓</td>
<td>x</td>
</tr>
</tbody>
</table>

18 Barium hydroxide is an alkali. It reacts with hydrochloric acid.
How does the pH of the hydrochloric acid change as an excess of aqueous barium hydroxide is added?
A The pH decreases from 14 and becomes constant at 7.
B The pH decreases from 14 to about 1.
C The pH increases from 1 and becomes constant at 7.
D The pH increases from 1 to about 14.
19 A compound is a salt if it
   A. can neutralise an acid.
   B. contains more than one element.
   C. dissolves in water.
   D. is formed when an acid reacts with a base.

Q#5/
17 The graph shows how the pH changes as an acid is added to an alkali.

\[ \text{acid + alkali} \rightarrow \text{salt + water} \]

Which letter represents the area of the graph where both acid and salt are present?

Q#6/
15 An experiment to determine the rate of a chemical reaction could be carried out using the apparatus shown.

Which reaction is being studied?
   A. \( \text{Cl}_2 + 2\text{KBr} \rightarrow 2\text{KCl} + \text{Br}_2 \)
   B. \( \text{Mg} + \text{H}_2\text{SO}_4 \rightarrow \text{MgSO}_4 + \text{H}_2 \)
   C. \( \text{NaCl} + \text{AgNO}_3 \rightarrow \text{NaNO}_3 + \text{AgCl} \)
   D. \( \text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O} \)

16 Copper(II) carbonate reacts with dilute sulfuric acid.

\[ \text{CuCO}_3(aq) + \text{H}_2\text{SO}_4(aq) \rightarrow \text{CuSO}_4(aq) + \text{CO}_2(g) + \text{H}_2\text{O}(l) \]

The speed of the reaction can be changed by varying the conditions.

Which conditions would always increase the speed of this chemical reaction?
   1. Increase the concentration of the reactants.
   2. Increase the size of the pieces of copper(II) carbonate.
   3. Increase the temperature.
   4. Increase the volume of sulfuric acid.

A. 1, 3 and 4  B. 1 and 3 only  C. 2 and 3  D. 3 and 4 only

17 Which type of reaction always forms a salt and water?
   A. exothermic
   B. neutralisation
   C. oxidation
   D. polymerisation

18 Which property is not characteristic of a base?
   A. It reacts with a carbonate to form carbon dioxide.
   B. It reacts with an acid to form a salt.
   C. It reacts with an ammonium salt to form ammonia.
   D. It turns universal indicator paper blue.

19 An alloy contains copper and zinc.

Some of the zinc has become oxidised to zinc oxide.

What is the result of adding an excess of dilute sulfuric acid to the alloy?
   A. A blue solution and a white solid remains.
   B. A colourless solution and a pink/brown solid remains.
   C. The alloy dissolves completely to give a blue solution.
   D. The alloy dissolves completely to give a colourless solution.
Q# 7/

17 Carbon dioxide is an acidic oxide that reacts with aqueous calcium hydroxide.

Which type of reaction takes place?

A decomposition  
B fermentation  
C neutralisation  
D oxidation

18 Which is not a typical property of an acid?

A They react with alkalis producing water.  
B They react with all metals producing hydrogen.  
C They react with carbonates producing carbon dioxide.  
D They turn litmus paper red.

Q# 8/

20 Which reaction will result in a decrease in pH?

A adding calcium hydroxide to acid soil  
B adding citric acid to sodium hydrogen carbonate solution  
C adding sodium chloride to silver nitrate solution  
D adding sodium hydroxide to hydrochloric acid

21 The oxide of element X was added to an acid. It reacted to form a salt and water.

What is the pH of the acid before the reaction and what type of element is X?

<table>
<thead>
<tr>
<th>pH</th>
<th>type of element X</th>
</tr>
</thead>
<tbody>
<tr>
<td>A greater than 7</td>
<td>metal</td>
</tr>
<tr>
<td>B greater than 7</td>
<td>non-metal</td>
</tr>
<tr>
<td>C less than 7</td>
<td>metal</td>
</tr>
<tr>
<td>D less than 7</td>
<td>non-metal</td>
</tr>
</tbody>
</table>
11.9 ESSENTIAL Assessed Activity 3 Topic 8.1 & 8.2 Paper 3/4 18 marks

6 Acid-base reactions are examples of proton transfer.

(a) Ethylamine is a weak base and sodium hydroxide is a strong base.

(i) In terms of proton transfer, explain what is meant by the term weak base.

(ii) Given aqueous solutions of both bases, describe how you could show that sodium hydroxide is the stronger base. How could you ensure a fair comparison between the two solutions?

(b) Ethylamine reacts with acids to form salts.

\[ \text{CH}_3\text{CH}_2\text{NH}_2 + \text{HCl} \rightarrow \text{CH}_3\text{CH}_2\text{NH}_3\text{Cl} \]

(i) Complete the equation for the reaction between sulfuric acid and ethylamine. Name the salt formed:

(ii) Amines and their salts have similar chemical properties to ammonia and ammonium salts.

Suggest a reagent that could be used to displace the weak base, ethylamine, from its salt ethylammonium chloride.

2 Oxides are classified as acidic, basic, neutral and amphoteric.

(a) Complete the table.

<table>
<thead>
<tr>
<th>type of oxide</th>
<th>pH of solution of oxide</th>
<th>example</th>
</tr>
</thead>
<tbody>
<tr>
<td>acidic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>basic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>neutral</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(b) (i) Explain the term amphoteric.

(ii) Name two reagents that are needed to show that an oxide is amphoteric.
11.10 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?

11.11 Exceptional Additional Activities, Further Reading and Exploring Beyond the Syllabus

To find out about the strongest acids click here, and for more information about the least reactive metals by going to this website:

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

Fluoroantimonic acid

From Wikipedia, the free encyclopedia

Fluoroantimonic acid is an inorganic compound with the chemical formula H$_2$FSbF$_6$ (also written H$_2$F[SbF$_6$], 2HF·SbF$_5$, or simply HF-SbF$_5$). It is an extremely strong acid, easily qualifying as a superacid. The Hammett acidity function, $H_0$, has been measured for different ratios of HF:SbF$_5$. While the $H_0$ of pure HF is −15, addition of just 1 mol % of SbF$_5$ lowers it to around −20. However, further addition of SbF$_5$ results in rapidly diminishing returns, with the $H_0$ reaching −21 at 10 mol %. The use of an extremely weak base as indicator shows that the lowest attainable $H_0$, even with > 50 mol % SbF$_5$, is somewhere between −21 and −23.

The "canonical" composition of fluoroantimonic acid is prepared by treating liquid hydrogen fluoride (HF) with liquid antimony pentafluoride (SbF$_5$) in a stoichiometric ratio of 2:1. It is the strongest superacid based on measured $H_0$ value. Only the carborane acids, whose $H_0$ could not be directly determined due to their high melting points, may be stronger acids than fluoroantimonic acid. It has been shown to protonate even hydrocarbons to afford pentacoordinate carbanions (carbonium ions). It is exceptionally corrosive and can only be stored in containers lined with Teflon.

Fluoroantimonic acid thermally decomposes when heated, generating free hydrogen fluoride gas and liquid antimony pentfluoride. At temperatures as low as 40 °C, fluoroantimonic acid will release HF into the gas phase. Antimony pentfluoride liquid can be recovered from fluoroantimonic acid by heating and releasing HF into the gas phase.

The reaction to produce fluoroantimonic acid results in formation of the fluoronium ion as a major species in equilibrium:

$$\text{SbF}_5 + 2 \text{HF} \rightleftharpoons \text{SbF}_4^+ + \text{H}_3\text{F}^-$$
### 12 Topic 8.3 & 8.4 Making Salts & Testing for Ions and Gases

#### 12.1 End of Topic 8.3 & 8.4 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><strong>Interacted with your teacher</strong></td>
<td>Ask your teacher 1 question, about anything, once a week</td>
<td>FUNDAMENTAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Try to answer one question asked by your teacher at least once a week</td>
<td>ESSENTIAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ask your teacher one question about something you do not understand in science once a week</td>
<td>ESSENTIAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ask your teacher one question about something to do with science every lesson</td>
<td>EXTENSION</td>
<td></td>
</tr>
<tr>
<td><strong>Notes and follow up notes</strong></td>
<td>Complete set of class note</td>
<td>FUNDAMENTAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Attempted</td>
<td>ESSENTIAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Completed</td>
<td>ESSENTIAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Completed to an exemplary standard</td>
<td>EXCEPTIONAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Attempted the Mind Map for this topic</td>
<td>ESSENTIAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Completed the Mind Map for this topic</td>
<td>EXTENSION</td>
<td></td>
</tr>
<tr>
<td><strong>Textbook</strong></td>
<td>Read ahead before the topic has been started</td>
<td>EXTENSION</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Highlighted key ideas and translate new words</td>
<td>FUNDAMENTAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Added to your class notes ideas and important information from the textbook that you learnt</td>
<td>EXTENSION</td>
<td></td>
</tr>
<tr>
<td><strong>Past Exam Questions</strong></td>
<td>Worked on at least 25% of the exam questions in this workbook</td>
<td>FUNDAMENTAL</td>
<td></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>ESSENTIAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Completed, marked and added additional key ideas where you have located the most difficult marks added to your notebook</td>
<td>EXTENSION</td>
<td></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>EXCEPTIONAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ask your teacher about an exam question that they cannot answer</td>
<td>EXCEPTIONALLY SMASHING!!</td>
<td></td>
</tr>
<tr>
<td><strong>Assessed Activities</strong></td>
<td>Complete the word list activities using the word list at the front of each topic as little as possible</td>
<td>FUNDAMENTAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities, either in class or as homework</td>
<td>ESSENTIAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 70% on average</td>
<td>ESSENTIAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 80% on average</td>
<td>EXTENSION</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Complete 2 assessed activities and scored over 90% on average</td>
<td>EXCEPTIONAL</td>
<td></td>
</tr>
<tr>
<td><strong>End of Topic Test</strong></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>ESSENTIAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Scored 30% higher than your current average</td>
<td>ESSENTIAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Scored 15% or more than your previous end of topic average</td>
<td>EXCEPTIONAL</td>
<td></td>
</tr>
</tbody>
</table>

---

#### Tests for anions

<table>
<thead>
<tr>
<th>Anion</th>
<th>Test</th>
<th>Test result</th>
</tr>
</thead>
<tbody>
<tr>
<td>carbonate (CO₃²⁻)</td>
<td>add dilute acid</td>
<td>effervescence, carbon dioxide produced</td>
</tr>
<tr>
<td>chromate (CrO₄²⁻) in solution</td>
<td>acetic acid, bromate oxalic acid, zinc oxide</td>
<td>white ppt.</td>
</tr>
<tr>
<td>bromide (Br⁻) in solution</td>
<td>acidify with dilute nitric acid, then add aqueous silver nitrate</td>
<td>cream ppt.</td>
</tr>
<tr>
<td>iodide (I⁻) in solution</td>
<td>acidify with dilute nitric acid, then add aqueous silver nitrate</td>
<td>yellow ppt.</td>
</tr>
<tr>
<td>nitrate (NO₃⁻) in solution</td>
<td>aqueous sodium hydroxide, then aluminium foil; warm carefully</td>
<td>ammonia produced</td>
</tr>
<tr>
<td>sulfate (SO₄²⁻) in solution</td>
<td>acidify, then add aqueous barium nitrate</td>
<td>white ppt.</td>
</tr>
<tr>
<td>sulfite (SO₃²⁻)</td>
<td>add dilute hydrochloric acid, wash gently and test for the presence of sulfur dioxide</td>
<td>sulfur dioxide produced will turn acidified aqueous potassium manganate(VII) from purple to colourless</td>
</tr>
</tbody>
</table>

---

### Tests for aqueous cations

<table>
<thead>
<tr>
<th>Cation</th>
<th>Effect of aqueous sodium hydroxide</th>
<th>Effect of aqueous ammonia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium (Al$^{3+}$)</td>
<td>White ppt., soluble in excess, giving a colourless solution</td>
<td>White ppt., insoluble in excess</td>
</tr>
<tr>
<td>Ammonium (NH$_4^+$)</td>
<td>Ammonia produced on warming</td>
<td>–</td>
</tr>
<tr>
<td>Calcium (Ca$^{2+}$)</td>
<td>White ppt., insoluble in excess</td>
<td>No ppt. or very slight white ppt.</td>
</tr>
<tr>
<td>Chromium(III) (Cr$^{3+}$)</td>
<td>Green ppt., soluble in excess</td>
<td>Green ppt., soluble in excess</td>
</tr>
<tr>
<td>Copper(II) (Cu$^{2+}$)</td>
<td>Light blue ppt., insoluble in excess</td>
<td>Light blue ppt., soluble in excess, giving a dark blue solution</td>
</tr>
<tr>
<td>Iron(II) (Fe$^{2+}$)</td>
<td>Green ppt., insoluble in excess</td>
<td>Green ppt., soluble in excess</td>
</tr>
<tr>
<td>Iron(III) (Fe$^{3+}$)</td>
<td>Red-brown ppt., insoluble in excess</td>
<td>Red-brown ppt., insoluble in excess</td>
</tr>
<tr>
<td>Zinc (Zn$^{2+}$)</td>
<td>White ppt., soluble in excess, giving a colourless solution</td>
<td>White ppt., soluble in excess, giving a colourless solution</td>
</tr>
</tbody>
</table>

### Tests for gases

<table>
<thead>
<tr>
<th>Gas</th>
<th>Test and test result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia (NH$_3$)</td>
<td>Turns damp red litmus paper blue</td>
</tr>
<tr>
<td>Carbon dioxide (CO$_2$)</td>
<td>Turns limewater milky</td>
</tr>
<tr>
<td>Chlorine (Cl$_2$)</td>
<td>Bleaches damp litmus paper</td>
</tr>
<tr>
<td>Hydrogen (H$_2$)</td>
<td>’Pops’ with a lighted splint</td>
</tr>
<tr>
<td>Oxygen (O$_2$)</td>
<td>Relights a glowing splint</td>
</tr>
<tr>
<td>Sulfur dioxide (SO$_2$)</td>
<td>Turns acidified aqueous potassium manganate(VII) from purple to colourless</td>
</tr>
</tbody>
</table>

### Flame tests for metal ions

<table>
<thead>
<tr>
<th>Metal ion</th>
<th>Flame colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lithium (Li$^+$)</td>
<td>Red</td>
</tr>
<tr>
<td>Sodium (Na$^+$)</td>
<td>Yellow</td>
</tr>
<tr>
<td>Potassium (K$^+$)</td>
<td>Lilac</td>
</tr>
<tr>
<td>Copper(II) (Cu$^{2+}$)</td>
<td>Blue-green</td>
</tr>
</tbody>
</table>

### 8.3 Preparation of salts

**Core**

- Demonstrate knowledge and understanding of the preparation, separation and purification of salts as examples of some of the techniques specified in section 2.2.2 and the reactions specified in section 8.1

**Supplement**

- Demonstrate knowledge and understanding of the preparation of insoluble salts by precipitation
- Suggest a method of making a given salt from a suitable starting material, given appropriate information

### 8.4 Identification of ions and gases

**Core**

- Describe the following tests to identify aqueous cations: aluminium, ammonium, calcium, chromium(III), copper(II), iron(II), iron(III) and zinc (using aqueous sodium hydroxide and aqueous ammonia as appropriate). (Formaldehyde complex ions are not required.)

**Cations:**
- Use of the flame test to identify lithium, sodium, potassium and copper(II)
- Carbonate (by reaction with dilute acid and then limewater), chloride, bromide and iodide (by reaction under acidic conditions with aqueous silver nitrate), nitrate (by reduction with aluminium), sulfate (by reaction under acidic conditions with aqueous barium ions) and sulfite (by reaction with dilute acids and then aqueous potassium manganate(VII))

**Gases:**
- Ammonia (using damp red litmus paper), carbon dioxide (using limewater), chlorine (using damp litmus paper), hydrogen (using lighted splint), oxygen (using a glowing splint), and sulfur dioxide (using aqueous potassium manganate(VII))

### 12.2 ESSENTIAL Glossary for Keywords for this topic

All of these keywords are covered in the first part of this topic in the previous chapter.
12.3 ESSENTIAL Classroom Active Learning Tasks Learning About Mnemonics

Cats (cations) are Pawsitive. This cat (who is world famous as “Buff Cat”) does not need to be positive because he is extremely buff. But all of the other cats are positively charged.

What makes a good mnemonic?

Usually it is an image or idea that stands out, that is able to make an impression on your emotions.

Not all things are as easy to remember: often, if it is hard to remember than it is usually a result of hesitation or nervousness when you are learning. The only way for many years I was able to know the charge of a cation was as a result of this mnemonic, I still only know the difference between left and right because if look at my left hand and extend my thumb and index finger, it makes an “L”. Other more complex ideas I can learn and use with relative ease, there is a famous saying “only the average person is good at everything”. Another useful phrase is “if you’re not railing it means you are not trying hard enough”. I still don’t know, instinctively, left from right. What you know and what you don’t know is a very poor measure of intelligence, it’s what you do and who you help that, I think, defines the value of a mind.

12.3.1 Reflection and Investigation

What is IQ (Intelligence Quotient)? When was it invented and why? Has it helped us better understand ourselves? Are there any negatives to IQ and what people have done as a result? Does having a higher IQ make you a better person?

What is EQ (there are two very different versions)?

Some people are professional (they earn a living) memory specialists, are they born with that ability or is it a skill set they have learnt?

12.4 Extension Classroom Active Learning Tasks Thinking deeper about mnemonics.

For a Zoom tutorial on ions tests scan this code:

Or click here

Ions tests mnemonics:

The chemistry behind these ideas is genuinely, almost, interesting. However, it goes into A2 Level and beyond, so this is just a collection of facts that you ought to memorise.

FUNDAMENTAL ANSWER: If you are struggling with this subject and would be happy with a B grade, then this answer would most likely be the best way forward. For all ion test questions simply write “white ppt”. Do not include anything else, this one answer can sometimes be up to 60% of the marks, and nearly always it is at least 25% of the marks. I will also allow you to spend longer on the other questions, especially question 2 which is a straightforward graph question.

ESSENTIAL ANSWER: Learn the colour of these transition metals

Iron (II) Chloride (Fe^{2+}): Green
Rust (Iron (III) oxide : red brown),
Copper (II) sulphate (hydrated) blue
Chromium (III) chloride (Cr^{3+}) – Gray green

Extension Answer: Learn all of the different conditions and tests:

<table>
<thead>
<tr>
<th>Cation</th>
<th>NaOH</th>
<th>NH₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al^{3+}</td>
<td>Drops</td>
<td>Excess</td>
</tr>
<tr>
<td>Ca^{2+}</td>
<td>Drops</td>
<td>Excess</td>
</tr>
<tr>
<td>Zn^{2+}</td>
<td>White squares</td>
<td></td>
</tr>
</tbody>
</table>

White squares represent conditions which return white ppt (7/12 squares)

Along the top row, use the alphabet for the order of NaOH and NH₃ as well as Drops and Excess.

Along the first column, again use the alphabet, which goes from A to Z to order the cations.

The shape of the soluble squares is a lot like a cat, which this fantastic drawing above shows, which is positive, but colours!!! You could draw whatever you wanted that would better help you remember

For the transition metals:
For the flame tests I use a system based on Left and Right:

<table>
<thead>
<tr>
<th>Cation</th>
<th>NaOH</th>
<th>NH₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cr³⁺</td>
<td>Green ppt</td>
<td>GrayGreen ppt</td>
</tr>
<tr>
<td>Cu²⁺</td>
<td>LightBlue ppt</td>
<td>LB ppt</td>
</tr>
<tr>
<td>Fe²⁺</td>
<td>Green ppt</td>
<td>Red-brown ppt</td>
</tr>
<tr>
<td>Fe³⁺</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Memorise:

- 1. **LEFT** Li
- 2. **RIGHT** R (red)
- 3. **LEFT** Cu Blue-green
- K [Blue-green]

Lithium is the first element in the series, which matches to Left, which matches to Right, which is red, so it burns with a red flame. Below red (or Right) is Left, #3, which matches to Lilac which is the colour of potassium’s flame. Sodium is yellow (it’s a really strong colour and why wood, which contains a lot of sodium chloride has a yellow flame, and copper is blue green as a compound, usually, and also in a flame test. There are lots of different ways to create a mnemonic, usually by the time you’ve created it you’ll have memorised the content, so you won’t need it. But getting better able to memorise things, especially boring things, is an essential part of science, and the more complicated and interesting jobs which require incredible attention to detail.

**REMEMBER!!!** Whenever you answer a question about ions while you are working on past exam papers, draw out these tables, it will help you to build habits which will be very useful in the exam later on.

### 12.5 Extension Classroom Active Learning Tasks 2

**Thinking deeper about mnemonics**

In the space below try to think of your own mnemonics to help you memorise these important, but extremely boring, facts.

---

**12.6 ESSENTIAL EXAM QUESTIONS Paper 2 66 marks Topic 8**

**Q# 1/IGCSE Chemistry/2018/m/Paper 22/**

20 Barium hydroxide is an alkali. It reacts with hydrochloric acid.

How does the pH of the hydrochloric acid change as an excess of aqueous barium hydroxide is added?

A The pH decreases from pH 14 and becomes constant at pH 7.
B The pH decreases from pH 14 to about pH 1.
C The pH increases from pH 1 and becomes constant at pH 7.
D The pH increases from pH 1 to about pH 14.

21 Which statement describes a chemical property of aluminium oxide, Al₂O₃?

A It reacts with acids but not with bases.
B It reacts with acids and bases.
C It reacts with bases but not with acids.
D It reacts with water.

22 The results of two tests on an aqueous solution of X are shown.

<table>
<thead>
<tr>
<th>test</th>
<th>observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>aqueous sodium hydroxide</td>
<td>green precipitate formed</td>
</tr>
<tr>
<td>acidified aqueous silver</td>
<td>yellow precipitate formed</td>
</tr>
<tr>
<td>nitrate added</td>
<td></td>
</tr>
</tbody>
</table>

What is X?

A copper(II) chloride
B copper(II) iodide
C iron(II) chloride
D iron(II) iodide
23. Four stages used to prepare an insoluble salt are listed.

1. drying
2. filtration
3. precipitation
4. washing

In which order are the stages done?

A. 2 → 1 → 3 → 4
B. 3 → 2 → 4 → 1
C. 3 → 4 → 1 → 2
D. 4 → 3 → 2 → 1

Q#2 / GCSE Chemistry/2017/w/Paper 23/

19. Copper(II) sulfate can be prepared by adding excess copper(II) carbonate to sulfuric acid. Why is an excess of copper(II) carbonate added?

A. to ensure all the copper(II) carbonate has reacted
B. to ensure all the sulfuric acid has reacted
C. to increase the rate of reaction
D. to increase the yield of copper(II) sulfate

20. Compound P reacts with hydrochloric acid to produce a gas that turns limewater milky. What is P?

A. sodium carbonate
B. sodium chloride
C. sodium hydroxide
D. sodium sulfate

Q#3 / GCSE Chemistry/2017/w/Paper 22/

Three solids, P, Q, and R, all react with dilute sulfuric acid to produce zinc sulfate. P and R produce gases during the reaction.

The gas produced when P reacts will not burn. The gas produced when R reacts will burn.

What are P, Q, and R?

<table>
<thead>
<tr>
<th></th>
<th>P</th>
<th>Q</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>zinc</td>
<td>zinc hydroxide</td>
<td>zinc carbonate</td>
</tr>
<tr>
<td>B</td>
<td>zinc carbonate</td>
<td>zinc</td>
<td>zinc oxide</td>
</tr>
<tr>
<td>C</td>
<td>zinc carbonate</td>
<td>zinc hydroxide</td>
<td>zinc</td>
</tr>
<tr>
<td>D</td>
<td>zinc oxide</td>
<td>zinc carbonate</td>
<td>zinc</td>
</tr>
</tbody>
</table>

20. Which ion forms a green precipitate with aqueous sodium hydroxide that dissolves in an excess of aqueous sodium hydroxide?

A. Ca^{2+}  B. Cr^{2+}  C. Cu^{2+}  D. Fe^{2+}
Q# 4  iGCSE Chemistry/2017/w/Paper 21/
17 Some properties of four oxides are listed.

Oxide 1 reacts with both acids and alkalis to form salts.
Oxide 2 reacts with acids to form salts but does not react with alkalis.
Oxide 3 reacts with alkalis to form salts but does not react with acids.
Oxide 4 does not react with acids or alkalis.

Which row describes the oxides?

<table>
<thead>
<tr>
<th>oxide</th>
<th>oxide 2</th>
<th>oxide 3</th>
<th>oxide 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>amphoteric</td>
<td>acidic</td>
<td>basic</td>
</tr>
<tr>
<td>B</td>
<td>amphoteric</td>
<td>basic</td>
<td>acidic</td>
</tr>
<tr>
<td>C</td>
<td>neutral</td>
<td>acidic</td>
<td>basic</td>
</tr>
<tr>
<td>D</td>
<td>neutral</td>
<td>basic</td>
<td>acidic</td>
</tr>
</tbody>
</table>

Q# 5  iGCSE Chemistry/2017/s/Paper 23/
18 Which oxide is amphoteric?
A Al₂O₃  B CaO  C Na₂O  D SO₂

19 Chloric(I) acid, HClO, is formed when chlorine dissolves in water. It is a weak acid.
What is meant by the term weak acid?
A It contains fewer hydrogen atoms than a strong acid.
B It is easily neutralised by a strong alkali.
C It is less concentrated than a strong acid.
D It is only partially ionised in solution.

20 Silver nitrate reacts with sodium chloride to produce silver chloride and sodium nitrate. The equation for the reaction is shown:

\[ \text{AgNO}_3(\text{aq}) + \text{NaCl}(\text{aq}) \rightarrow \text{AgCl}(s) + \text{NaNO}_3(\text{aq}) \]

How is silver chloride separated from the reaction mixture?
A crystallisation
B distillation
C evaporation
D filtration

21 Aqueous sodium hydroxide reacts with an aqueous solution of compound Y to give a green precipitate.
Aqueous ammonia also reacts with an aqueous solution of compound Y to give a green precipitate.

Which ion is present in Y?
A chromium(III)
B copper(II)
C iron(II)
D iron(III)

Q# 6  iGCSE Chemistry/2017/s/Paper 22/
18 Which type of oxide is aluminium oxide?

A. acidic
B. amphoteric
C. basic
D. neutral

19 Which statements about a weak acid, such as ethanoic acid, are correct?

1. It reacts with a carbonate.
2. It does not neutralise aqueous sodium hydroxide solution.
3. It turns red litmus blue.
4. It is only partially ionised in aqueous solution.

A. 1 and 2  B. 1 and 4  C. 2 and 3  D. 3 and 4

20 Silver chloride is a white solid which is insoluble in water.

Which statement describes how a sample of pure silver chloride can be made?

A. Add aqueous silver nitrate to aqueous sodium chloride and then filter.
B. Add aqueous silver nitrate to dilute hydrochloric acid, evaporate and then crystallise.
C. Add silver carbonate to dilute hydrochloric acid, evaporate and then crystallise.
D. Add silver to dilute hydrochloric acid, filter and then wash the residue.

21 Dilute sulfuric acid is added to two separate aqueous solutions, X and Y. The observations are shown.

| solution X | white precipitate |
| solution Y | bubbles of a colourless gas |

Which row shows the ions present in the solutions?

| solution X | solution Y |
| A. Ba²⁺ | CO₃²⁻ |
| B. Ca²⁺ | Cl⁻ |
| C. Cu²⁺ | CO₃²⁻ |
| E. Fe³⁺ | NO₃⁻ |

Q# 7 / GCSE Chemistry/2017/a/Paper 21/
19 Which row shows how the hydrogen ion concentration and pH of ethanoic acid compare to those of hydrochloric acid of the same concentration?

<table>
<thead>
<tr>
<th>ethanoic acid compared to hydrochloric acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>hydrogen ion concentration</td>
</tr>
<tr>
<td>A higher</td>
</tr>
<tr>
<td>B higher</td>
</tr>
<tr>
<td>C lower</td>
</tr>
<tr>
<td>D lower</td>
</tr>
</tbody>
</table>

20 A pure sample of the insoluble salt barium carbonate can be made using the method given.

   step 1  Dissolve barium chloride in water.
   step 2  Separately dissolve sodium carbonate in water.
   step 3  Mix the two solutions together.
   step 4  Filter the mixture.
   step 5  
   step 6  Dry the residue between two sheets of filter paper.

Which instruction is missing from step 5?

A  Heat the residue to dryness.
B  Heat the residue to the point of crystallisation.
C  Place the filtrate in an evaporating basin.
D  Wash the residue with water.

21 Substance X reacts with warm dilute hydrochloric acid to produce a gas which decolourises acidified aqueous potassium manganate(VII).

Substance X gives a yellow flame in a flame test.

What is X?

A  potassium chloride
B  potassium sulfite
C  sodium chloride
D  sodium sulfite
Q# 8/ iGCSE Chemistry/2017/m/Paper 22/
18 Beryllium oxide reacts with both sulfuric acid and aqueous sodium hydroxide.

Which type of oxide is beryllium oxide?
A acidic
B amphoteric
C basic
D neutral

19 A student investigates two acids W and X.

The same volumes of W and X are reacted separately with excess magnesium.

The student makes the following observations.
1 Hydrogen gas is produced at a faster rate with W than with X.
2 The total volume of hydrogen gas produced is the same for both acids.

Which statement explains these observations?
A The pH of W is higher than the pH of X.
B W is an organic acid.
C W is a stronger acid than X.
D W is more concentrated than X.

Q# 9/ iGCSE Chemistry/2016/w/Paper 23/
23 Compound T is added to dilute hydrochloric acid and warmed gently.

The mixture gives off a gas which turns acidified aqueous potassium manganate(VII) from purple to colourless.

A flame test on compound T gives a lilac flame.

What is compound T?
A sodium sulfate
B sodium sulfite
C potassium sulfate
D potassium sulfite

Q# 10/ iGCSE Chemistry/2016/w/Paper 22/

21 The diagram shows the steps in the preparation of a salt.

Which salt is prepared by this method?
A barium sulfate
B copper(I) sulfate
C potassium sulfate
D sodium sulfate
23 Aqueous sodium hydroxide was added slowly, until in excess, to separate solutions of W, X, Y and Z.

The results are shown.

<table>
<thead>
<tr>
<th>solution</th>
<th>initial observation with aqueous sodium hydroxide</th>
<th>final observation with excess aqueous sodium hydroxide</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>white precipitate formed</td>
<td>precipitate dissolves</td>
</tr>
<tr>
<td>X</td>
<td>white precipitate formed</td>
<td>no change</td>
</tr>
<tr>
<td>Y</td>
<td>pale blue precipitate formed</td>
<td>no change</td>
</tr>
<tr>
<td>Z</td>
<td>green precipitate formed</td>
<td>no change</td>
</tr>
</tbody>
</table>

Which row identifies the metal ions in the solutions?

<table>
<thead>
<tr>
<th>metal ion in solution W</th>
<th>metal ion in solution X</th>
<th>metal ion in solution Y</th>
<th>metal ion in solution Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>A aluminium</td>
<td>calcium</td>
<td>copper(II)</td>
<td>iron(II)</td>
</tr>
<tr>
<td>B aluminium</td>
<td>calcium</td>
<td>iron(II)</td>
<td>copper(II)</td>
</tr>
<tr>
<td>C aluminium</td>
<td>iron(II)</td>
<td>calcium</td>
<td>copper(II)</td>
</tr>
<tr>
<td>D calcium</td>
<td>aluminium</td>
<td>copper(II)</td>
<td>iron(II)</td>
</tr>
</tbody>
</table>

QF 11/ IGCSE Chemistry/2016/w/Paper 21/

19 Hydrogen chloride gas reacts with water to produce an acidic solution. The equation for the reaction is shown.

\[ \text{HCl} + \text{H}_2\text{O} \rightarrow \text{Cl}^- + \text{H}_3\text{O}^+ \]

Which statement describes what happens during the reaction?

A The chloride ion is formed by accepting an electron from the water.
B The hydrogen chloride loses an electron to form the chloride ion.
C The water accepts a proton from the hydrogen chloride.
D The water donates a proton to the hydrogen chloride.

20 The apparatus shown is used to prepare aqueous copper(II) sulfate.

What are X and Y?

<table>
<thead>
<tr>
<th></th>
<th>X</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>copper</td>
<td>aqueous iron(II) sulfate</td>
</tr>
<tr>
<td>B</td>
<td>copper(II) chloride</td>
<td>sulfuric acid</td>
</tr>
<tr>
<td>C</td>
<td>copper(II) oxide</td>
<td>sulfuric acid</td>
</tr>
<tr>
<td>D</td>
<td>sulfur</td>
<td>aqueous copper(II) chloride</td>
</tr>
</tbody>
</table>

Germanium oxide reacts with concentrated hydrochloric acid.

Germanium oxide reacts with concentrated aqueous sodium hydroxide.

Germanium oxide does not dissolve when added to water.

Which type of oxide is germanium oxide?

A acidic
B amphoteric
C basic
D neutral
Information about some silver compounds is shown in the table.

<table>
<thead>
<tr>
<th>compound</th>
<th>formula</th>
<th>solubility in water</th>
</tr>
</thead>
<tbody>
<tr>
<td>silver carbonate</td>
<td>Ag₂CO₃</td>
<td>insoluble</td>
</tr>
<tr>
<td>silver chloride</td>
<td>AgCl</td>
<td>insoluble</td>
</tr>
<tr>
<td>silver nitrate</td>
<td>AgNO₃</td>
<td>soluble</td>
</tr>
<tr>
<td>silver oxide</td>
<td>Ag₂O</td>
<td>insoluble</td>
</tr>
</tbody>
</table>

Which equation shows a reaction which cannot be used to make a silver salt?

A. AgNO₃(aq) + HCl(aq) → AgCl(s) + HNO₃(aq)
B. Ag₂O(s) + 2HNO₃(aq) → 2AgNO₃(aq) + H₂O(l)
C. Ag₂CO₃(s) + 2HNO₃(aq) → 2AgNO₃(aq) + H₂O(l) + CO₂(g)
D. 2Ag(s) + 2HCl(aq) → 2AgCl(s) + H₂(g)

Q# 12/ IGCSE Chemistry/2016/w/Paper 21/

Four substances, P, Q, R and S, are tested as shown.

<table>
<thead>
<tr>
<th>test</th>
<th>substance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P</td>
</tr>
<tr>
<td>dilute hydrochloric acid added</td>
<td>gas given off which 'pops' with a litmus splint</td>
</tr>
<tr>
<td>dilute aqueous sodium hydroxide added and warmed gently</td>
<td>no reaction</td>
</tr>
</tbody>
</table>

What are P, Q, R and S?

<table>
<thead>
<tr>
<th></th>
<th>P</th>
<th>Q</th>
<th>R</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Mg</td>
<td>Na₂CO₃</td>
<td>NH₄Cl</td>
<td>NaCl</td>
</tr>
<tr>
<td>B</td>
<td>Mg</td>
<td>NH₄Cl</td>
<td>Na₂CO₃</td>
<td>NaCl</td>
</tr>
<tr>
<td>C</td>
<td>Mg</td>
<td>Na₂CO₃</td>
<td>NaCl</td>
<td>NH₄Cl</td>
</tr>
<tr>
<td>D</td>
<td>Na₂CO₃</td>
<td>Mg</td>
<td>NaCl</td>
<td>NH₄Cl</td>
</tr>
</tbody>
</table>

Q# 13/ IGCSE Chemistry/2016/s/Paper 23/

20. Barium sulfate is an insoluble salt.

It can be made by reacting copper(II) sulfate solution with barium nitrate solution.

\[ \text{CuSO}_4(\text{aq}) + \text{Ba(NO}_3)_2(\text{aq}) \rightarrow \text{Cu(NO}_3)_2(\text{aq}) + \text{BaSO}_4(\text{s}) \]

What is the correct order of steps to obtain a pure, dry sample of barium sulfate from the reaction mixture?

<table>
<thead>
<tr>
<th>step 1</th>
<th>step 2</th>
<th>step 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>A filter</td>
<td>evaporate the filtrate to dryness</td>
<td>leave the solid formed to cool</td>
</tr>
<tr>
<td>B filter</td>
<td>evaporate the filtrate to the point of crystallisation</td>
<td>leave the filtrate to cool</td>
</tr>
<tr>
<td>C filter</td>
<td>leave the residue in a warm place to dry</td>
<td>wash the residue with water</td>
</tr>
<tr>
<td>D filter</td>
<td>wash the residue with water</td>
<td>leave the residue in a warm place to dry</td>
</tr>
</tbody>
</table>

Q# 14/ IGCSE Chemistry/2016/s/Paper 22/

20. Silver chloride is insoluble in water and is prepared by precipitation.

Which two substances can be used to make silver chloride?

A. barium chloride and silver nitrate
B. hydrochloric acid and silver
C. hydrochloric acid and silver bromide
D. sodium chloride and silver iodide

Q# 15/ IGCSE Chemistry/2016/s/Paper 21/

18. Which statements are properties of an acid?

1. reacts with ammonium sulfate to form ammonia
2. turns red litmus blue

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</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>✗</td>
<td>✓</td>
</tr>
<tr>
<td>D</td>
<td>✗</td>
<td>✗</td>
</tr>
</tbody>
</table>
19 Which row describes whether an amphoteric oxide reacts with acids and bases?

<table>
<thead>
<tr>
<th></th>
<th>reacts with acids</th>
<th>reacts with bases</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>B</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>C</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>D</td>
<td>yes</td>
<td>yes</td>
</tr>
</tbody>
</table>

20 Which substance reacts with dilute sulfuric acid to form a salt that can be removed from the resulting mixture by filtration?

A. aqueous barium chloride
B. aqueous sodium hydroxide
C. copper
D. copper(II) carbonate

Q# 16/ iGCSE Chemistry/2016/m/Paper 22/

18 Concentrated hydrochloric acid is a **strong acid**.

What is meant by the terms ‘strong’ and ‘acid’?

<table>
<thead>
<tr>
<th></th>
<th>acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>contains a low proportion of water, accepts protons</td>
</tr>
<tr>
<td>B</td>
<td>contains a low proportion of water, donates protons</td>
</tr>
<tr>
<td>C</td>
<td>fully ionised, accepts protons</td>
</tr>
<tr>
<td>D</td>
<td>fully ionised, donates protons</td>
</tr>
</tbody>
</table>

20 A salt is made by adding an excess of an insoluble metal oxide to an acid.

How is the excess metal oxide removed from the mixture?

A. chromatography
B. crystallisation
C. distillation
D. filtration

21 A substance is heated with aluminium foil in aqueous sodium hydroxide. A gas is produced which turns damp, red litmus paper blue.

Which anion is present in the substance?

A. carbonate
B. iodide
C. nitrate
D. sulfate

12.6.1 ESSENTIAL EXAM QUESTIONS Paper 2 66 marks Topic 8 Mark Scheme

Q# 1/GCSE Chemistry/2018/m/Paper 22/  
Q# 2/GCSE Chemistry/2017/w/Paper 23/  
Q# 3/GCSE Chemistry/2017/w/Paper 22/  
Q# 4/GCSE Chemistry/2017/w/Paper 21/  
Q# 5/GCSE Chemistry/2017/s/Paper 23/
12.7 ESSENTIAL EXAM QUESTIONS Paper 3/4 Topic 8.3 & 8.4 116Marks

Topic Chem 8.3 Q# 1/iGCSE Chemistry/2013/s/Paper 3 1/

7. The hydroxides of the Group I metals are soluble in water. Most other metal hydroxides are insoluble in water.

(a) (i) Crystals of lithium chloride can be prepared from lithium hydroxide by titration.

[Diagram of a burette with a conical flask containing 25.0 cm³ of aqueous lithium hydroxide and indicator.]

25.0 cm³ of aqueous lithium hydroxide is pipetted into the conical flask. A few drops of an indicator are added. Dilute hydrochloric acid is added slowly to the alkali until the indicator just changes colour. The volume of acid needed to neutralise the lithium hydroxide is noted.

A neutral solution of lithium chloride, which still contains the indicator, is left. Describe how you could obtain a neutral solution of lithium chloride which does not contain an indicator:

...........................................................................................................................................................................................................................................[2]
(i) You cannot prepare a neutral solution of magnesium chloride by the same method. Describe how you could prepare a neutral solution of magnesium chloride.

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

(b) Strontium chloride-6-water can be made from the insoluble compound, strontium carbonate, by the following reactions.

\[
\text{SrCO}_3(s) + 2\text{HCl}(aq) \rightarrow \text{SrCl}_2(aq) + \text{CO}_2(g) + \text{H}_2\text{O}(l) \\
\text{SrCl}_2(aq) + 6\text{H}_2\text{O}(l) \rightarrow \text{SrCl}_2\cdot6\text{H}_2\text{O}(s)
\]

The following method was used to prepare the crystals.

1. Add excess strontium carbonate to hot hydrochloric acid.
2. Filter the resulting mixture.
3. Partially evaporate the filtrate and allow to cool.
4. Filter off the crystals of \(\text{SrCl}_2\cdot6\text{H}_2\text{O}\).
5. Dry the crystals between filter papers.

(i) How would you know when excess strontium carbonate had been added in step 1?

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

(ii) Why is it necessary to filter the mixture in step 2?

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

(iii) In step 3, why partially evaporate the filtrate rather than evaporate to dryness?

........................................................................................................................................ [1]
5 Insoluble salts are made by precipitation.

(a) A preparation of the insoluble salt calcium fluoride is described below.

To 15 cm$^3$ of aqueous calcium chloride, 30 cm$^3$ of aqueous sodium fluoride is added. The concentration of both solutions is 1.00 mol / dm$^3$. The mixture is filtered and the precipitate washed with distilled water. Finally, the precipitate is heated in an oven.

(i) Complete the equation.

$$\text{Ca}^{2+} + \text{F}^- \rightarrow \text{[ ]}$$  \[2\]

(ii) Why is the volume of sodium fluoride solution double that of the calcium chloride solution?

---------------------------------------------------------------  \[1\]

(iii) Why is the mixture washed with distilled water?

---------------------------------------------------------------  \[1\]

(iv) Why is the solid heated?

---------------------------------------------------------------  \[1\]

7 Crystals of sodium sulphate-10-water, Na$_2$SO$_4$.10H$_2$O, are prepared by titration.

(a) 25.0 cm$^3$ of aqueous sodium hydroxide(aq) concentration 2.24 mol/dm$^3$ is pipetted into a conical flask. A few drops of an indicator are added. Using a burette, dilute sulphuric acid is slowly added until the indicator just changes colour. The volume of acid needed to neutralise the alkali is noted.

Suggest how you would continue the experiment to obtain pure, dry crystals of sodium sulphate-10-water.

---------------------------------------------------------------  \[4\]
4 Sulphuric acid is a typical strong acid.

(a) Change the equations given into a different format.

(i) \( \text{Mg} + \text{H}_2\text{SO}_4 \rightarrow \text{MgSO}_4 + \text{H}_2 \)

Change into a word equation.  

(ii) \( \text{Li}_2\text{O} + \text{H}_2\text{SO}_4 \rightarrow \text{Li}_2\text{SO}_4 + \text{H}_2\text{O} \)

Change into a symbol equation.  

(iii) \( \text{CuO} + 2\text{H}^+ \rightarrow \text{Cu}^{2+} + \text{H}_2\text{O} \)

Change the ionic equation into a symbol equation.  

(iv) \( \text{Na}_2\text{CO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + \text{CO}_2 + \text{H}_2\text{O} \)

Change into a word equation.  

(b) When sulphuric acid dissolves in water, the following reaction occurs.

\[ \text{H}_2\text{SO}_4 + \text{H}_2\text{O} \rightarrow \text{HSO}_4^{-} + \text{H}_3\text{O}^{+} \]

Explain why water is behaving as a base in this reaction.  

(c) Sulphuric acid is a strong acid, ethanoic acid is a weak acid.

Explain the difference between a strong acid and a weak acid.  

3 There are three methods of preparing salts.

Method A – use a burette and an indicator.

Method B – mix two solutions and obtain the salt by precipitation.

Method C – add an excess of base or a metal to a dilute acid and remove the excess by filtration.

For each of the following salt preparations, choose one of the methods A, B or C, name any additional reagent needed and then write or complete the equation

(i) the soluble salt; zinc sulphate, from the insoluble base, zinc oxide

method .................................................................  
reagent .................................................................  
word equation .................................................................  

(ii) the soluble salt; potassium chloride, from the soluble base, potassium hydroxide

method .................................................................  
reagent .................................................................  
equation .................................................................  

(iii) the insoluble salt; lead(II) iodide, from the soluble salt, lead(II) nitrate

method .................................................................  
reagent .................................................................  
equation \( \text{Pb}^{2+} + \)  

[Total: 10]
(b) In the above method, a soluble salt was prepared by neutralising an acid with an insoluble base. Other salts have to be made by different methods.

(i) Give a brief description of how the soluble salt, rubidium sulphate could be made from the soluble base, rubidium hydroxide.

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

(ii) Suggest a method of making the insoluble salt, calcium fluoride.

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

(c) The major ore of strontium is its carbonate, SrCO₃. Strontium is extracted by the electrolysis of its molten chloride.

(i) Name the reagent that will react with the carbonate to form the chloride.

................................................................................................................................................. [1]
4 (a) Insoluble compounds are made by precipitation.

(i) Complete the word equation for the preparation of zinc carbonate.

\[ \text{ ) } + \text{ sodium carbonate } \rightarrow \text{ zinc carbonate } + \text{ ) } \]

(ii) Complete the following symbol equation.

\[ \text{Pb(NO}_3\text{)}_2 + \text{ ) } \rightarrow \text{ ) } \]

(iii) Write an ionic equation for the precipitation of the insoluble salt, silver(I) chloride.

(b) 2.0 cm\(^3\) portions of aqueous sodium hydroxide were added to 4.0 cm\(^3\) of aqueous iron(III) chloride. Both solutions had a concentration of 1.0 mol/dm\(^3\). After each addition, the mixture was stirred, centrifuged and the height of the precipitate of iron(III) hydroxide was measured. The results are shown on the following graph.

(i) Complete the ionic equation for the reaction.

\[ \text{Fe}^{3+} + \text{ OH}^- \rightarrow \]

(ii) On the same grid, sketch the graph that would have been obtained if iron(II) chloride had been used instead of iron(III) chloride.

(iii) If aluminium chloride had been used instead of iron(II) chloride, the shape of the graph would be different. How are the shapes of these two graphs different and why?

\[ \text{difference in shape } \]

\[ \text{reason for difference } \]

(d) Nitrogen dioxide, oxygen and water react to form dilute nitric acid. Describe how lead(II) nitrate crystals could be prepared from dilute nitric acid and lead(II) oxide.

(b) There are three ways of making salts from sulphuric acid. 

\[ \text{titration using a burette and indicator } \]

\[ \text{precipitation by mixing the solutions and filtering } \]

\[ \text{neutralisation of sulphuric acid using an excess of an insoluble base } \]

Complete the following table of salt preparations.

<table>
<thead>
<tr>
<th>method</th>
<th>reactant 1</th>
<th>reactant 2</th>
<th>salt</th>
</tr>
</thead>
<tbody>
<tr>
<td>titration</td>
<td>sulphuric acid</td>
<td></td>
<td>sodium sulphate</td>
</tr>
<tr>
<td>neutralisation</td>
<td>sulphuric acid</td>
<td></td>
<td>zinc sulphate</td>
</tr>
<tr>
<td>precipitation</td>
<td>sulphuric acid</td>
<td></td>
<td>barium sulphate</td>
</tr>
<tr>
<td></td>
<td>sulphuric acid</td>
<td>copper(II) oxide</td>
<td>copper(II) sulphate</td>
</tr>
</tbody>
</table>
(d) **Sulphuric acid is a typical strong acid.**

(i) Explain the term **strong acid**. ........................................................................................................... [2]

(ii) Write a word equation for the reaction between zinc carbonate and sulphuric acid. ................................................................. [2]

(iii) Write an equation for the reaction between sodium hydroxide and sulphuric acid. .................................................................................. [2]

(iv) Write an ionic equation for the reaction between magnesium and sulphuric acid. ........................................................................ [2]

(b) **Zinc oxide is used to make aqueous zinc chloride. This can be used to preserve wood. Describe how this solution could be made.**

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

(c) **Describe how you could test the solution to find out which ion, Fe\(^{3+}\) or Fe\(^{2+}\), is present.**

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

<table>
<thead>
<tr>
<th><strong>gas</strong></th>
<th><strong>test for gas</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>ammonia</td>
<td>bleaches damp litmus paper</td>
</tr>
<tr>
<td>hydrogen</td>
<td>relights a glowing splint</td>
</tr>
<tr>
<td></td>
<td>turns limewater milky</td>
</tr>
</tbody>
</table>

(Total: 5)
3. A South Korean chemist has discovered a cure for smelly socks. Small particles of silver are attached to a polymer, poly(propylene), and this is woven into the socks.

(b) To show that the polymer contains silver the following test was carried out.

The polymer fibres were chopped into small pieces and warmed with nitric acid. The silver atoms were oxidised to silver(II) ions. The mixture was filtered. Aqueous sodium chloride was added to the filtrate and a white precipitate formed:

(i) Why was the mixture filtered?

(ii) Explain why the change of silver atoms to silver ions is oxidation.

(iii) Give the name of the white precipitate.

2. Sulphur dioxide is easily oxidised in the presence of water.

\[ \text{SO}_2 + 2\text{H}_2\text{O} - 2\text{e}^- \rightarrow \text{SO}_4^{2-} + 4\text{H}^+ \]

(i) What colour change would be observed when an excess of aqueous sulphur dioxide is added to an acidic solution of potassium manganate(VII)?

2. Calcium and other minerals are essential for healthy teeth and bones. Tablets can be taken to provide these minerals.

(b) Describe the reactions, if any, of zinc and copper(II) ions with an excess of aqueous sodium hydroxide.

(i) zinc ions

addition of aqueous sodium hydroxide .................................................................

excess sodium hydroxide ..............................................................................

(ii) copper(II) ions

addition of aqueous sodium hydroxide .................................................................

excess sodium hydroxide ..............................................................................
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.

(a) Vines are attacked by a fungus that ruins the grapes. In 1882 it was discovered that spraying the vines with Bordeaux mixture killed the fungus.

The fungicide, Bordeaux mixture, contains water, calcium hydroxide and copper(II) sulphate.

(i) Name the raw material from which calcium hydroxide is made.

(ii) The mixture contains four ions. Complete the list of ions.

\[ \text{Cu}^{2+}, \text{OH}^- \quad \text{and} \quad \text{ } \]

(iii) A different fungicide can be made by the reaction between an excess of aqueous ammonia and a copper(II) salt. Describe the observations for this reaction.

addition of aqueous ammonia

then excess aqueous ammonia

(b) Number of moles of HCl = 0.020 x 2.20 = 0.044

correct answer scores = 2

(c) Mass of one mole = 78.5
45.9 is LiCl, 2H₂O
56 / 76.5 x 100

Note: if correct option given mark this and ignore the rest of the response

Q# 2/ iGCSE Chemistry/2013/s/Paper 31/ Q7

Q# 3/ iGCSE Chemistry/2009/s/Paper 31/ Q5

\[ \text{Li}_2\text{CO}_3 \text{ does not dissolve} / \text{no effervescence;} \]

\[ \text{to remove excess} / \text{unreacted} \text{ strontium carbonate;} \]

\[ \text{water of crystallisation needed} / 6\text{H}_2\text{O} \text{ in crystals} / \text{would get anhydrous salt} / \text{crystals dehydrate;} \]

Note: to obtain crystals

explanation why 8 cm³ react fully

comment about mole ratio

[1]
Q# 4/ iGCSE Chemistry/2009/s/Paper 31/

5 (a) (i) \( \text{Ca}^{2+} + 2\text{F}^- \rightarrow \text{CaF}_2 \)
    [2]
    Not balanced ONLY [1]
    Both species must be correct for first mark. Second mark is for correct balancing.

(iii) Mole ratio \( \text{Ca}^{2+} : \text{F}^- = 1:2 \)
    Answer must mention moles
    accept argument based on charges or number of ions
    accept 2 moles of \( \text{NaF} \) react with 1 mole of \( \text{CaCl}_2 \)
    NOT just "2" in equation
    If fluoride must specify atoms or ions

(iii) to remove traces of solutions or to remove soluble
    impurities or to remove a named salt sodium chloride
    or sodium fluoride or calcium chloride
    To remove impurities is not enough

(iv) to dry (precipitate) or to remove water or to evaporate water
    NOT to evaporate some of water NOT to crystallise salt
    [1]

Q# 5/ iGCSE Chemistry/2009/s/Paper 31/

7 (a) repeat experiment without indicator or use carbon to remove indicator
    [1]
    (partially) evaporate or boil or heat
    allow to cool or crystallise or crystals
    dry crystals
    MUST be in correct order
    NB evaporate to dryness, marks one and two ONLY

Q# 6/ iGCSE Chemistry/2009/s/Paper 31/

4 (a) (i) magnesium + sulphuric acid = magnesium sulphate + hydrogen
    ACCEPT hydrogen sulphate
    [1]

(ii) \( \text{Li}_2\text{O} + \text{H}_2\text{SO}_4 \rightarrow \text{Li}_2\text{SO}_4 + \text{H}_2\text{O} \)
    formulae correct but not balanced [1]

(iii) \( \text{Cu}_2\text{O} \rightarrow \text{H}_2\text{SO}_4 \rightarrow \text{Cu}_2\text{SO}_4 + \text{H}_2\text{O} \)
    OR \( \text{Cu}_2\text{O} + 2\text{HCl} \rightarrow \text{CuCl}_2 + \text{H}_2\text{O} \)
    OR \( \text{Cu}_2\text{O} + 2\text{HNO}_3 \rightarrow \text{Cu(NO}_3)_2 + \text{H}_2\text{O} \)
    formulae correct but not balanced [1]

(iv) sodium carbonate + sulphuric acid = sodium sulphate + carbon dioxide + water
    [1]

(b) It accepts a proton
    [2]
    \( \text{it accepts a hydrogen ion} \) ONLY

(c) sulphuric acid is completely ionised
    [1]
    or few molecules and many ions
    ethanoic acid is partially ionised
    or many molecules and few ions
    [1]
Q# 11/ iGCSE Chemistry/2004/s/Paper 3/ Q4

4. (a) (i) **Named soluble zinc salt** corresponding sodium salt if hydroxide or oxide than Q2

(ii) **Correct equation** not balanced [1] only

(iii) **Correct equation** [2]

(b) (i) Fe**(3+)** + 3OH\(^-\) = Fe(OH)\(_3\)

(ii) Max at 80° (\(\text{90°}\))

Same shape of graph [1]

Just the above shape, the height of the precipitate and the volume of sodium hydroxide are irrelevant [1]

(iii) Maximum (then) height of precipitate decreases or graph slopes down to x axis or comes to zero hydroxide dissolves in excess or it is amphoteric [1]

Q# 12/ iGCSE Chemistry/2003/s/Paper 3/ Q4

(d) **Add excess lead oxide to nitric acid** can imply excess filter NOT if residue is lead nitrate evaporate or heat solution [1]


(b) **sodium hydroxide or carbonate or hydrogen carbonate**

**zinc oxide or hydroxide or carbonate** NOT zinc

**barium nitrate or chloride or hydroxide or barium ions** neutralisation NOT acid/base [1]

Q# 14/ iGCSE Chemistry/2003/w/Paper 3/ Q5

(d) (i) completely ionized or good proton donor for explanation based on high concentration of H\(^+\) or low pH or proton donor ONLY [1]

(ii) word equation correct water missing ONLY [1] accept correct symbol equation

(iii) 2NaOH + H\(_2\)SO\(_4\) → Na\(_2\)SO\(_4\) + 2H\(_2\)O

unbalanced [1] NOT word equation or NaOH + H\(_2\)SO\(_4\) → NaH\(_2\)SO\(_4\) + H\(_2\)O

(iv) Mg + 2H\(^+\) → Mg\(^{2+}\) + H\(_2\)

Molecular equation ONLY [1] NOT word equation

OR add hydrochloric acid forms (zinc chloride and) water [Max 2]

Q# 15/ iGCSE Chemistry/2001/w/Paper 3/ Q4

(b) hydrochloric acid excess zinc oxide filter

OR add hydrochloric acid forms (zinc chloride and) water

Q# 16/ iGCSE Chemistry/2011/w/Paper 3/ Q5

(c) add sodium hydroxide solution / ammonia(eq)

Fe**(3+)** green precipitate

Fe**(3+)** brown precipitate [1]

Q# 17/ iGCSE Chemistry/2008/w/Paper 3/1

1. red illnous paper blue

OR white fumar/smoke with HCl (g) or (aq)

chlorine [1]

“pop” with a lighted splint or burn with a pop or goes pop and extinguishes flame NOT glowing splint

oxygen [1]

carbon dioxide

ACCEPT correct formulations [1]

Q# 18/ iGCSE Chemistry/2005/s/Paper 3/ Q2

(b) for zinc and sodium hydroxide white precipitate dissolves in excess (only if precipitate mentioned) [1]

for zinc and ammonia same results [1]

Mark either first (sodium hydroxide or aqueous ammonia), if completely correct, then an additional [1] can be awarded for stating that the other has the same results.
Q# 19/ iGCSE Chemistry/2005/w/Paper 3/Q3:
(b) (i) to remove fibres or remove solid NOT precipitate, NOT impurities, NOT to obtain a filtrate 
(ii) because silver atoms have lost electrons OR oxidation number increased 
(iii) silver chloride

Q# 20/ iGCSE Chemistry/2004/w/Paper 3/Q2/iGCSE 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 relicts.

Q# 21/ iGCSE Chemistry/2004/w/Paper 3:
(b) (i) sodium hydroxide COND ammonia or alkaline gas or litmus red to blue if aluminium added we +U 
(ii) barium sulphate [1] cond bromine oxidizes or reacts with [1] [1] sulphur dioxide to form sulphate ion 

Q# 22/ iGCSE Chemistry/2003/w/Paper 3/Q5 (c):
(i) pink or purple [1] colourless NOT clear [1] 

Q# 23/ iGCSE Chemistry/2003/w/Paper 3/Q5
(c) (i) pink or purple [1] colourless NOT clear [1] 

Q# 24/ iGCSE Chemistry/2003/w/Paper 3/Q2:
(b) (i) white precipitate COND upon a precipitate dissolves in excess or forms solution [1] 
(ii) blue precipitate COND upon a precipitate does not dissolve in excess [1] 

Q# 25/ iGCSE Chemistry/2002/w/Paper 3:
2 (a) (i) limestone or quicklime or calcium oxide OR marble or chalk or calcium carbonate NOT just lime

(b) Ca$^2+$ and SO$_4^{2-}$ [2]

(iii) blue precipitate accept light blue precipitate than blue solution dissolves or solution deep blue [1] [1] 

Q# 1/ iGCSE Chemistry/2018/w/Paper 63/Q1
Q# 2/ iGCSE Chemistry/2018/w/Paper 62/Q1
Q# 3/ 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 of lumps of copper(II) carbonate]

dilute nitric acid

[Diagram of copper(II) carbonate reaction]

lumps of copper(II) carbonate

(b) Describe a test for carbon dioxide:

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

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

Q# 2/ iGCSE Chemistry/2018/w/Paper 62/Q1
1 Magnesium ribbon was burned in air.

![Diagram of magnesium burning]

(e) Suggest the pH value shown when Universal Indicator was added to the mixture.

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

Q# 3/ iGCSE Chemistry/2018/w/Paper 62/Q1
(d) Describe a test for carbon dioxide:

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

result .............................................................................................................................................. [2]
Q# 4/ 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.

\[ \text{dilute nitric acid} \]

\[ \text{25.0 cm³ of aqueous potassium hydroxide with indicator} \]

(b) Name a suitable indicator that could be used.

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

A student did the titration four times and recorded the following results.

<table>
<thead>
<tr>
<th>titration number</th>
<th>volume of dilute nitric acid/cm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>18.1</td>
</tr>
<tr>
<td>2</td>
<td>18.9</td>
</tr>
<tr>
<td>3</td>
<td>18.3</td>
</tr>
<tr>
<td>4</td>
<td>18.2</td>
</tr>
</tbody>
</table>

c (i) Which one of the results is anomalous?

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

(ii) Suggest what might have caused this result to be anomalous.

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

(iii) Use the other results to calculate the average volume of dilute nitric acid that reacted with the aqueous potassium hydroxide.

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

(d) The equation for the reaction taking place in the titration is shown.

\[ \text{HNO}_3 + \text{KOH} \rightarrow \text{KNO}_3 + \text{H}_2\text{O} \]

The student concluded that the aqueous potassium hydroxide was more concentrated than the dilute nitric acid.

Explain whether or not the student's conclusion was correct.

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

Q# 5/ 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.

\[ \text{cerussite} \rightarrow \text{dilute acid} \]

(c) Name the dilute acid used in step 2.

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

(ii) State the effect of a lighted splint on the hydrogen produced.

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

Q# 6/ IGCSE Chemistry/2017/w/Paper 62/Q1

(ii) State the effect of a lighted splint on the hydrogen produced.

........................................................................................................... [1]
Q# 7 / 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.

(d) Describe how crystals of zinc chloride could be obtained from the zinc chloride solution.

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

Q# 8 / iGCSE Chemistry/2017/s/Paper 61/Q1

1 A student prepared strontium nitrate crystals.

The diagram shows some of the stages in this preparation.

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

Q# 9 / iGCSE Chemistry/2017/m/Paper 62/Q1

1 A student prepared strontium nitrate crystals.

The diagram shows some of the stages in this preparation.

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

Q# 10 / iGCSE Chemistry/2016/w/Paper 61/Q1

1 (a) Name the dilute acid used.
........................................................................................................................................ [1]

(b) Give one expected observation in stage 2.
........................................................................................................................................ [1]

(c) Why is heat not necessary in stage 2?
........................................................................................................................................ [1]

(d) Which of the reactants is in excess? Explain your answer.
........................................................................................................................................ [2]

(e) Describe how crystals of strontium nitrate could be obtained from the mixture in stage 3.
........................................................................................................................................ [3]

(f) The gas collected at the positive electrode turned limewater milky.
(i) Based on this observation, what gas was present?
........................................................................................................................................ [1]

(g) Give one test to distinguish between oxygen and hydrogen.
........................................................................................................................................ [2]
Experiment 1

- A measuring cylinder was used to pour 25 cm³ of solution L into a conical flask.
- Ten drops of thymolphthalein indicator were added to the conical flask.
- A burette was filled up to the 0.0 cm³ mark with dilute hydrochloric acid.
- Dilute hydrochloric acid was added from the burette to the conical flask until the solution just changed to colourless at the end-point of the titration.

(a) Use the burette diagram to record the final burette reading in the table and complete the table.

<table>
<thead>
<tr>
<th></th>
<th>Experiment 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>final burette reading/cm³</td>
<td></td>
</tr>
<tr>
<td>initial burette reading/cm³</td>
<td>0.0</td>
</tr>
</tbody>
</table>
| difference/cm³               |              | [1]

Experiment 2

- Ten drops of methyl orange indicator were added to the solution in the conical flask from Experiment 1.
- Dilute hydrochloric acid was added from the burette to the conical flask until the solution just changed colour.
(b) Use the burette diagram to record the final burette reading in the table and complete the table.

<table>
<thead>
<tr>
<th></th>
<th>Experiment 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>final burette reading/cm³</td>
<td></td>
</tr>
<tr>
<td>initial burette reading/cm³</td>
<td>12.0</td>
</tr>
<tr>
<td>difference/cm³</td>
<td></td>
</tr>
</tbody>
</table>

Experiment 3

- The conical flask was emptied and rinsed with distilled water.
- Experiment 1 was repeated using methyl orange indicator instead of thymolphthalein indicator and adding dilute hydrochloric acid from the burette to the conical flask until the solution just changed colour.
(c) Use the burette diagrams to record the burette readings in the table and complete the table.

<table>
<thead>
<tr>
<th></th>
<th>Experiment 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>final burette reading/cm³</td>
<td></td>
</tr>
<tr>
<td>initial burette reading/cm³</td>
<td></td>
</tr>
</tbody>
</table>
| difference/cm³               |              | [2]
Q# 12/ IGCSE Chemistry/ 2017/ m/ Paper 62/ Q2

2 A student investigated the reaction between dilute hydrochloric acid and two different aqueous solutions of sodium hydroxide labelled solution \( O \) and solution \( P \).

Two experiments were carried out.

**Experiment 1**

- A burette was filled with dilute hydrochloric acid. The initial burette reading was recorded.
- Using a measuring cylinder, \( 20 \) cm\(^3\) of solution \( O \) were poured into a conical flask.
- Thymolphthalein indicator was added to the conical flask.
- The dilute hydrochloric acid was added from the burette, while swirling the flask, until the solution just changed colour. 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></th>
<th>Initial reading</th>
<th>final burette reading/cm(^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>29</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>initial burette reading/cm(^3)</th>
<th>difference/cm(^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>29</td>
<td>31</td>
</tr>
</tbody>
</table>

**Experiment 2**

- The conical flask was emptied and rinsed with distilled water.
- Experiment 1 was repeated using solution \( P \) instead of solution \( O \).

(b) Use the burette diagrams to record the readings in the table and complete the table.

<table>
<thead>
<tr>
<th></th>
<th>Initial reading</th>
<th>final burette reading/cm(^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>23</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>30</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>initial burette reading/cm(^3)</th>
<th>difference/cm(^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30</td>
<td>15</td>
</tr>
</tbody>
</table>
Q# 13/ IGCSE Chemistry/2016/61/Q2

A student investigated what happened when dilute nitric acid reacted with aqueous solutions of two different alkalis, solution N and solution O.

Two experiments were carried out.

(a) **Experiment 1**

A measuring cylinder was used to pour 50 cm$^3$ of solution N into a polystyrene cup. The initial temperature of the solution was measured.

A burette was filled with nitric acid to the 0.0 cm$^3$ mark.

5.0 cm$^3$ of nitric acid were added to solution N in the polystyrene cup and the solution stirred. The maximum temperature of the solution was measured.

A further 5.0 cm$^3$ of nitric acid were added to the polystyrene cup and the solution stirred. The maximum temperature of the solution was measured.

The student continued to add 5.0 cm$^3$ portions of nitric acid to the polystyrene cup, until a total volume of 40 cm$^3$ of nitric acid had been added. After each addition, the solution was stirred and the maximum temperature measured.

Use the thermometers to record the maximum temperatures in the table.

<table>
<thead>
<tr>
<th>Volume of nitric acid added/cm$^3$</th>
<th>0.0</th>
<th>5.0</th>
<th>10.0</th>
<th>15.0</th>
<th>20.0</th>
<th>25.0</th>
<th>30.0</th>
<th>35.0</th>
<th>40.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum temperature of the solution in the polystyrene cup/°C</td>
<td>0.0</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
</tr>
</tbody>
</table>
(b) Experiment 2

Experiment 1 was repeated using solution O instead of solution N.
Use the thermometer diagrams to record the maximum temperatures in the table.

<table>
<thead>
<tr>
<th>volume of nitric acid added/cm³</th>
<th>0.0</th>
<th>5.0</th>
<th>10.0</th>
<th>15.0</th>
<th>20.0</th>
<th>25.0</th>
<th>30.0</th>
<th>35.0</th>
<th>40.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>thermometer diagram</td>
<td>10</td>
<td>15</td>
<td>20</td>
<td>25</td>
<td>30</td>
<td>35</td>
<td>40</td>
<td>45</td>
<td>50</td>
</tr>
<tr>
<td>maximum temperature</td>
<td>10</td>
<td>15</td>
<td>20</td>
<td>25</td>
<td>30</td>
<td>35</td>
<td>40</td>
<td>45</td>
<td>50</td>
</tr>
</tbody>
</table>

[2]

(c) Plot the results for Experiments 1 and 2 on the grid and draw two smooth line graphs. Clearly label your graphs.

(d) Use your graph to estimate the maximum temperature of the solution when 13 cm³ of nitric acid were added to 50 cm³ of solution N in Experiment 1.
Show clearly on the grid how you worked out your answer.

[2]

(e) Name a suitable indicator that could be used in Experiment 1.

[1]

(f) Solution N and solution O were the same concentration.
In which experiment is the temperature change greater? Suggest why the temperature change is greater in this experiment.

[2]

(g) How would the results differ in Experiment 1 if 100 cm³ of solution N were used?

[1]

(h) Suggest why a polystyrene cup was used in these experiments and not a copper can.

[1]

(i) State one source of error in the experiments. Suggest an improvement to reduce this source of error.

source of error
improvement

[2]

Q# 14/IGCSE Chemistry/2016/Paper 63/Q2

(b) The gas produced in experiment 3 was tested with a lighted splint and the result recorded below.

<table>
<thead>
<tr>
<th>test</th>
<th>lighted splint</th>
</tr>
</thead>
<tbody>
<tr>
<td>result</td>
<td>popped</td>
</tr>
</tbody>
</table>

Name the gas given off in experiment 3.

[1]
3 Solution T and liquid U were analysed. Solution T was aqueous sodium hydroxide. Tests were done on solution T and liquid U.

**Tests on solution T**

Complete the expected observations.

Solution T was divided into four portions in three test-tubes and one boiling tube.

(a) (i) A flame test was done on the first portion of solution T.

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

(ii) The pH of the first portion of solution T was tested.

pH = ......................... [1]  

(b) • A few drops of aqueous zinc sulfate were added to the second portion of solution T in a test-tube. The test-tube was shaken to mix the solutions.

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

• An excess of aqueous zinc sulfate was then added to the mixture.

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

(c) Ammonium chloride was added to the third portion of solution T in a boiling tube. The mixture was heated and the gas produced was tested.

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

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

(d) An excess of aqueous chromium(III) chloride was added to the fourth portion of solution T in a test-tube.

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

---

**Tests on liquid U**

Some of the tests and observations are shown.

<table>
<thead>
<tr>
<th>tests on liquid U</th>
<th>observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>The appearance of liquid U was studied.</td>
<td>colourless, pleasant smelling</td>
</tr>
<tr>
<td>A few drops of liquid U were placed on a watch glass.</td>
<td>burned with a blue flame</td>
</tr>
<tr>
<td>The surface of the liquid was touched with a lit match.</td>
<td></td>
</tr>
</tbody>
</table>

(e) What conclusion can you draw about liquid U?

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

[Total: 10]

---

Q# 18/ IGCSE Chemistry/2018/4/Paper 62/Q3

3 Two substances, solid E and solution F, were analysed. Solid E was iron(II) sulfate. Tests were done on solid E and solution F.

**Tests on solid E**

Complete the expected observations.

(a) Describe the appearance of solid E.

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

Solid E was added to distilled water in a test-tube. The test-tube was shaken to dissolve solid E and form solution E. Solution E was divided into four equal portions in four test-tubes.

(b) Dilute nitric acid and aqueous silver nitrate were added to the first portion of solution E.

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

(c) Dilute nitric acid and aqueous barium nitrate were added to the second portion of solution E.

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

(d) An excess of aqueous sodium hydroxide was added to the third portion of solution E.

observations ................................................................. [2]
Q# 19/ IGCSE Chemistry/2018/S/Paper 61/Q3

3. Two substances, solution A and solid B, were analysed.

**Tests on solution A**

Some of the tests and observations are shown.

<table>
<thead>
<tr>
<th>Tests on solution A</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solution A was divided into three equal portions in three test-tubes.</td>
<td></td>
</tr>
<tr>
<td><strong>Test 1</strong></td>
<td></td>
</tr>
<tr>
<td>Drops of aqueous sodium hydroxide were added to the first portion of solution A.</td>
<td>White precipitate formed</td>
</tr>
<tr>
<td>An excess of aqueous sodium hydroxide was then added to the mixture.</td>
<td>White precipitate was insoluble</td>
</tr>
<tr>
<td><strong>Test 2</strong></td>
<td></td>
</tr>
<tr>
<td>An excess of aqueous ammonia was added to the second portion of solution A.</td>
<td>No precipitate formed</td>
</tr>
</tbody>
</table>

(f) What conclusion can you draw about the cation present in solution F?

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

.............................................................................................................................................. [Total: 7]

(a) Identify the gas produced in test 2.

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

(b) Identify solution A.

.............................................................................................................................................. [2]
tests on solid B

Solid B was zinc carbonate.

Complete the expected observations.

(e) Dilute nitric acid was added to solid B. The gas produced was tested.

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

The zinc nitrate solution formed in the test in (e) was divided into two portions in two test-tubes.

(d) (i) Drops of aqueous sodium hydroxide were added to the first portion of the zinc nitrate solution.

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

(ii) An excess of aqueous sodium hydroxide was then added to the mixture.

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

(e) (i) Drops of aqueous ammonia were added to the second portion of the zinc nitrate solution.

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

(ii) An excess of aqueous ammonia was then added to the mixture.

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

Total: 10

Q# 20/IGCSE Chemistry/2017/Paper 63/03

3 Two solutions, Y and Z, were analysed.

Solution Y was aqueous chromium(III) nitrate.

Tests were carried out on both solutions.

tests on solution Y

Complete the expected observations.

The solution was divided into two equal portions in two test-tubes.

(a) (i) A few drops of aqueous sodium hydroxide were added to the first portion of solution Y and the test-tube shaken to mix the solutions.

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

(ii) An excess of aqueous sodium hydroxide was then added to the mixture.

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

(iii) The mixture from (a)(ii) was poured into a boiling tube and a small piece of aluminium foil was added. The mixture was heated and the gas produced was tested.

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

(b) Identify the gas produced in (a)(iii).

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

tests on solution Z

Tests were carried out and the following observations made.

<table>
<thead>
<tr>
<th>tests on solution Z</th>
<th>observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solution Z was divided into three equal portions in three test-tubes.</td>
<td></td>
</tr>
<tr>
<td>Test 1</td>
<td>pH10</td>
</tr>
<tr>
<td>The pH of the first portion of solution Z was tested.</td>
<td></td>
</tr>
<tr>
<td>Test 2</td>
<td></td>
</tr>
<tr>
<td>A few drops of aqueous copper(II) sulfate were added to the second portion of solution Z.</td>
<td>dark blue solution formed</td>
</tr>
<tr>
<td>An excess of aqueous copper(II) sulfate was then added to the mixture.</td>
<td>light blue precipitate formed</td>
</tr>
<tr>
<td>Test 3</td>
<td></td>
</tr>
<tr>
<td>The second portion of solution Y was added to the third portion of solution Z.</td>
<td>grey-green precipitate formed</td>
</tr>
</tbody>
</table>
(c) Identify solution Z.

Q# 21/ IGCSE Chemistry/2017/w/Paper 62/Q3
3 Two solid salts, U and W, were analysed. Solid U was sodium carbonate. Tests were carried out on each solid.

**tests on solid U**

Complete the expected observations.

(a) Describe the appearance of solid U.

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

About half of solid U was dissolved in distilled water to produce solution U. Solution U was divided into two equal portions in two test-tubes.

(b) Dilute hydrochloric acid was added to the first portion of solution U. The gas produced was tested.

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

(c) Name the gas produced in (b).

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

(d) A flame test was carried out on solid U.

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

tests on solid W

Tests were carried out and the following observations made.

<table>
<thead>
<tr>
<th>tests on solid W</th>
<th>observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance of solid W.</td>
<td>white crystals</td>
</tr>
<tr>
<td>Solid W was dissolved in distilled water to produce solution W. The solution was divided into two equal portions in two test-tubes.</td>
<td></td>
</tr>
<tr>
<td><strong>test 1</strong></td>
<td>Dilute nitric acid and aqueous silver nitrate were added to the first portion of solution W.</td>
</tr>
<tr>
<td><strong>test 2</strong></td>
<td>The second portion of solution U was added to the second portion of solution W.</td>
</tr>
<tr>
<td></td>
<td>An excess of dilute hydrochloric acid was then added to the mixture.</td>
</tr>
</tbody>
</table>

(e) What conclusions can you draw about solid W?

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

Q# 22/ IGCSE Chemistry/2017/w/Paper 61/Q3
3 Two solid salts, F and G, were analysed. Solid F was iron(III) nitrate. Tests were carried out on each solid.

tests on solid F

Complete the expected observations.

Solid F was dissolved in distilled water to produce solution F. Solution F was divided into three equal portions in three test-tubes.

(a) (i) A few drops of aqueous sodium hydroxide were added to the first portion of solution F until a change was seen.

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

(ii) An excess of aqueous sodium hydroxide was then added to the mixture from (a)(i).

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

(b) An excess of aqueous ammonia was added to the second portion of solution F until a change was seen.

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

(c) Aluminium foil and aqueous sodium hydroxide were added to the third portion of solution F. The mixture was heated and the gas which was produced was tested.

test for gas .............................................................................................................. [2]

test result ............................................................................................................... [1]

(d) Identify the gas produced in (c).

... .............................................................................................................................. [1]
Q# 23/ IGCSE Chemistry/2017/s/Paper 63/Q3

Two substances, solid J and solution K, were analysed.

<table>
<thead>
<tr>
<th>tests</th>
<th>observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>test 1</td>
<td>A flame test was carried out on solid G.</td>
</tr>
<tr>
<td>test 2</td>
<td>Dilute nitric acid was added to solid G. The gas produced was passed through limewater.</td>
</tr>
</tbody>
</table>

(e) Identify solid G.

Q# 24/ IGCSE Chemistry/2017/s/Paper 61/Q3

Two solids, E and F, were analysed.

<table>
<thead>
<tr>
<th>tests</th>
<th>observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>test 1</td>
<td>Appearance of solid J</td>
</tr>
<tr>
<td>test 2</td>
<td>Dilute hydrochloric acid was added to solid J. The mixture was heated and the gas given off was tested with damp litmus paper.</td>
</tr>
</tbody>
</table>

Q# 23/ IGCSE Chemistry/2017/s/Paper 63/Q3

Solid J was added to the second portion of the solution. The gas given off was tested with a splint.

(a) Name the gas given off in test 1.

(b) (i) Name the precipitate formed in test 2

(ii) A new test 2 was carried out. Iron(II) sulfate crystals were added to water, the mixture was shaken and then aqueous sodium hydroxide was added. What would be observed?

Q# 24/ IGCSE Chemistry/2017/s/Paper 61/Q3

Solid E was heated gently then strongly. The solid turned black.

<table>
<thead>
<tr>
<th>observations</th>
<th>tests on solid E</th>
</tr>
</thead>
<tbody>
<tr>
<td>green solid</td>
<td>Appearance of solid E</td>
</tr>
<tr>
<td>the solid turned black</td>
<td>test 1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>observations</th>
<th>tests on solid E</th>
</tr>
</thead>
<tbody>
<tr>
<td>rapid effervescence</td>
<td>test 2</td>
</tr>
<tr>
<td>a pale blue precipitate formed, which then dissolved to form a dark blue solution</td>
<td>Dilute sulfuric acid was added to solid E. The gas given off was tested. Excess aqueous ammonia was then added to the mixture in the test-tube.</td>
</tr>
</tbody>
</table>
test 3
A flame test was carried out on solid E.
blue-green colour

(a) **Test 1** states that the solid should be heated gently then strongly.

In terms of safety, explain why it is necessary to heat gently at first.

(b) Identify the gas given off in **test 2**.

(c) Identify solid E.

**Tests on solid F**

Complete the expected observations.

(d) Describe the appearance of solid F.

Distilled water was added to solid F in a test-tube and shaken to dissolve solid F.

(e) (i) To the first portion of the solution, an excess of aqueous sodium hydroxide was added.

(ii) To the second portion of the solution, dilute nitric acid and aqueous silver nitrate were added.

(f) A flame test was carried out on solid F.

(g) Describe how you would carry out a flame test.

Q 25/ IGCSE Chemistry 2017/m/Paper 62/Q3

3 Two solids, Q and R, which are both salts, were analysed. Solid Q was zinc bromide. Tests were carried out on each solid.

(a) (i) Drops of aqueous sodium hydroxide were added to the first portion of the solution until a change was seen.

(ii) Excess aqueous sodium hydroxide was then added to the mixture.

(b) (i) Drops of aqueous ammonia were added to the second portion of the solution until a change was seen.

(ii) Excess aqueous ammonia was then added to the mixture.

(c) Dilute nitric acid and aqueous silver nitrate were added to the third portion of the solution.
tests on solid R
Tests were carried out and the following observations made:

<table>
<thead>
<tr>
<th>tests on solid R</th>
<th>observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>test 1</td>
<td>A flame test was carried out on solid R.</td>
</tr>
<tr>
<td>test 2</td>
<td>Dilute nitric acid and aqueous barium nitrate were added to the first portion of the solution.</td>
</tr>
<tr>
<td>test 3</td>
<td>Dilute nitric acid and aqueous silver nitrate were added to the second portion of the solution.</td>
</tr>
</tbody>
</table>

(d) Identify solid R:

Q# 26/IGCSE Chemistry/2016/Paper 63/Q3
3 Two solutions, solution Q and solution R, were analysed. Solution Q was aqueous sulfuric acid.

tests on solution Q
(a) Solution Q was divided into four equal portions in four test-tubes. The following tests were carried out.

(i) test 1
The pH of the first portion of solution Q was measured.

(ii) test 2
Magnesium ribbon was added to the second portion of solution Q. The gas given off was tested.

(iii) test 3
Sodium carbonate was added to the third portion of solution Q. The gas given off was tested.

(iv) test 4
Dilute nitric acid and aqueous barium nitrate were added to the fourth portion of solution Q.

tests on solution R
Solution R was divided into three equal portions in three test-tubes. The following tests were carried out:

<table>
<thead>
<tr>
<th>tests</th>
<th>observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>test 5</td>
<td>The pH of the first portion of solution R was measured.</td>
</tr>
<tr>
<td>test 6</td>
<td>Drops of aqueous sodium hydroxide were added to the second portion of solution R and the test-tube shaken.</td>
</tr>
<tr>
<td>test 7</td>
<td>Excess aqueous sodium hydroxide was then added to the test-tube.</td>
</tr>
<tr>
<td>test 8</td>
<td>Aqueous iron(II) sulfate was added to the third portion of solution R and the mixture shaken.</td>
</tr>
</tbody>
</table>
(b) Identify solution R.

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

Q# 27/ IG CSE Chemistry/2016/w/Paper 62/Q3

3 Two solutions, solution S and solution T, were analysed. Solution S was dilute hydrochloric acid. The tests on solution S and solution T, and some of the observations, are shown.

**Tests on solution S**

(a) Solution S was divided into four equal portions in four test-tubes. The following tests were carried out.

Complete the observations for tests 1–4.

(i) **Test 1**

The pH of the first portion of solution S was tested.

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

(ii) **Test 2**

Copper(II) oxide was added to the second portion of the solution. The mixture was heated.

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

(iii) **Test 3**

Solid sodium carbonate was added to the third portion of the solution. The gas given off was tested.

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

(iv) **Test 4**

Dilute nitric acid and aqueous silver nitrate were added to the fourth portion of the solution.

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

---

**Tests on solution T**

(b) Tests were carried out on solution T and the following observations made.

<table>
<thead>
<tr>
<th>tests</th>
<th>observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solution T was divided into three equal portions in three test-tubes.</td>
<td>yellow solution</td>
</tr>
<tr>
<td>Appearance of the solution.</td>
<td></td>
</tr>
<tr>
<td>Drops of aqueous sodium hydroxide were added to the second portion of the solution and the test-tube shaken.</td>
<td>red-brown precipitate</td>
</tr>
<tr>
<td>Excess aqueous sodium hydroxide was then added to the test-tube.</td>
<td>no visible change</td>
</tr>
<tr>
<td>Aqueous sodium hydroxide and aluminium foil were added to the third portion of the solution and the mixture heated. The gas given off was tested with pH indicator paper.</td>
<td>pungent gas formed, pH 10</td>
</tr>
</tbody>
</table>

Identify solution T.

........................................................................................................................................... [2]
3 Solid P, which is an aluminium salt, was analysed. The tests on solid P, and some of the observations, are shown.

**tests on solid P**

(a) **test 1**

Solid P was divided into three portions. The first portion of solid P was heated.

**observations** condensation formed on the sides of the test-tube

Any gases given off were tested with cobalt(II) chloride paper.

**observations** cobalt(II) chloride paper turned from blue to pink

What does test 1 tell you about solid P?

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

(b) **test 2**

A flame test was carried out on the second portion of solid P.

**observations** ................................................................................................................................. [1]

(tests on a solution of P)

Distilled water was added to the rest of solid P in a test-tube and shaken to dissolve.

(c) The solution was divided into four equal portions in four test-tubes. The following tests were carried out.

(i) **test 3**

Several drops of aqueous sodium hydroxide were added to the first portion of the solution.

Excess aqueous sodium hydroxide was then added to the mixture.

**observations** .................................................................................................................................

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

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

(ii) **test 4**

Several drops of aqueous ammonia were added to the second portion of the solution.

Excess aqueous ammonia was then added to the mixture.

**observations** ................................................................................................................................. [2]

Two further tests were carried out and the following observations made.

<table>
<thead>
<tr>
<th>tests on a solution of P</th>
<th>observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>test 5</td>
<td>no visible reaction</td>
</tr>
<tr>
<td>test 6</td>
<td>white precipitate formed</td>
</tr>
</tbody>
</table>

(d) What does test 5 tell you about solid P?

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

(e) Identify solid P.

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

(f) Describe the appearance of solid P.

................................................................................................................................. [1]
## Q# 29/ iGCSE Chemistry/2016/s/Paper 63/Q3

3 A mixture of two solids, G and H, was analysed. Solid G was zinc nitrate, which is water soluble, and solid H is insoluble in water. The tests on the mixture, and some of the observations, are shown.

Distilled water was added to the mixture in a boiling tube and shaken. The contents of the boiling tube were filtered keeping the filtrate and the residue.

### Tests on filtrate

(a) The filtrate was divided into four test-tubes and the following tests carried out.

(i) Drops of aqueous sodium hydroxide were added to the first portion of the solution. Excess aqueous sodium hydroxide was then added to the test-tube.

<table>
<thead>
<tr>
<th>observations</th>
<th>3</th>
</tr>
</thead>
</table>

(ii) Using the second portion of the solution, the test in (a)(i) was repeated using aqueous ammonia instead of aqueous sodium hydroxide.

<table>
<thead>
<tr>
<th>observations</th>
<th>2</th>
</tr>
</thead>
</table>

(iii) Dilute nitric acid was added to the third portion of the solution followed by aqueous silver nitrate.

<table>
<thead>
<tr>
<th>observations</th>
<th>1</th>
</tr>
</thead>
</table>

(iv) Aqueous sodium hydroxide and aluminium foil were added to the fourth portion of the solution. The mixture was warmed and the gas given off was tested.

<table>
<thead>
<tr>
<th>observations</th>
<th>3</th>
</tr>
</thead>
</table>

## Q# 30/ iGCSE Chemistry/2016/s/Paper 62/Q3

3 Two solids, E and F, were analysed. Solid E was sodium thiosulphate. Both solids were found to be water soluble. The tests on the solids, and some of the observations, are shown below.

### Tests on solid E

(a) Describe the appearance of the solid.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
</tr>
</thead>
</table>

(b) Distilled water was added to solid E in a test-tube and shaken to dissolve.

The solution was divided into two portions in two test-tubes and the following tests carried out.

(i) Aqueous sodium hydroxide was added to the first portion of the solution.

<table>
<thead>
<tr>
<th>observations</th>
<th>1</th>
</tr>
</thead>
</table>

(ii) Dilute hydrochloric acid was added to the second portion of the solution. The mixture was warmed. The gas given off was tested with a piece of filter paper soaked in aqueous acidified potassium manganate(VII) solution.

<table>
<thead>
<tr>
<th>observations</th>
<th>2</th>
</tr>
</thead>
</table>

(c) A flame test was carried out on solid E.

| observations | 1 |
(a) Identify solid C.

(b) Describe the appearance of solution D.

(c) Tests were carried out on solution D.

(i) Test 1

Drops of aqueous sodium hydroxide were added to solution D.

Excess aqueous sodium hydroxide was then added to the mixture.

(iii) Test 3

Dilute nitric acid was added to solution D followed by aqueous silver nitrate.

(d) Chromium(III) can be converted to chromium(VI). Chromium(VI) is hazardous.

Suggest one safety precaution when using chromium(VI).

<table>
<thead>
<tr>
<th>tests on solid F</th>
<th>observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>The solid was heated. The gas given off was tested with damp, red litmus paper.</td>
<td>pungent gas evolved red litmus paper turned blue</td>
</tr>
<tr>
<td>Aqueous sodium hydroxide was added to solid F and the mixture heated. The gas given off was tested.</td>
<td>pungent gas evolved Universal Indicator paper showed pH 10</td>
</tr>
</tbody>
</table>

(d) Identify the gas given off in the tests on solid F.

(e) Identify one of the ions in solid F.

3 Two substances, C and D, were analysed. Solid C was a salt and solution D was an aqueous solution of chromium(III) chloride.

The tests on solid C, and some of the observations, are in the following table.

<table>
<thead>
<tr>
<th>tests on solid C</th>
<th>observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid C was added to distilled water in a test-tube and shaken to dissolve. The solution was divided into two portions in test-tubes, and the following tests carried out. Appearance of the solution. The pH of the first portion of the solution was tested. Dilute nitric acid was added to the second portion of the solution followed by aqueous silver nitrate. A flame test was carried out on solid C.</td>
<td>colourless liquid pH = 7 cream precipitate yellow flame colour</td>
</tr>
</tbody>
</table>

(i) Test 1

Excess aqueous ammonia was added to solution D.

(iii) Test 3

Dilute nitric acid was added to solution D followed by aqueous silver nitrate.

(d) Chromium(III) can be converted to chromium(VI). Chromium(VI) is hazardous.

Suggest one safety precaution when using chromium(VI).
Q# 32/ iGCSE Chemistry/2016/m/Paper 62/Q3

3 Two solids, L and M, were analysed. Solid L was copper(II) chloride and solid M was a different salt.
The tests on the solids, and some of the observations, are shown.

**tests on solid L**

(a) Describe the appearance of solid L.
   observation ................................................................. [1]

(b) Distilled water was added to solid L and shaken to dissolve.
   The solution was divided into four equal portions in four test-tubes and the following tests carried out.

(i) Drops of aqueous ammonia were added to the first portion of the solution.
   Excess ammonia solution was then added to the mixture and shaken.
   observation .................................................................

(ii) Excess aqueous sodium hydroxide was added to the second portion of the solution.
   observation ................................................................. [1]

(iii) Dilute nitric acid was added to the third portion of the solution followed by aqueous silver nitrate.
   observation ................................................................. [1]

(iv) Dilute nitric acid was added to the fourth portion of the solution followed by aqueous barium nitrate.
   observation ................................................................. [1]

**tests on solid M**

Tests are carried out and the following observations made.

<table>
<thead>
<tr>
<th>tests on solid M</th>
<th>observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance of the solid.</td>
<td>white crystals</td>
</tr>
<tr>
<td>The solid was heated and the gas given off was tested with damp red litmus paper.</td>
<td>a sublimates formed on the sides of the test-tube</td>
</tr>
<tr>
<td>litmus paper turned blue</td>
<td></td>
</tr>
<tr>
<td>Solid M was dissolved in water to form a solution.</td>
<td></td>
</tr>
<tr>
<td>Aqueous sodium hydroxide was added to the solution and the mixture heated. The gas given off was tested.</td>
<td>pungent gas evolved</td>
</tr>
<tr>
<td>pH paper showed pH 10</td>
<td></td>
</tr>
<tr>
<td>Dilute nitric acid was added to the solution followed by aqueous silver nitrate.</td>
<td>yellow precipitate</td>
</tr>
</tbody>
</table>

(c) Identify solid M.
   ............................................................................................................. [2]
Q# 33/ I GCSE Chemistry/2017/ v Paper 62/Q3

3 Two solids, E and F, which are both salts, were analysed. Solid F was lithium chloride. Tests were carried out on each solid. Some of the tests and observations are shown.

<table>
<thead>
<tr>
<th>tests on solid E</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>test 1</td>
<td></td>
</tr>
<tr>
<td>A flame test was carried out on solid E.</td>
<td>yellow colour</td>
</tr>
</tbody>
</table>

**test 2**

10 cm³ of distilled water were poured into a boiling tube. The initial temperature of the water was measured. Solid E was added to the boiling tube and the boiling tube was shaken to dissolve solid E. The temperature of the solution was measured after 1 minute.

(a) Use the thermometer diagrams in the table to record the temperatures and complete the table.

<table>
<thead>
<tr>
<th>temperature of the solution after 1 minute/°C</th>
<th>20</th>
<th>15</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>initial temperature of the water/°C</td>
<td>30</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>temperature difference/°C</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The solution was divided into two equal portions in two test-tubes and the following tests carried out.

<table>
<thead>
<tr>
<th>tests on solid E</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>test 3</td>
<td></td>
</tr>
<tr>
<td>Dilute hydrochloric acid was added to the first portion of the solution. The gas given off was tested with filter paper dipped into acidic aqueous potassium manganate(VII).</td>
<td>filter paper turned from purple to colourless</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>test 4</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>An excess of aqueous sodium hydroxide was added to the second portion of the solution.</td>
<td>no change</td>
</tr>
</tbody>
</table>

(b) What does the temperature change tell you about the process occurring in test 2? [1]

(c) Name the gas given off in test 3. [1]

(d) Identify solid E. [2]

**tests on solid F**

Complete the expected observations.

(e) A flame test was carried out on solid F.

<table>
<thead>
<tr>
<th>observations</th>
<th></th>
</tr>
</thead>
</table>

Solid F was added to distilled water in a test-tube and the test-tube shaken to dissolve solid F.

(f) Dilute nitric acid and aqueous silver nitrate were added to the solution.

<table>
<thead>
<tr>
<th>observations</th>
<th></th>
</tr>
</thead>
</table>

Q# 35/ I GCSE Chemistry/2017/ v Paper 61/Q4

4 A sample of furniture cleaner contains aqueous sodium chloride, aqueous ammonia and sand.

(a) Give a test to show the presence of ammonia in the mixture. [1]

Q# 36/ I GCSE Chemistry/2017/ m Paper 62/Q4

4 When solid barium hydroxide is added to solid ammonium chloride a reaction takes place.

(b) How could you show whether or not the final mixture contains ammonium ions? [2]
12.8.1 ESSENTIAL EXAM QUESTIONS 272 Marks Paper 6 Topic 8.3 & 8.4 Mark Scheme

**Q# 1**/iGCSE Chemistry/2018/w/Paper 63/Q1
1. (a) 1 M Litmus solution
2. (b) M2 milky

**Q# 2**/iGCSE Chemistry/2018/w/Paper 62/Q1
1. (a) pH 7 and not >14

**Q# 3**/iGCSE Chemistry/2018/s/Paper 62/Q1
1. (a) limewater / sodium hydroxide solution
2. (b) milky / cloudy / milky precipitate

**Q# 4**/iGCSE Chemistry/2018/s/Paper 61/Q1
1. (b) methyl orange / phenolphthalein / litmus
2. (c) 24.0 ml
3. (d) a reaction of an exotherm acid
4. (d) a reaction of an exotherm acid
5. (e) smaller volume of acid needed

**Q# 5**/iGCSE Chemistry/2017/w/Paper 63/
1. (a) nitric acid

**Q# 6**/iGCSE Chemistry/2017/w/Paper 62/
1. (a) wax

**Q# 7**/iGCSE Chemistry/2017/w/Paper 61/
1. (a) box map / wax / pressure
2. to crystallise
3. cool / leave to stand

**Q# 8**/iGCSE Chemistry/2017/m/Paper 63/
1. (a) nitric acid
2. (b) box / leaf / pressure
3. the reaction is fast at room temperature
4. potassium carbonate
5. solid is left behind
6. to evaporate
7. to crystallise point / glass rod test until saturation point

**Q# 9**/iGCSE Chemistry/2017/m/Paper 62/
1. (a) last, glowing spiclet
2. twist / helix


<table>
<thead>
<tr>
<th>Q# 10/</th>
<th>iGCSE Chemistry/2016/w/Paper 61/</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(a)</td>
<td>lighted splinter, no effect on light for oxygen</td>
</tr>
<tr>
<td>1(b)</td>
<td>splinter for hydrogen, no effect</td>
</tr>
<tr>
<td>1(c)</td>
<td>glowing splinter, no change for oxygen</td>
</tr>
<tr>
<td>1(d)</td>
<td>no effect for hydrogen</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Q# 11/</th>
<th>iGCSE Chemistry/2018/m/Paper 62/Q2</th>
</tr>
</thead>
<tbody>
<tr>
<td>2(a)</td>
<td>Table of results for final reading and difference completed correctly</td>
</tr>
<tr>
<td></td>
<td>11.6</td>
</tr>
<tr>
<td>2(b)</td>
<td>Table of results for final reading and difference completed correctly</td>
</tr>
<tr>
<td></td>
<td>23.8, 11.5</td>
</tr>
<tr>
<td>2(c)</td>
<td>Final reading completed correctly, 24.1</td>
</tr>
<tr>
<td></td>
<td>Initial reading completed correctly, 0.9</td>
</tr>
<tr>
<td></td>
<td>Difference correct, 23.2</td>
</tr>
<tr>
<td>2(d)</td>
<td>Yellow to orange</td>
</tr>
<tr>
<td>2(e)</td>
<td>To remove impurities / chemical residue, solution washed</td>
</tr>
<tr>
<td>2(f)</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Q# 12/</th>
<th>iGCSE Chemistry/2017/m/Paper 62/</th>
</tr>
</thead>
<tbody>
<tr>
<td>2(a)</td>
<td>Paraffin / varnished</td>
</tr>
<tr>
<td>2(b)</td>
<td>Effect, no effect</td>
</tr>
<tr>
<td></td>
<td>Reason, no change in resistant concentrations, solution washed</td>
</tr>
<tr>
<td>2(c)</td>
<td>0.2</td>
</tr>
<tr>
<td>2(d)</td>
<td>Different indicators used, solution washed</td>
</tr>
<tr>
<td>2(e)</td>
<td>More than one colour change, cannot find end point</td>
</tr>
<tr>
<td>2(f)</td>
<td>Repeat experiments</td>
</tr>
<tr>
<td>2(g)</td>
<td>Compare / average / check spread of results</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Q# 13/</th>
<th>iGCSE Chemistry/2016/w/Paper 61/</th>
</tr>
</thead>
<tbody>
<tr>
<td>2(a)</td>
<td>Table of results for Experiment 1, all temperature boxes completed correctly</td>
</tr>
<tr>
<td></td>
<td>20, 21, 22, 23, 24, 25, 26, 27, 28</td>
</tr>
<tr>
<td>2(b)</td>
<td>Table of results for Experiment 2, initial and other temperature boxes completed correctly</td>
</tr>
<tr>
<td></td>
<td>20, 21, 22, 23, 24, 25, 26, 27, 28</td>
</tr>
<tr>
<td>2(c)</td>
<td>All points correctly plotted on smooth line graphs, labels</td>
</tr>
<tr>
<td></td>
<td>Value from graph (27°C), shown clearly</td>
</tr>
<tr>
<td>2(d)</td>
<td>Phenolphthalein / litmus / suitable named indicator</td>
</tr>
<tr>
<td>2(e)</td>
<td>Experiment 1, solution N, in a stronger acid than a higher pH</td>
</tr>
<tr>
<td>2(f)</td>
<td>Measured results, temperature changes, results would be smaller</td>
</tr>
<tr>
<td></td>
<td>Larger double volume needed to reach same temperature changes</td>
</tr>
<tr>
<td>2(g)</td>
<td>Polyethylene is a combustion / happens at high temperature</td>
</tr>
<tr>
<td>2(h)</td>
<td>Source of error, heat losses, using a measuring cylinder, Improvements: lag or insulated / use burette</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Q# 14/</th>
<th>iGCSE Chemistry/2016/s/Paper 63/</th>
</tr>
</thead>
<tbody>
<tr>
<td>2(a)</td>
<td>Hydrogen gas</td>
</tr>
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</table>

Q# 17/ iGCSE Chemistry/2018/s/Paper 63/Q3

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(a)</td>
<td>yellow</td>
<td>1</td>
</tr>
<tr>
<td>1(b)</td>
<td>pH 1–14</td>
<td>1</td>
</tr>
<tr>
<td>1(c)</td>
<td>white precipitate</td>
<td>1</td>
</tr>
<tr>
<td>1(d)</td>
<td>clear / colourless</td>
<td>1</td>
</tr>
<tr>
<td>1(e)</td>
<td>white precipitate</td>
<td>1</td>
</tr>
<tr>
<td>2(a)</td>
<td>pH / litmus paper</td>
<td>1</td>
</tr>
<tr>
<td>2(b)</td>
<td>turn red / turn blue</td>
<td>1</td>
</tr>
<tr>
<td>3(a)</td>
<td>FeSO₄</td>
<td>1</td>
</tr>
<tr>
<td>3(b)</td>
<td>precipitate</td>
<td>1</td>
</tr>
</tbody>
</table>

Q# 18/ iGCSE Chemistry/2018/s/Paper 62/Q3

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(a)</td>
<td>place / green / solid / crystals</td>
<td>1</td>
</tr>
<tr>
<td>1(b)</td>
<td>no change / no reaction / no precipitate / no observation</td>
<td>1</td>
</tr>
<tr>
<td>1(c)</td>
<td>white precipitate</td>
<td>1</td>
</tr>
<tr>
<td>2(a)</td>
<td>green</td>
<td>1</td>
</tr>
<tr>
<td>2(b)</td>
<td>precipitate</td>
<td>1</td>
</tr>
<tr>
<td>3(a)</td>
<td>green precipitate</td>
<td>1</td>
</tr>
<tr>
<td>3(b)</td>
<td>sodium</td>
<td>1</td>
</tr>
</tbody>
</table>

Q# 19/ iGCSE Chemistry/2018/s/Paper 61/Q3

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(a)</td>
<td>more particles of molecules in a given volume</td>
<td>1</td>
</tr>
<tr>
<td>1(b)</td>
<td>more chance of collision</td>
<td>1</td>
</tr>
<tr>
<td>1(c)</td>
<td>use a pipette / burette</td>
<td>1</td>
</tr>
<tr>
<td>1(d)</td>
<td>time would be shorter</td>
<td>1</td>
</tr>
<tr>
<td>1(e)</td>
<td>idea of depth of solution in greater</td>
<td>1</td>
</tr>
<tr>
<td>1(f)</td>
<td>sketch curve roughly same shape and above original</td>
<td>1</td>
</tr>
</tbody>
</table>

Q# 20/ iGCSE Chemistry/2017/w/Paper 63/

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(a)</td>
<td>hydrogen / H₂</td>
<td>1</td>
</tr>
<tr>
<td>1(b)</td>
<td>sulphur</td>
<td>1</td>
</tr>
<tr>
<td>1(c)</td>
<td>acid</td>
<td>1</td>
</tr>
<tr>
<td>1(d)</td>
<td>steam / steamy</td>
<td>1</td>
</tr>
<tr>
<td>1(e)</td>
<td>milky / cloudy / white ppt.</td>
<td>1</td>
</tr>
<tr>
<td>1(f)</td>
<td>white</td>
<td>1</td>
</tr>
<tr>
<td>1(g)</td>
<td>precipitate</td>
<td>1</td>
</tr>
<tr>
<td>2(a)</td>
<td>dissolve / clear / goes colourless</td>
<td>1</td>
</tr>
<tr>
<td>2(b)</td>
<td>white precipitate</td>
<td>1</td>
</tr>
<tr>
<td>2(c)</td>
<td>dissolves / clear / goes colourless</td>
<td>1</td>
</tr>
</tbody>
</table>

Q# 21/ iGCSE Chemistry/2017/w/Paper 62/

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(a)</td>
<td>green</td>
<td>1</td>
</tr>
<tr>
<td>1(b)</td>
<td>precipitate</td>
<td>1</td>
</tr>
<tr>
<td>1(c)</td>
<td>green solution / precipitate dissolves</td>
<td>1</td>
</tr>
<tr>
<td>1(a)(ii)</td>
<td>bubbles / fizzing / effervescence</td>
<td>1</td>
</tr>
<tr>
<td>1(a)(iii)</td>
<td>(red) litmus paper / Universal Indicator paper</td>
<td>1</td>
</tr>
<tr>
<td>1(a)(iv)</td>
<td>red litmus paper / turns blue / Universal Indicator paper / turns purple</td>
<td>1</td>
</tr>
<tr>
<td>3(a)</td>
<td>ammonia / NH₃</td>
<td>1</td>
</tr>
<tr>
<td>3(b)</td>
<td>aqueous ammonia / NH₃</td>
<td>1</td>
</tr>
<tr>
<td>3(c)</td>
<td>solution / solution / solution</td>
<td>1</td>
</tr>
</tbody>
</table>

Q# 22/ iGCSE Chemistry/2017/w/Paper 62/

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(a)</td>
<td>white (crystals)</td>
<td>1</td>
</tr>
<tr>
<td>1(b)</td>
<td>bubbles / effervescence</td>
<td>1</td>
</tr>
<tr>
<td>1(c)</td>
<td>steam / steamy</td>
<td>1</td>
</tr>
<tr>
<td>1(d)</td>
<td>dume / milky</td>
<td>1</td>
</tr>
<tr>
<td>3(a)</td>
<td>carbon dioxide</td>
<td>1</td>
</tr>
<tr>
<td>3(b)</td>
<td>yellow</td>
<td>1</td>
</tr>
<tr>
<td>3(c)</td>
<td>non-transition metal / Group II metal / Barium / Calcium / Magnesium</td>
<td>1</td>
</tr>
<tr>
<td>3(d)</td>
<td>chinkle</td>
<td>1</td>
</tr>
</tbody>
</table>
### Q# 22/ iGCSE Chemistry/2017/w/Paper 61/

<table>
<thead>
<tr>
<th>Q22(a)</th>
<th>red/orange precipitate</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q22(b)</td>
<td>no change</td>
<td>1</td>
</tr>
<tr>
<td>Q22(c)</td>
<td>red/orange precipitate</td>
<td>1</td>
</tr>
<tr>
<td>Q22(d)</td>
<td>turns blue</td>
<td>1</td>
</tr>
<tr>
<td>Q22(e)</td>
<td>ammoxid</td>
<td>1</td>
</tr>
<tr>
<td>Q22(f)</td>
<td>blue</td>
<td>1</td>
</tr>
</tbody>
</table>

### Q# 23/ iGCSE Chemistry/2017/s/Paper 63/

<table>
<thead>
<tr>
<th>Q23(a)</th>
<th>chlorine</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q23(b)</td>
<td>iron(III)</td>
<td>1</td>
</tr>
<tr>
<td>Q23(c)</td>
<td>hydrogen</td>
<td>1</td>
</tr>
<tr>
<td>Q23(d)</td>
<td>green</td>
<td>1</td>
</tr>
<tr>
<td>Q23(e)</td>
<td>precipitate</td>
<td>1</td>
</tr>
<tr>
<td>Q23(f)</td>
<td>oxygen</td>
<td>1</td>
</tr>
<tr>
<td>Q23(g)</td>
<td>catalyst</td>
<td>1</td>
</tr>
<tr>
<td>Q23(h)</td>
<td>transition element compound/ manganese dioxide</td>
<td>1</td>
</tr>
</tbody>
</table>

### Q# 24/ iGCSE Chemistry/2017/s/Paper 61/

<table>
<thead>
<tr>
<th>Q24(a)</th>
<th>solid out of the tube</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q24(b)</td>
<td>carbon dioxide</td>
<td>1</td>
</tr>
<tr>
<td>Q24(c)</td>
<td>copper(Cu²⁺)</td>
<td>1</td>
</tr>
<tr>
<td>Q24(d)</td>
<td>carbonate(CO₃²⁻)</td>
<td>1</td>
</tr>
<tr>
<td>Q24(e)</td>
<td>white</td>
<td>1</td>
</tr>
<tr>
<td>Q24(f)(i)</td>
<td>no reaction/change</td>
<td>1</td>
</tr>
<tr>
<td>Q24(f)(ii)</td>
<td>yellow</td>
<td>1</td>
</tr>
<tr>
<td>Q24(f)(iii)</td>
<td>precipitate</td>
<td>1</td>
</tr>
</tbody>
</table>

### Q# 25/ iGCSE Chemistry/2017/m/Paper 62/

<table>
<thead>
<tr>
<th>Q25(a)</th>
<th>white</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q25(b)</td>
<td>white precipitate</td>
<td>1</td>
</tr>
<tr>
<td>Q25(c)</td>
<td>white precipitate</td>
<td>1</td>
</tr>
<tr>
<td>Q25(d)</td>
<td>white precipitate dissolves</td>
<td>1</td>
</tr>
<tr>
<td>Q25(e)</td>
<td>cream</td>
<td>1</td>
</tr>
<tr>
<td>Q25(f)</td>
<td>sodium</td>
<td>1</td>
</tr>
</tbody>
</table>

### Q# 26/ iGCSE Chemistry/2016/w/Paper 63/

<table>
<thead>
<tr>
<th>Q26(a)</th>
<th>pH 1-3</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q26(b)</td>
<td>effervescent/bubbling/solid disappears</td>
<td>1</td>
</tr>
<tr>
<td>Q26(c)</td>
<td>gas</td>
<td>1</td>
</tr>
<tr>
<td>Q26(d)</td>
<td>hydrogen</td>
<td>1</td>
</tr>
<tr>
<td>Q26(e)</td>
<td>white precipitate</td>
<td>1</td>
</tr>
<tr>
<td>Q26(f)</td>
<td>calcium(Ca²⁺)</td>
<td>1</td>
</tr>
<tr>
<td>Q26(g)</td>
<td>hydroxide(CO₃⁻)</td>
<td>1</td>
</tr>
</tbody>
</table>

### Q# 27/ iGCSE Chemistry/2016/w/Paper 62/

<table>
<thead>
<tr>
<th>Q27(a)</th>
<th>pH 1-3</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q27(b)</td>
<td>solid disappears/disappears</td>
<td>1</td>
</tr>
<tr>
<td>Q27(c)</td>
<td>blue/green colour</td>
<td>1</td>
</tr>
<tr>
<td>Q27(d)</td>
<td>solid dissolves</td>
<td>1</td>
</tr>
<tr>
<td>Q27(e)</td>
<td>turns milky</td>
<td>1</td>
</tr>
<tr>
<td>Q27(f)</td>
<td>white precipitate</td>
<td>1</td>
</tr>
<tr>
<td>Q27(g)</td>
<td>iron(II)</td>
<td>1</td>
</tr>
<tr>
<td>Q27(h)</td>
<td>sodium</td>
<td>1</td>
</tr>
</tbody>
</table>

### Q# 28/ iGCSE Chemistry/2016/w/Paper 61/

<table>
<thead>
<tr>
<th>Q28(a)</th>
<th>water present/hydrated</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q28(b)</td>
<td>no change/clear</td>
<td>1</td>
</tr>
<tr>
<td>Q28(c)</td>
<td>white precipitate dissolves</td>
<td>1</td>
</tr>
<tr>
<td>Q28(d)</td>
<td>white precipitate</td>
<td>1</td>
</tr>
<tr>
<td>Q28(e)</td>
<td>white precipitate</td>
<td>1</td>
</tr>
<tr>
<td>Q28(f)</td>
<td>not a halide</td>
<td>1</td>
</tr>
<tr>
<td>Q28(g)</td>
<td>(aluminium) sulfate</td>
<td>1</td>
</tr>
<tr>
<td>Q28(h)</td>
<td>white (crystals)</td>
<td>1</td>
</tr>
</tbody>
</table>

### Q# 29/ iGCSE Chemistry/2016/s/Paper 63/

<table>
<thead>
<tr>
<th>Q29(a)</th>
<th>white</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q29(b)</td>
<td>precipitate/dissolves</td>
<td>1</td>
</tr>
<tr>
<td>Q29(c)</td>
<td>white precipitate/dissolves</td>
<td>1</td>
</tr>
<tr>
<td>Q29(d)</td>
<td>no reaction/change</td>
<td>1</td>
</tr>
<tr>
<td>Q29(e)</td>
<td>any 3 from: effervescent/bubbling/milky/cream</td>
<td>1</td>
</tr>
<tr>
<td>Q29(f)</td>
<td>litmus</td>
<td>1</td>
</tr>
<tr>
<td>Q29(g)</td>
<td>soluble</td>
<td>1</td>
</tr>
</tbody>
</table>
### Q# 30/ iGCSE Chemistry/2016/v/Paper 62/

<table>
<thead>
<tr>
<th>(a) sodium</th>
<th>yellow (solid crystals/powder)</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>(b)</td>
<td>no change.</td>
<td>1</td>
</tr>
<tr>
<td>(c)</td>
<td>turns from purple/pink to yellow/white</td>
<td>2</td>
</tr>
<tr>
<td>(d)</td>
<td>yellow/orange/flame.</td>
<td>1</td>
</tr>
<tr>
<td>(e)</td>
<td>ammonia/H₂.</td>
<td>1</td>
</tr>
<tr>
<td>(f)</td>
<td>ammonium/H₃O⁺.</td>
<td>1</td>
</tr>
</tbody>
</table>

### Q# 31/ iGCSE Chemistry/2016/v/Paper 61/

<table>
<thead>
<tr>
<th>a) sodium bromide</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>(b) water</td>
<td>1</td>
</tr>
<tr>
<td>(c) green</td>
<td>5</td>
</tr>
<tr>
<td>(d) precipitate</td>
<td>1</td>
</tr>
<tr>
<td>(e) with excess green solution/colourless</td>
<td>1</td>
</tr>
<tr>
<td>(f) 2 grey/green</td>
<td>2</td>
</tr>
<tr>
<td>(g) precipitate</td>
<td>1</td>
</tr>
<tr>
<td>(h) white precipitate</td>
<td>1</td>
</tr>
<tr>
<td>(i) turns backward/protective clothing</td>
<td>1</td>
</tr>
</tbody>
</table>

### Q# 32/ iGCSE Chemistry/2016/m/Paper 62/

| a) blue/green (solid crystals) | 1 |
| (b) (i) blue | 4 |
| (ii) pale blue | 1 |
| (iii) deep blue | 1 |
| (iv) decolourised | 1 |
| (c) white precipitate | 1 |
| (d) no reaction/change/precipitate | 1 |
| (e) ammonium bicarbonate | 1 |

### Q# 33/ iGCSE Chemistry/2017/v/Paper 62/G3

<table>
<thead>
<tr>
<th>a)</th>
<th>The final temperature recorded correctly, 18.23</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>b)</td>
<td>enthalpy change calculated.</td>
<td>4</td>
</tr>
<tr>
<td>c)</td>
<td>sulfur dioxide</td>
<td>4</td>
</tr>
<tr>
<td>d)</td>
<td>sodium/H⁺</td>
<td>4</td>
</tr>
<tr>
<td>e)</td>
<td>sulfur/SO²⁻</td>
<td>1</td>
</tr>
<tr>
<td>f)</td>
<td>red</td>
<td>1</td>
</tr>
<tr>
<td>g)</td>
<td>white</td>
<td>1</td>
</tr>
<tr>
<td>h)</td>
<td>precipitate</td>
<td>1</td>
</tr>
</tbody>
</table>

### Q# 35/ iGCSE Chemistry/2017/v/Paper 61/

### Q# 37/ iGCSE Chemistry/2016/w/Paper 61/

| 4 | Method adding Ag nitre to acid
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Using weighed amount of Ag nitre to acid</td>
</tr>
<tr>
<td></td>
<td>With a named indicator added to the acid</td>
</tr>
<tr>
<td></td>
<td>Until the indicator changes colour</td>
</tr>
<tr>
<td></td>
<td>The experiment using the smaller amount of Ag nitre is better</td>
</tr>
<tr>
<td></td>
<td>Method adding acid to Ag nitre</td>
</tr>
<tr>
<td></td>
<td>Using weighed amount/known masses of Ag nitre and acid</td>
</tr>
<tr>
<td></td>
<td>Add acid to it gradually/Return to louqor</td>
</tr>
<tr>
<td></td>
<td>With a named indicator added to the acid</td>
</tr>
<tr>
<td></td>
<td>Until the indicator changes colour</td>
</tr>
<tr>
<td></td>
<td>The volume of acid added</td>
</tr>
<tr>
<td></td>
<td>Repeat with Ag nitre</td>
</tr>
<tr>
<td></td>
<td>Conclusion: e.g. 'the experiment using the larger volume of acid is better'</td>
</tr>
</tbody>
</table>

### Q# 38/ iGCSE Chemistry/2016/w/Paper 62/

<table>
<thead>
<tr>
<th>a)</th>
<th>making the salt</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Any 4 steps:</td>
</tr>
<tr>
<td></td>
<td>Known volume/sulphur acid</td>
</tr>
<tr>
<td></td>
<td>Add named indicator</td>
</tr>
<tr>
<td></td>
<td>Add potassium hydroxide solution to the acid until the indicator changes colour/Neutralised</td>
</tr>
<tr>
<td></td>
<td>Note/review the volume of potassium hydroxide solution added</td>
</tr>
<tr>
<td></td>
<td>Repeat without indicator OR Add (decolourising) charcoal</td>
</tr>
</tbody>
</table>

### Q# 39/ iGCSE Chemistry/2017/m/Paper 62/

<table>
<thead>
<tr>
<th>a)</th>
<th>obtaining crystals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Any 2 steps:</td>
</tr>
</tbody>
</table>
|   | Heat/evaporate solution to crystallisation point UNTIL CRYSTALLISED OR until crystals start to form OR until 
|   | Solution is clear |
|   | Leave to cool |
|   | Filter to get crystals |
|   | Dry crystals (on filter paper) leave to dry |

12.9  FUNDAMENTAL Assessed Activity 1  Keyword Test

<table>
<thead>
<tr>
<th>English</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>litmus</td>
<td></td>
</tr>
<tr>
<td>amphoteric hydroxides</td>
<td></td>
</tr>
<tr>
<td>acidic oxides</td>
<td></td>
</tr>
<tr>
<td>neutralisation</td>
<td></td>
</tr>
<tr>
<td>pH scale</td>
<td></td>
</tr>
<tr>
<td>precipitation reaction</td>
<td></td>
</tr>
<tr>
<td>weak acid</td>
<td></td>
</tr>
<tr>
<td>acid</td>
<td></td>
</tr>
<tr>
<td>indicator</td>
<td></td>
</tr>
<tr>
<td>base</td>
<td></td>
</tr>
<tr>
<td>strong alkali</td>
<td></td>
</tr>
<tr>
<td>strong acid</td>
<td></td>
</tr>
<tr>
<td>weak alkali</td>
<td></td>
</tr>
<tr>
<td>corrosive</td>
<td></td>
</tr>
<tr>
<td>Universal Indicator</td>
<td></td>
</tr>
<tr>
<td>alcalis</td>
<td></td>
</tr>
<tr>
<td>basic oxide</td>
<td></td>
</tr>
<tr>
<td>suspension</td>
<td></td>
</tr>
</tbody>
</table>

12.10  ESSENTIAL Assessed Activity Topic 8 2  Paper 2 16marks

Q# 1/
17 The results of some experiments with sulfur dioxide are shown.

<table>
<thead>
<tr>
<th>experiment</th>
<th>description</th>
<th>result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>mix with dilute hydrochloric acid</td>
<td>does not react</td>
</tr>
<tr>
<td>2</td>
<td>mix with concentrated sodium hydroxide</td>
<td>a salt forms</td>
</tr>
<tr>
<td>3</td>
<td>add Universal Indicator</td>
<td>Universal Indicator turns purple</td>
</tr>
<tr>
<td>4</td>
<td>add acidified aqueous potassium manganate(VII)</td>
<td>purple solution turns colourless</td>
</tr>
</tbody>
</table>

Which results are correct?
A  1, 2 and 4  B  2, 3 and 4  C  1 and 2 only  D  3 and 4 only

18 A white precipitate is produced when small amounts of two colourless solutions are mixed together.

Which pairs of solutions produce a white precipitate?

A  sodium hydroxide and zinc nitrate
B  sodium hydroxide and aluminium chloride
C  barium chloride and sulfuric acid
D  acidified barium nitrate and potassium sulfate

A  1, 2, 3 and 4  B  1, 2 and 4 only  C  1 and 2 only  D  2 only

19 Solution O is warmed with ammonium chloride.

In a separate experiment, solution Q is added to methyl orange.

Which observations show that solution Q is basic?

<table>
<thead>
<tr>
<th>warmed with ammonium chloride</th>
<th>added to methyl orange</th>
</tr>
</thead>
<tbody>
<tr>
<td>A gas is produced</td>
<td>turns red</td>
</tr>
<tr>
<td>B gas is produced</td>
<td>turns yellow</td>
</tr>
<tr>
<td>C no reaction</td>
<td>turns red</td>
</tr>
<tr>
<td>D no reaction</td>
<td>turns yellow</td>
</tr>
</tbody>
</table>

A  B  C  D
Q# 2/
17 In which row are the oxides correctly identified?

<table>
<thead>
<tr>
<th></th>
<th>acidic</th>
<th>basic</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>magnesium oxide, calcium oxide</td>
<td>sulfur dioxide, carbon dioxide</td>
</tr>
<tr>
<td>B</td>
<td>magnesium oxide, sulfur dioxide</td>
<td>carbon dioxide, calcium oxide</td>
</tr>
<tr>
<td>C</td>
<td>sulfur dioxide, carbon dioxide</td>
<td>calcium oxide, magnesium oxide</td>
</tr>
<tr>
<td>D</td>
<td>sulfur dioxide, magnesium oxide</td>
<td>calcium oxide, carbon dioxide</td>
</tr>
</tbody>
</table>

18 When dilute sulfuric acid is added to solid X, a colourless solution is formed and a gas is produced.

What is X?
A copper(II) oxide
B sodium oxide
C copper(II) carbonate
D sodium carbonate

19 A few drops of methyl orange are added to a reaction mixture.

During the reaction, a gas is produced and the methyl orange turns from red to orange.

What are the reactants?
A aqueous sodium hydroxide and ammonium chloride
B aqueous sodium hydroxide and calcium carbonate
C dilute hydrochloric acid and magnesium
D dilute hydrochloric acid and aqueous sodium hydroxide

Q# 3/
18 The equation represents an equilibrium in aqueous ammonia.

\[ \text{NH}_3(aq) + \text{H}_2\text{O}(l) \rightleftharpoons \text{NH}_4^+(aq) + \text{OH}^-(aq) \]

How does aqueous ammonia behave in this reaction?
A as a strong acid
B as a strong base
C as a weak acid
D as a weak base

Q# 4/
1 A gas is released at point X in the apparatus shown.

Which gas turns the damp Universal Indicator paper red most quickly?
A ammonia, NH$_3$
B chlorine, Cl$_2$
C hydrogen chloride, HCl
D sulfur dioxide, SO$_2$

Q# 5/
18 Which statement about acids and bases is correct?
A A base is a donor of hydrogen ions.
B An acid is an acceptor of protons.
C A strong acid is fully ionised in aqueous solution.
D A weak acid cannot be used to neutralise a strong base.

19 The solubility of some salts is shown.

<table>
<thead>
<tr>
<th></th>
<th>chloride</th>
<th>nitrate</th>
<th>sulfate</th>
<th>carbonate</th>
</tr>
</thead>
<tbody>
<tr>
<td>barium</td>
<td>soluble</td>
<td>soluble</td>
<td>insoluble</td>
<td>insoluble</td>
</tr>
<tr>
<td>lead(II)</td>
<td>insoluble</td>
<td>soluble</td>
<td>insoluble</td>
<td>insoluble</td>
</tr>
<tr>
<td>potassium</td>
<td>soluble</td>
<td>soluble</td>
<td>soluble</td>
<td>soluble</td>
</tr>
<tr>
<td>zinc</td>
<td>soluble</td>
<td>soluble</td>
<td>soluble</td>
<td>insoluble</td>
</tr>
</tbody>
</table>
Which two aqueous solutions produce an insoluble salt when mixed together?

A. barium chloride and zinc nitrate
B. barium nitrate and lead(II) nitrate
C. lead(II) nitrate and potassium carbonate
D. potassium nitrate and zinc sulfate

20. Which methods are suitable for preparing both zinc sulfate and copper(II) sulfate?
   1. reacting the metal oxide with warm dilute aqueous sulfuric acid
   2. reacting the metal with dilute aqueous sulfuric acid
   3. reacting the metal carbonate with dilute aqueous sulfuric acid

   A. 1, 2 and 3    B. 1 and 2 only    C. 1 and 3 only    D. 2 and 3 only

17. Which statement about oxides is correct?
   A. A solution of magnesium oxide has a pH less than pH 7.
   B. A solution of sulfur dioxide has a pH greater than pH 7.
   C. Magnesium oxide reacts with nitric acid to make a salt.
   D. Sulfur dioxide reacts with hydrochloric acid to make a salt.

18. Which solution has the lowest pH?
   A. 0.1 mol/dm³ ammonia solution
   B. 0.1 mol/dm³ ethanoic acid
   C. 0.1 mol/dm³ lithium hydroxide
   D. 0.1 mol/dm³ nitric acid

19. A student mixes silver nitrate and barium chloride to form a white precipitate of silver chloride. The equation is shown.

   \[ 2\text{AgNO}_3 + \text{BaCl}_2 \rightarrow 2\text{AgCl} + \text{Ba(NO}_3\text{)}_2 \]

   Which row describes the solubility of the salts?

<table>
<thead>
<tr>
<th></th>
<th>soluble</th>
<th>insoluble</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>silver nitrate</td>
<td>barium chloride, barium nitrate and silver chloride</td>
</tr>
<tr>
<td>B</td>
<td>silver nitrate and barium chloride</td>
<td>barium nitrate and silver chloride</td>
</tr>
<tr>
<td>C</td>
<td>silver nitrate, barium chloride and barium nitrate</td>
<td>silver chloride</td>
</tr>
<tr>
<td>D</td>
<td>silver nitrate, barium chloride and silver chloride</td>
<td>barium nitrate</td>
</tr>
</tbody>
</table>

20. Which methods are suitable for preparing both zinc sulfate and copper(II) sulfate?
   1. reacting the metal oxide with warm dilute aqueous sulfuric acid
   2. reacting the metal with dilute aqueous sulfuric acid
   3. reacting the metal carbonate with dilute aqueous sulfuric acid

   A. 1, 2 and 3    B. 1 and 2 only    C. 1 and 3 only    D. 2 and 3 only
12.11 ESSENTIAL Assessed Activity 3 Paper 3/4 Topic 8.2 & 8.2 17 Marks

Q#1/

2 Three ways of making salts are
- titration using a soluble base or carbonate
- neutralisation using an insoluble base or carbonate
- precipitation.

(a) Complete the following table of salt preparations.

<table>
<thead>
<tr>
<th>method</th>
<th>reagent 1</th>
<th>reagent 2</th>
<th>salt</th>
</tr>
</thead>
<tbody>
<tr>
<td>titration</td>
<td></td>
<td></td>
<td>sodium nitrate</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>neutralisation</td>
<td>nitric acid</td>
<td>copper(II) nitrate</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>precipitation</td>
<td></td>
<td>silver(I) chloride</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>neutralisation</td>
<td>sulfuric acid</td>
<td>zinc(II) carbonate</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(b) (i) Write an ionic equation with state symbols for the preparation of silver(I) chloride.

(ii) zinc carbonate + hydrochloric acid → ------------------------ + _______________________________ [1]

Q#3/

8 Soluble salts can be made using a base and an acid.

(a) Complete this method of preparing dry crystals of the soluble salt cobalt(II) chloride-6-water from the insoluble base cobalt(II) carbonate.

Step 1
Add an excess of cobalt(II) carbonate to hot dilute hydrochloric acid.

Step 2

Step 3

Step 4


12.12 ESSENTIAL Assessed Activity 4 Paper 6 Topic 8.2 & 8.2 Tests for Ions 24 marks

Q#4/

4 Aqueous solutions of barium hydroxide are alkaline.

Plan an investigation to find the concentration of an aqueous solution of barium hydroxide.

You are provided with an aqueous solution of barium hydroxide, dilute hydrochloric acid of known concentration and common laboratory apparatus.

(ii) MgO + ..........HCl → + _______________________________ [1]

Q#3/
Solid P and solid Q were analysed. Solid P was lithium nitrate. Tests were done on each solid.

Tests on solid P

Complete the expected observations.

(a) Describe the appearance of solid P.

Solid P was divided into three portions.

(b) Aqueous sodium hydroxide and a small piece of aluminium foil were added to the first portion of solid P. The mixture was heated and the gas produced was tested.

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

(c) The second portion of solid P was dissolved in distilled water. Dilute nitric acid and aqueous barium nitrate were then added to the solution.

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

d) A flame test was done on the third portion of solid P.

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

Tests on solid Q

Some of the tests and observations are shown.

<table>
<thead>
<tr>
<th>tests on solid Q</th>
<th>observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>The appearance of solid Q was studied.</td>
<td>pink crystals</td>
</tr>
<tr>
<td>Solid Q was heated in a hard glass test-tube.</td>
<td>condensation formed at the top of the test-tube</td>
</tr>
<tr>
<td>Dilute nitric acid and aqueous silver nitrate were added to an aqueous solution of solid Q.</td>
<td>white precipitate</td>
</tr>
</tbody>
</table>
(e) What conclusions can you draw about the identity of solid Q?

[Total: 2]

Q# 16/
3 Two solids, solid G and solid H, were analysed. Tests were done on each solid.

tests on solid G

Some of the tests and observations are shown.

<table>
<thead>
<tr>
<th>tests on solid G</th>
<th>observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>test 1</td>
<td></td>
</tr>
<tr>
<td>A flame test was done on solid G.</td>
<td>lilac colour</td>
</tr>
<tr>
<td>Solid G was dissolved in distilled water.</td>
<td></td>
</tr>
<tr>
<td>test 2</td>
<td></td>
</tr>
<tr>
<td>Dilute hydrochloric acid was added to</td>
<td></td>
</tr>
<tr>
<td>the solution. The solution was warmed</td>
<td></td>
</tr>
<tr>
<td>gently. The gas produced was tested</td>
<td></td>
</tr>
<tr>
<td>filter paper turned from purple to</td>
<td></td>
</tr>
<tr>
<td>colourless</td>
<td></td>
</tr>
</tbody>
</table>

(a) Name the gas produced in test 2.  
[Total: 1]

(b) Identify solid G.  
[Total: 2]

tests on solid H

Solid H was calcium nitrate.

Complete the expected observations.

Solid H was added to distilled water in a test-tube. The test-tube was shaken to dissolve solid H.  
The solution was divided into four portions in four test-tubes.

(c) (i) Drops of aqueous sodium hydroxide were added to the first portion of the solution.  
observations ................................................................. [2]  
(ii) An excess of aqueous sodium hydroxide was then added to the mixture from (c)(i).  
observations ................................................................. [1]

(d) An excess of aqueous ammonia was added to the second portion of the solution.  
observations ................................................................. [1]

(e) Dilute nitric acid and aqueous silver nitrate were added to the third portion of the solution.  
observations ................................................................. [1]

(f) Aluminium foil and aqueous sodium hydroxide were added to the fourth portion of the solution.  
The mixture was warmed and the gas produced was tested.  
observations ................................................................. [2]  
[Total: 10]
12.13 Essential End of Topic 8.3 & 8.4 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?

12.14 Exceptional Additional Activities, Further Reading and Exploring Beyond the Syllabus

This is a unit which is particularly well suited to learning how to create and use mnemonics. The more often you practice anything, like creating mnemonics, the better you will get at it.

Mnemonics. Find out about different ways to memorise facts by reading articles about memory techniques which are available here: [https://www.smashingsciencecn.org/igcse-chem-additional-resources](https://www.smashingsciencecn.org/igcse-chem-additional-resources)

Another helpful technique includes Cornell Notetaking, by the way!!!
## 13 Topic 10 Metals

### 13.1 End of Topic 10 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>Textbook</td>
<td>Read ahead before the topic has been started</td>
<td></td>
<td>ESSENTIAL</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>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>ESSENTIAL</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 30% 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>
</tbody>
</table>

### 13.2 ESSENTIAL Topic 10 Syllabus

#### 10 Metals

10.1 Properties of metals

- List the general physical properties of metals
- Describe the general chemical properties of metals, e.g. reaction with dilute acids and reaction with oxygen
- Explain in terms of their properties why alloys are used instead of pure metals
- Identify representations of alloys from diagrams of structure
### 10.2 Reactivity series

**Core**
- Place in order of reactivity: potassium, sodium, calcium, magnesium, zinc, iron, hydrogen and copper, by reference to the reactions, if any, of the metals with:
  - water or steam
  - dilute hydrochloric acid
  - and the reduction of their oxides with carbon

**Supplement**
- Describe the reactivity series as related to the tendency of a metal to form its positive ion, illustrated by its reaction, if any, with:
  - the aqueous ions
  - the oxides
  - of the other listed metals
- Describe and explain the action of heat on the oxides, carbonates and nitrates of the listed metals
- Account for the apparent unreactivity of aluminium in terms of the oxide layer which adheres to the metal.

- Deduce an order of reactivity from a given set of experimental results

### 10.3 Extraction of metals

**Core**
- Describe the ease in obtaining metals from their ores by relating the elements to the reactivity series
- Describe and state the essential reactions in the extraction of iron from haematite
- Describe the conversion of iron into steel using basic oxides and oxygen
- Know that aluminium is extracted from the ore bauxite by electrolysis
- Discuss the advantages and disadvantages of recycling metals, limited to iron and steel and aluminium

**Supplement**
- Describe in outline, the extraction of zinc from zinc blende
- Describe in detail, the extraction of aluminium from bauxite including the role of cryolite and the reactions at the electrodes

### 10.4 Uses of metals

**Core**
- Name the uses of aluminium:
  - in the manufacture of aircraft because of its strength and low density
  - in food containers because of its resistance to corrosion
- Name the uses of copper related to its properties (electrical wiring and in cooking utensils)
- Name the uses of mild steel (car bodies and machinery) and stainless steel (chemical plant and cutlery)

**Supplement**
- Explain the uses of zinc for galvanising and for making brass
- Explain the idea of changing the properties of iron by the controlled use of additives to form steel alloys

---

### 13.3 ESSENTIAL Glossary for Keywords for this topic

<table>
<thead>
<tr>
<th>Topic</th>
<th>English</th>
<th>Chinese</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>alloy steels are made when iron is mixed with other transition metals (and a small amount of carbon)</td>
<td>铁与其他过渡金属（和少量碳）混合后制成合金钢</td>
</tr>
<tr>
<td>10</td>
<td>alloys mixtures of elements (usually metals) designed to have the properties useful for a particular purpose; for example, solder (an alloy of tin and lead) has a low melting point</td>
<td>具有特定目的有用特性的元素（通常为金属）混合物的合金；例如：焊料（锡铅合金）的熔点低</td>
</tr>
<tr>
<td>10</td>
<td>basic oxygen process the process used to make steel from iron from the blast furnace: oxygen is blown into the molten iron using an ‘oxygen lance’ and lime is added to remove non-metallic impurities</td>
<td>基本氧工艺：用于从高炉中的铁制造钢的过程；使用“氧气枪”将氧气吹入铁水中，并添加石灰以除去非金属杂质</td>
</tr>
<tr>
<td>10</td>
<td>blast furnace a furnace for smelting iron ores such as hematite (Fe₂O₃) with carbon to produce pig (or cast) iron (in a modified form the furnace can be used to extract metals such as zinc)</td>
<td>高炉：用碳冶炼赤铁矿（Fe₂O₃）等铁矿石以生产生铁（铸铁）的炉子（该炉的改进形式可用于提炼锌等金属）</td>
</tr>
<tr>
<td>10</td>
<td>carbon steel alloys of iron and carbon only; the amount of carbon in steels can vary between 0.2% and 1.5%</td>
<td>仅含铁和碳的碳钢合金；钢中的碳含量可以在0.2%至1.5%之间变化</td>
</tr>
<tr>
<td>10</td>
<td>galvanising the protection of iron and steel objects by coating with a layer of zinc</td>
<td>通过镀锌层来保护钢铁物体</td>
</tr>
<tr>
<td>10</td>
<td>ore a naturally occurring mineral from which a metal can be extracted</td>
<td>矿石天然矿物：从中可以提取金属</td>
</tr>
<tr>
<td>10</td>
<td>reactivity series of metals an order of reactivity, giving the most reactive metal first, based on results from a range of experiments involving metals reacting with oxygen, water, dilute hydrochloric acid and metal salt solutions</td>
<td>根据一系列涉及金属与氧气、水、稀盐酸和金属盐溶液反应的实验结果；金属的一系列反应性是反应性的顺序，从而使金属具有最高的活性</td>
</tr>
</tbody>
</table>
### 13.4 ESSENTIAL Classroom Active Learning Tasks 1 Reactivity of Metals

Fill in this table, first with the metals English name, then with how they react with oxygen, water and dilute acids. Use the Table on the next page to help you fill this in.

Use the syllabus above to circle the elements and reactions that you must know.

<table>
<thead>
<tr>
<th>Metal</th>
<th>Symbol</th>
<th>Reaction with Oxygen</th>
<th>Reaction with water</th>
<th>Reaction with dilute acids</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>K</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>Na</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Ca</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>Mg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>Al</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z</td>
<td>Zn</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>Fe</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>Pb</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Cu</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>Ag</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>Au</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 13.5 EXTENSION INFORMATION Reactivity of Metals with Water, Steam, Dilute Acids and Air

The reaction of some metals with air and water was investigated; these were our results.

<table>
<thead>
<tr>
<th>Metal</th>
<th>Cold Water</th>
<th>Hot Water</th>
<th>Steam</th>
<th>Air (O₂ &amp; H₂O)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium</td>
<td>Vigorous</td>
<td>Very Vigorous</td>
<td>Violent</td>
<td>Rapid</td>
</tr>
<tr>
<td>Sodium</td>
<td>Very Violent</td>
<td>Explosive</td>
<td>Explosive</td>
<td>Very rapid even when cold.</td>
</tr>
<tr>
<td>Potassium</td>
<td>Very Violent, Explosive</td>
<td>Explosive</td>
<td>Explosive</td>
<td>Very rapid even when cold.</td>
</tr>
<tr>
<td>Iron</td>
<td>Slow (days)</td>
<td>Slow (days)</td>
<td>Slow (hours)</td>
<td></td>
</tr>
<tr>
<td>Lead</td>
<td>Slow (Many Years)</td>
<td>Slow (Many Years)</td>
<td>Slow (Months)</td>
<td>No reaction</td>
</tr>
<tr>
<td>Gold</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td>Slow (decades)</td>
<td>Slow (decades)</td>
<td>Slow (decades)</td>
<td>Slow (decades)</td>
</tr>
<tr>
<td>Aluminium</td>
<td>Fast (hours) once coated in oxide reaction stops</td>
<td>Fast (hours) once coated in oxide reaction stops</td>
<td>Fast (hours) once coated in oxide reaction stops</td>
<td>Fast (hours) once coated in oxide reaction stops</td>
</tr>
<tr>
<td>Lithium</td>
<td>Very Vigorous</td>
<td>Very Fast (Burns)</td>
<td>Violent</td>
<td>Rapid</td>
</tr>
<tr>
<td>Zinc</td>
<td>Fast (hours) once coated in oxide reaction stops</td>
<td>Fast (hours) once coated in oxide reaction stops</td>
<td>Fast (hours) once coated in oxide reaction stops</td>
<td>Fast (hours) once coated in oxide reaction stops</td>
</tr>
<tr>
<td>Silver</td>
<td>Slow (Centuries)</td>
<td>Slow (decades)</td>
<td>Slow (months)</td>
<td>Slow (decades)</td>
</tr>
<tr>
<td>Magnesium</td>
<td>Fast (hours)</td>
<td>Fast (minutes)</td>
<td>Fast (burns)</td>
<td>Fast</td>
</tr>
</tbody>
</table>

The metals can be placed in this order of reactivity (1=most reactive):

```
1  7
2  8
3  9
4 10
5 11
6 12
```
13.6  Extension Classroom active learning task 2 Comparing the Reactivity of Two Metals

We can use a voltmeter to measure how hard a metal is able to push electrons around a circuit. Draw a labelled diagram of a galvanic (voltaic) cell that would allow you to test which element is more reactive, iridium or platinum.

Exceptional Task – Why can’t we simply look at how these metals react with acids or oxygen?

13.7  Extension Classroom active learning task 3 Extracting Metals Multi-mark questions about extracting Iron, Aluminium and Zinc

Q# 1/ IGCSE Chemistry/2017/w/Paper 43/

3 Iron is extracted from its ore using coke in a blast furnace.

(b) Describe the reactions occurring in the blast furnace.

In your answer, include:
- Two reasons for using coke in the blast furnace,
- A chemical equation for the reduction of iron(II) oxide,
- An explanation for using limestone in the blast furnace.

Q# 2/ IGCSE Chemistry/2016/w/Paper 42/

6 Aluminium is a very important metal.

Aluminium is extracted from its ore, bauxite, by electrolysis. Bauxite is an impure form of aluminium oxide, Al₂O₃.

(a) Describe how aluminium is extracted from bauxite. Include an ionic half-equation for the reaction at each electrode.

description
13.8 Exceptional Analysis Classroom active learning task 4 Comparing the Reactivity of Two Metals

Look at the next question and the mark scheme.

How is it different to the previous question about the extraction of iron ore? Do you think it is harder or easier? Why?

Are there any similarities between these two questions? Can you find any other questions from previous years about the extraction of iron using the blast furnace? If so, can you see any trends or patterns in what the examiners are interested in and how the same question changes with time.

Mark Scheme for T10 Multi-mark questions

Q#1 / IGCSE Chemistry/2017/w/Paper 43/  
(a) Lösungsmittel and solvent molecules have a similar size. There are no large molecules or ions that could interact with each other.  
(b) As the temperature increases, the solution becomes more concentrated.  
(c) The concentration of the solution increases as the temperature increases.

Q#2 / IGCSE Chemistry/2016/w/Paper 42/  
(a) The addition of salt increases the freezing point of the solution.  
(b) The addition of salt decreases the boiling point of the solution.  
(c) The solution becomes more concentrated as the temperature increases.

Q#3 / IGCSE Chemistry/2016/w/Paper 42/  
(a) Ionic half-equation for the anode reaction: 

2H⁺ → H₂  

(b) Ionic half-equation for the cathode reaction: 

2H₂O + 2e⁻ → H₂ + 2OH⁻  

[5]

Common Mistakes

- Not balancing the equation.
- Forgetting to include the phase changes (s, l, g).
- Not mentioning the reaction conditions (temperature, pressure).

Mark Scheme for T10 Multi-mark questions

Q#3 / IGCSE Chemistry/2016/s/Paper 42/  
(a) Electrolysis of water produces hydrogen and oxygen gases: 

2H₂O(l) → 2H₂(g) + O₂(g)  

(b) Electrolysis of molten salt produces metallic and non-metallic elements: 

2NaCl(s) → 2Na(l) + Cl₂(g)
13.9 **ESSENTIAL Classroom Active Learning Tasks 4 Uses of Metals**


**d) Give an explanation for each of the following.**

(i) Aluminium is used extensively in the manufacture of aircraft.

(ii) Aluminium is used to make food containers.

(iii) Aluminium electricity cables have a steel core.

**Topic Chem 10.4 Q# 62/ iGCSE Chemistry/2006/w/Paper 3/Q6**

**b) Impure copper is extracted from the ore. This copper is refined by electrolysis.**

(iii) One use of this pure copper is electrical conductors, another is to make alloys. Name the metal that is alloyed with copper to make brass.

**Topic Chem 10.4 Q# 63/ iGCSE Chemistry/2006/s/Paper 3/Q1**

**e) Most of the iron is converted into mild steel or stainless steel. Give one use for each.**

(i) Mild steel

(ii) Stainless steel

**Topic Chem 10.4 Q# 64/ iGCSE Chemistry/2003/w/Paper 3/Q3**

**b) A major use of zinc is to make diecasting alloys. These contain about 4% of aluminium and they are stronger and less malleable than pure zinc.**

(i) Give one other large scale use of zinc.

**Topic Chem 10.4 Q# 65/ iGCSE Chemistry/2003/s/Paper 3/Q6**

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.

(d) Stainless steel is an alloy of iron. It contains iron, other metals and about 0.5% of carbon.

(i) State a use of stainless steel.

(ii) Name a metal, other than iron, in stainless steel.

**Topic Chem 10.4 Q# 66/ iGCSE Chemistry/2002/w/Paper 3/Q1**

4 For over 5000 years copper has been obtained by the reduction of its ores. More recently the metal has been purified by electrolysis.

(a) Copper is used to make alloys.

(i) Give two other uses of copper.

(c) One property of aluminium is that it resists corrosion because it is covered with a layer of its oxide.

(i) Give one use of the metal that depends on this property.

(ii) Give another use of the metal that depends on a different property.

**Topic Chem 10.4 Q# 67/ iGCSE Chemistry/2002/s/Paper 3/Q1**

(b) Zinc is used to make alloys.

(i) Name an alloy that contains zinc.

(ii) What is the other metal in this alloy?
Mark Scheme for T10 Uses of Metals

Q# 61/ IGCSE Chemistry/2008/w/Paper 31/Q6
(d) (i) low density or light or resistant to corrosion accept strength/weight ratio or alloys are strong strong on its own is neutral [1]

(ii) not attacked or corroded or unreactive oxide layer easily shaped or malleable or ductile any TWO [2]

(iii) for strength or so it does not break or does not sag or can have pylons further apart NOT steel is a better conductor NOT aluminium protects steel from rusting [1]

Q# 62/ IGCSE Chemistry/2006/w/Paper 3/Q6 (b)
(iii) Zinc [1]

Q# 63/ IGCSE Chemistry/2006/w/Paper 3/ Q1
(e) mild steel cars or machinery or fridges etc. [1]

stainless steel cutlery or chemical plants etc. [1]

Q# 64/ IGCSE Chemistry/2003/w/Paper 3/
(b) (i) making brass or any zinc containing alloy or galvanising [1]

(ii) nickeld or chromium or molybdenum or niobium or titanium [1]

Q# 65/ IGCSE Chemistry/2003/w/Paper 3/ Q1
(d) (i) Cutlery or chemical plant or watches or utensils or surgical instruments or cars or sinks or aircraft or garden tools [1]

(ii) nickel or chromium or molybdenum or niobium or titanium [1]

Q# 66/ IGCSE Chemistry/2002/w/Paper 3/Q4a
4 (a) (i) wiring NOT good conductor pipes utensils roofs electropolishing lightening conductor bi-metallic strips NOT coinage metal or any other use than involves an alloy TWO from above [2]

Q# 67/ IGCSE Chemistry/2002/w/Paper 3/Q11

(c) (i) packaging of food or window frames or roofs accept “ease” NOT aircraft cars etc [1]

(ii) low density light alloys for aircraft or electrical cables good conductor or fail malleable good conductor of heat if use repeated with different properties then 2/3
27 Which statement about the manufacture of aluminium by electrolysis is correct?

A Aluminium ions are oxidised to aluminium by gaining electrons.
B Aluminium is extracted from its ore hematite.
C Molten cryolite is used to dissolve the aluminium oxide.
D Oxygen is formed at the negative electrode.

Q#2/IGCSE Chemistry/2018/w/Paper 22/

24 Heating copper(II) carbonate produces copper(II) oxide and carbon dioxide.

Heating the copper(II) oxide formed with carbon produces copper.

Which processes are involved in this conversion of copper(II) carbonate to copper?

A sublimation followed by oxidation
B sublimation followed by reduction
C thermal decomposition followed by oxidation
D thermal decomposition followed by reduction

25 Four metals, W, X, Y and Z, are separately reacted with water and dilute hydrochloric acid.

The results are shown.

<table>
<thead>
<tr>
<th>metal</th>
<th>W</th>
<th>X</th>
<th>Y</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>reaction with water</td>
<td>fizzes</td>
<td>no reaction</td>
<td>fizzes vigorously</td>
<td>no reaction</td>
</tr>
<tr>
<td>reaction with dilute hydrochloric acid</td>
<td>fizzes</td>
<td>no reaction</td>
<td>fizzes violently</td>
<td>fizzes</td>
</tr>
</tbody>
</table>

What is the order of reactivity of the four metals starting with the least reactive?

<table>
<thead>
<tr>
<th>least reactive</th>
<th>most reactive</th>
</tr>
</thead>
<tbody>
<tr>
<td>A X W Z Y</td>
<td>A X Z W Y</td>
</tr>
<tr>
<td>B X Z W Y</td>
<td>B X Z W Y</td>
</tr>
<tr>
<td>C Y W Z X</td>
<td>C Y W Z X</td>
</tr>
<tr>
<td>D Y Z W X</td>
<td>D Y Z W X</td>
</tr>
</tbody>
</table>

26 Which statement about the uses of metals is not correct?

A Aluminium is used in aircraft because of its strength and good electrical conductivity.
B Copper is used in electrical wiring because of its good electrical conductivity.
C Stainless steel resists corrosion and is used to make cutlery.
D Transition elements are often used as catalysts.

27 Bauxite contains aluminium oxide.

Aluminium is extracted from aluminium oxide by electrolysis.

Why is cryolite added to the electrolytic cell used to extract aluminium?

A Cryolite prevents the carbon anodes being burned away.
B Cryolite removes impurities from the bauxite.
C Cryolite increases the rate at which aluminium ions are discharged.
D Molten cryolite dissolves the aluminium oxide.

Q#3/IGCSE Chemistry/2018/w/Paper 21/

24 A student heated copper(II) carbonate and copper(II) nitrate in separate test-tubes.

Both compounds decomposed.

Which row shows the gases produced from each reaction?

<table>
<thead>
<tr>
<th>copper(II) carbonate</th>
<th>copper(II) nitrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>A carbon dioxide</td>
<td>nitrogen dioxide only</td>
</tr>
<tr>
<td>B carbon dioxide</td>
<td>oxygen only</td>
</tr>
<tr>
<td>C carbon dioxide</td>
<td>oxygen and nitrogen dioxide</td>
</tr>
<tr>
<td>D oxygen</td>
<td>oxygen and nitrogen dioxide</td>
</tr>
</tbody>
</table>

25 Metal X reacts with steam but not with cold water.

What is X?

A calcium
B copper
C sodium
D zinc
26. Which row shows uses of the metals listed?

<table>
<thead>
<tr>
<th></th>
<th>aluminium</th>
<th>copper</th>
<th>mild steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>aircraft manu.</td>
<td>food containers</td>
<td>cutlery</td>
</tr>
<tr>
<td>B</td>
<td>cutlery</td>
<td>electrical wiring</td>
<td>chemical plant</td>
</tr>
<tr>
<td>C</td>
<td>electrical wiring</td>
<td>aircraft manu.</td>
<td>cooking utensils</td>
</tr>
<tr>
<td>D</td>
<td>food containers</td>
<td>cooking utensils</td>
<td>car bodies</td>
</tr>
</tbody>
</table>

27. Aluminium objects do not need protection from corrosion.

Iron objects must be protected from corrosion.

Why does aluminium resist corrosion?
A. Aluminium does not form ions easily.
B. Aluminium does not react with water or air.
C. Aluminium has a protective oxide layer.
D. Aluminium is below iron in the reactivity series.

Q#4/IGCSE Chemistry/2018/s/Paper 23/

24. Which diagram represents a solid alloy?

A  
B  
C  
D  

25. The ionic equations for four reactions are shown.

\[ Z + X^+ \rightarrow Z^{2+} + X \]
\[ Z + 2W^+ \rightarrow Z^{2+} + 2W \]
\[ X + 2W^+ \rightarrow X^{2+} + 2W \]
\[ Y + Z^{2+} \rightarrow Y^{3+} + Z \]

26. What is the order of reactivity of the four metals, W, X, Y and Z?

<table>
<thead>
<tr>
<th></th>
<th>most reactive</th>
<th>least reactive</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>W</td>
<td>X</td>
</tr>
<tr>
<td>B</td>
<td>X</td>
<td>W</td>
</tr>
<tr>
<td>C</td>
<td>Y</td>
<td>Z</td>
</tr>
<tr>
<td>D</td>
<td>Z</td>
<td>W</td>
</tr>
</tbody>
</table>

26. Which equation represents the first stage in the extraction of zinc from zinc blende?

A. \(2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2\)
B. \(ZnS + H_2O \rightarrow ZnO + H_2S\)
C. \(ZnO + CO \rightarrow Zn + CO_2\)
D. \(ZnO + H_2SO_4 \rightarrow ZnSO_4 + H_2O\)

27. Which statement explains why aluminium is used to manufacture aircraft?

A. It has a low density.
B. It is a good conductor of electricity.
C. It is a good conductor of heat.
D. It is ductile.

Q#5/IGCSE Chemistry/2018/s/Paper 22/

24. Stainless steel is an alloy of iron, carbon and other metals.

Which row is correct?

<table>
<thead>
<tr>
<th></th>
<th>stainless steel is harder than pure iron</th>
<th>stainless steel resists corrosion better than pure iron</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>
25. Metal X is more reactive than metal Y. Metal Y is more reactive than metal Z. Which statement is correct?

A. When metal X is placed in a solution of Y sulfate, there is no reaction.
B. When metal X is placed in a solution of Z sulfate, a reaction occurs.
C. When metal Y is placed in a solution of Z sulfate, there is no reaction.
D. When metal Z is placed in a solution of X sulfate, a reaction occurs.

26. Which statement about the industrial extraction of zinc is correct?

A. Cryolite is added to lower the melting point.
B. Molten zinc oxide is electrolysed.
C. Zinc oxide is heated with coke.
D. Zinc sulfide is heated with coke.

27. Which row describes the use of an alloy and the property upon which the use depends?

<table>
<thead>
<tr>
<th>alloy</th>
<th>use</th>
<th>property</th>
</tr>
</thead>
<tbody>
<tr>
<td>A mild steel</td>
<td>cutlery</td>
<td>resistant to corrosion</td>
</tr>
<tr>
<td>B mild steel</td>
<td>machinery</td>
<td>strong</td>
</tr>
<tr>
<td>C stainless steel</td>
<td>cutlery</td>
<td>low density</td>
</tr>
<tr>
<td>D stainless steel</td>
<td>machinery</td>
<td>good conductor of electricity</td>
</tr>
</tbody>
</table>

Q# 6/ IGCE Chemistry/2018/s/Paper 21/

24. The following statements are made about the metals copper, iron, magnesium and zinc.

1. Their oxides are acidic.
2. They all conduct electricity in the solid state.
3. They all have high melting points.
4. They all react with dilute acids to form hydrogen.

Which statements are correct?

A. 1 and 2  B. 1 and 4  C. 2 and 3  D. 3 and 4

Q# 7/ IGCE Chemistry/2018/m/Paper 22/

25. Silver is a less reactive metal than cadmium. Cadmium is a less reactive metal than barium. Which statement is correct?

A. Barium does not react when heated with silver oxide.
B. Cadmium displaces barium from a solution of barium chloride.
C. Cadmium displaces silver from a solution of silver nitrate.
D. Cadmium reacts when heated with barium oxide.

26. Aluminium metal is extracted from aluminium oxide using electrolysis. Which statement about the extraction process is not correct?

A. A large amount of electricity is required.
B. Molten cryolite is used to dissolve the aluminium oxide.
C. Oxygen gas is released which reacts to form carbon dioxide.
D. The negative electrodes burn away and have to be replaced.

27. Which statement explains why aluminium is used in the manufacture of aircraft?

A. It conducts heat well.
B. It has a low density.
C. It is a good conductor of electricity.
D. It is easy to recycle.
26 The list gives the order of some metals and hydrogen in the reactivity series.

Metal X is also included:

<table>
<thead>
<tr>
<th>most reactive</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mg</td>
</tr>
<tr>
<td></td>
<td>Zn</td>
</tr>
<tr>
<td></td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>X</td>
</tr>
<tr>
<td>least reactive</td>
<td>Cu</td>
</tr>
</tbody>
</table>

Which row correctly shows the properties of metal X?

<table>
<thead>
<tr>
<th>reacts with dilute acids</th>
<th>oxide reduced by carbon</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>no</td>
</tr>
<tr>
<td>B</td>
<td>no</td>
</tr>
<tr>
<td>C</td>
<td>yes</td>
</tr>
<tr>
<td>D</td>
<td>yes</td>
</tr>
</tbody>
</table>

28 Which metal carbonate does not produce carbon dioxide when it is heated?

A copper(II) carbonate
B iron(II) carbonate
C potassium carbonate
D zinc carbonate

28 Some metal nitrates and carbonates decompose when heated strongly.

Metal Q has a nitrate that decomposes to give a salt and a colourless gas only.

The carbonate of metal Q does not decompose when heated with a Bunsen burner.

What is metal Q?

A calcium
B copper
C sodium
D zinc

Q# 9 / IGCSE Chemistry/2017/w/Paper 22/

28 Aluminium is extracted from bauxite by electrolysis.

Which row shows the anode material and the anode reaction?

<table>
<thead>
<tr>
<th>anode material</th>
<th>anode reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>carbon</td>
</tr>
<tr>
<td>B</td>
<td>carbon</td>
</tr>
<tr>
<td>C</td>
<td>steel</td>
</tr>
<tr>
<td>D</td>
<td>steel</td>
</tr>
</tbody>
</table>

Q# 8 / IGCSE Chemistry/2017/w/Paper 23/

26 Aluminium is obtained by the electrolysis of a mixture of aluminium oxide and cryolite.

Why is cryolite used?

A as a catalyst to speed up the process
B as a coolant to prevent the process getting too hot
C as a solvent for aluminium oxide
D as the main source of aluminium ions
27. Which statement about the metal zinc is not correct?
   A. It forms an oxide more readily than iron.
   B. It is manufactured by the electrolysis of zinc blende.
   C. It is used to make brass.
   D. It is used to prevent iron from rusting.

28. Calcium nitrate decomposes when it is heated.

   What is the equation for the thermal decomposition of calcium nitrate?
   A. $2\text{Ca(NO}_3\text{)}_2 \rightarrow 2\text{CaO} + \text{O}_2 + 4\text{NO}_2$
   B. $\text{Ca(NO}_3\text{)}_2 \rightarrow \text{Ca(NO}_3\text{)}_2 + \text{O}_2$
   C. $\text{Ca(NO}_3\text{)}_2 \rightarrow \text{Ca} + \text{O}_2 + 2\text{NO}_2$
   D. $\text{Ca(NO}_3\text{)}_2 \rightarrow \text{Ca} + 3\text{O}_2 + \text{N}_2$

Q# 11 / iGCSE Chemistry/2017/w/Paper 21/

25. What is a property of all metals?
   A. conduct electricity
   B. hard
   C. low melting points
   D. react with water

26. Aluminium is extracted by the electrolysis of aluminium oxide.

   Which statement is not correct?
   A. Aluminium ions are oxidised at the cathode.
   B. Carbon dioxide is made at the anode.
   C. Cryolite is added to lower the melting point of the aluminium oxide.
   D. The electrodes are made from graphite.

27. Which row describes how the metals are used?

<table>
<thead>
<tr>
<th></th>
<th>mixed with zinc to form brass</th>
<th>used to galvanise iron</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. aluminium</td>
<td>tin</td>
<td></td>
</tr>
<tr>
<td>B. aluminium</td>
<td>zinc</td>
<td></td>
</tr>
<tr>
<td>C. copper</td>
<td>tin</td>
<td></td>
</tr>
<tr>
<td>D. copper</td>
<td>zinc</td>
<td></td>
</tr>
</tbody>
</table>

28. Information about the nitrates and carbonates of two metals, Q and R, is shown.

<table>
<thead>
<tr>
<th></th>
<th>appearance</th>
<th>solubility in water</th>
<th>effect of heat</th>
</tr>
</thead>
<tbody>
<tr>
<td>nitrate of Q</td>
<td>white solid</td>
<td>soluble</td>
<td>colourless gas evolved which relights a glowing splint</td>
</tr>
<tr>
<td>carbonate of Q</td>
<td>white solid</td>
<td>soluble</td>
<td>no reaction</td>
</tr>
<tr>
<td>nitrate of R</td>
<td>white solid</td>
<td>soluble</td>
<td>brown gas evolved</td>
</tr>
<tr>
<td>carbonate of R</td>
<td>white solid</td>
<td>insoluble</td>
<td>colourless gas evolved which turns limewater milky</td>
</tr>
</tbody>
</table>

Which statement is correct?

A. Q is calcium and R is magnesium.
B. Q is magnesium and R is sodium.
C. Q is potassium and R is copper.
D. Q is sodium and R is calcium.

Q# 11 / iGCSE Chemistry/2017/s/Paper 23/

25. Which equation from the zinc extraction process shows the metal being produced by reduction?

A. $\text{ZnO} + \text{C} \rightarrow \text{Zn} + \text{CO}$
B. $2\text{ZnS} + 3\text{O}_2 \rightarrow 2\text{ZnO} + 2\text{SO}_2$
C. $\text{Zn}(g) \rightarrow \text{Zn}(l)$
D. $\text{Zn}(l) \rightarrow \text{Zn}(s)$
27 The section of the reactivity series shown includes a newly discovered element, symbol X.

The only oxide of X has the formula XO.

Ca
Mg
Fe
X
H
Cu

Which equation shows a reaction which occurs?

A \( \text{Cu}(s) + X^2(aq) \rightarrow \text{Cu}^2(aq) + X(s) \)
B \( 2X(s) + \text{Cu}^2(aq) \rightarrow 2X^2(aq) + \text{Cu}(s) \)
C \( X(s) + \text{Fe}_2\text{O}_3(s) \rightarrow 2\text{Fe}(s) + 3\text{XO}(s) \)
D \( X(s) + 2\text{HCl}(aq) \rightarrow \text{XCl}_2(aq) + \text{H}_2(g) \)

Q# 12/IGCSE Chemistry/2017/s/Paper 22/

25 Which process is involved in the extraction of zinc from zinc blende?

A Cryolite is added to lower the melting point of zinc blende.
B Molten zinc blende is electrolysed.
C Zinc blende is heated with carbon.
D Zinc blende is roasted in air.

26 Element E:

- forms an alloy
- has a basic oxide
- is below hydrogen in the reactivity series.

What is E?

A carbon
B copper
C sulfur
D zinc

27 A list of metals is shown.

aluminium
copper
iron
magnesium
silver
zinc

Which metal will displace all of the other metals from aqueous solutions of their salts?

A aluminium
B iron
C magnesium
D zinc

Q# 13/IGCSE Chemistry/2017/s/Paper 21/

25 Metal X is added to a colourless aqueous solution of the sulfate of metal Y.

A coloured solution is formed and metal Y is deposited at the bottom of the beaker.

Which row describes elements X and Y and their relative reactivity?

<table>
<thead>
<tr>
<th>type of element</th>
<th>relative reactivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A X is a transition element</td>
<td>X is more reactive than Y</td>
</tr>
<tr>
<td>B X is a transition element</td>
<td>Y is more reactive than X</td>
</tr>
<tr>
<td>C Y is a transition element</td>
<td>X is more reactive than Y</td>
</tr>
<tr>
<td>D Y is a transition element</td>
<td>Y is more reactive than X</td>
</tr>
</tbody>
</table>

26 Element E:

- forms an alloy
- has a basic oxide
- is below hydrogen in the reactivity series.

What is E?

A carbon
B copper
C sulfur
D zinc
27 Zinc metal is extracted from its ore zinc blende in a similar method to that used to extract iron from hematite.

In which way is zinc extraction different from iron extraction?

A Carbon and carbon monoxide are the main reducing agents.
B Hot air at the base of the furnace reacts with coke to keep the furnace hot.
C The metal is removed as a vapour at the top of the furnace.
D The metal oxide is added into the top of the furnace.

28 Stainless steel is an alloy of iron and other metals. It is strong and does not rust but it costs much more than normal steel.

What is not made from stainless steel?

A cutlery
B pipes in a chemical factory
C railway lines
D cutlery

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<th>Q# 1</th>
<th>iGCSE Chemistry/2018/w/Paper 23/</th>
</tr>
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<tbody>
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<td>A</td>
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<tr>
<td>25</td>
<td>C</td>
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<tr>
<td>26</td>
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<td>27</td>
<td>C</td>
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<td>C</td>
</tr>
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<td>26</td>
<td>A</td>
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<td>27</td>
<td>A</td>
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<td>C</td>
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<td>D</td>
</tr>
<tr>
<td>26</td>
<td>D</td>
</tr>
<tr>
<td>27</td>
<td>C</td>
</tr>
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<td>B</td>
</tr>
<tr>
<td>25</td>
<td>C</td>
</tr>
<tr>
<td>26</td>
<td>A</td>
</tr>
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<td>27</td>
<td>A</td>
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<td>A</td>
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<td>25</td>
<td>B</td>
</tr>
<tr>
<td>26</td>
<td>C</td>
</tr>
<tr>
<td>27</td>
<td>B</td>
</tr>
</tbody>
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</tr>
<tr>
<td>25</td>
<td>C</td>
</tr>
<tr>
<td>26</td>
<td>D</td>
</tr>
<tr>
<td>27</td>
<td>B</td>
</tr>
</tbody>
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<tr>
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<td>D</td>
</tr>
<tr>
<td>25</td>
<td>B</td>
</tr>
<tr>
<td>26</td>
<td>C</td>
</tr>
<tr>
<td>27</td>
<td>D</td>
</tr>
</tbody>
</table>

13.10.1 ESSENTIAL EXAM QUESTIONS Topic 10 Paper 2 250marks Mark Scheme

<table>
<thead>
<tr>
<th>Q# 8</th>
<th>iGCSE Chemistry/2017/w/Paper 23/</th>
</tr>
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<tbody>
<tr>
<td>26</td>
<td>A</td>
</tr>
<tr>
<td>27</td>
<td>D</td>
</tr>
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</table>

<table>
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<tr>
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<tbody>
<tr>
<td>26</td>
<td>C</td>
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<td>27</td>
<td>D</td>
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<td>B</td>
</tr>
<tr>
<td>27</td>
<td>C</td>
</tr>
</tbody>
</table>

13.11 ESSENTIAL EXAM QUESTIONS Paper 3/4 268marks Topic 10

These questions are organised by sub-topic order, so if you are not going to solve all of them, make sure that you solve questions from both

Topic Chem.10.1 Q# 1 | iGCSE Chemistry/2003/w/Paper 3/Q2 (b)

(iii) Suggest why the introduction of a different metallic atom into the structure makes the alloy stronger than the pure metal.

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

Topic Chem.10.1 Q# 2 | iGCSE Chemistry/2002/w/Paper 3/

4 For over 5000 years copper has been obtained by the reduction of its ores. More recently the metal has been purified by electrolysis.
2 Describe how to separate the following. In each example, give a description of the procedure used and explain why the method works.

(a) Copper powder from a mixture containing copper and zinc powders.

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

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

5 The reactivity series shows the metals in order of reactivity.

(a) The reactivity series can be established using displacement reactions. A piece of zinc is added to aqueous lead nitrate. The zinc becomes coated with a black deposit of lead.

\[ \text{Zn} + \text{Pb}^{2+} \rightarrow \text{Zn}^{2+} + \text{Pb} \]

Zinc is more reactive than lead.

The reactivity series can be written as a list of ionic equations.

\[ \ldots \rightarrow \ldots \downarrow + \ldots \text{most reactive metal: the best reductant (reducing agent)} \]

\[ \text{Zn} \rightarrow \text{Zn}^{2+} + 2e^- \]

\[ \text{Fe} \rightarrow \text{Fe}^{2+} + 2e^- \]

\[ \text{Pb} \rightarrow \text{Pb}^{2+} + 2e^- \]

\[ \text{Cu} \rightarrow \text{Cu}^{2+} + 2e^- \]

\[ \text{Ag} \rightarrow \text{Ag}^{+} + e^- \]

(i) In the space at the top of the list, write an ionic equation for a metal which is more reactive than zinc.

(ii) Write an ionic equation for the reaction between aqueous silver(I) nitrate and zinc.

(iii) Explain why the positive ions are likely to be oxidants (oxidising agents).

(iv) Deduce which ion is the best oxidant (oxidising agent).

(v) Which ion(s) in the list can oxidise lead metal?
(b) A reactivity series can also be established by measuring the voltage of simple cells. The diagram shows a simple cell.

\[ \text{voltmeter} \]

\[ \text{copper electrode} \]

\[ \text{cadmium electrode} \]

\[ \text{sulfuric acid} \]

Results from cells using the metals tin, cadmium, zinc and copper are given in the table below.

<table>
<thead>
<tr>
<th>cell</th>
<th>electrode 1 positive electrode</th>
<th>electrode 2 negative electrode</th>
<th>voltage/volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>copper</td>
<td>cadmium</td>
<td>0.74</td>
</tr>
<tr>
<td>2</td>
<td>copper</td>
<td>tin</td>
<td>0.48</td>
</tr>
<tr>
<td>3</td>
<td>copper</td>
<td>zinc</td>
<td>1.10</td>
</tr>
</tbody>
</table>

Write the four metals in order of increasing reactivity and explain how you used the data in the table to determine this order.

(i) The equation for the thermal decomposition of silver(I) nitrate is given below.

\[ 2\text{AgNO}_3 \rightarrow 2\text{Ag} + 2\text{NO}_2 + \text{O}_2 \]

What are the products formed when copper(II) nitrate is heated?

(ii) Complete the equation for the action of heat on sodium nitrate.

\[ \text{[The equation]} \]

5 Reactive metals tend to have unreactive compounds. The following is part of the reactivity series.

sodium calcium zinc copper silver least reactive

The table above is the one mentioned in question 5(c) and 5(d)

(c) Which of the metals in the list on page 5 have oxides which are not reduced by carbon?

(d) Choose from the list on page 5, metals whose ions would react with zinc.

(a) (i) Name a metal hydroxide which does not decompose when heated.

(b) All nitrates decompose when heated.

(i) The equation for the thermal decomposition of silver(I) nitrate is given below.

\[ 2\text{AgNO}_3 \rightarrow 2\text{Ag} + 2\text{NO}_2 + \text{O}_2 \]

What are the products formed when copper(II) nitrate is heated?

(ii) Write the equation for the thermal decomposition of copper(II) hydroxide.

(iii) Suggest why these two hydroxides behave differently.

(b) (i) Metal nitrates, except those of the Group 1 metals, form three products when heated. Name the products formed when zinc nitrate is heated.

(ii) Write the equation for the thermal decomposition of potassium nitrate.
7 Excess hydrochloric acid was added to powdered zinc. The hydrogen evolved was collected and its volume measured every 20 seconds.

The experiments were repeated at the same temperature using the same number of moles of powdered magnesium and aluminium.

(a) Identify metals A, B and C by choosing from zinc, magnesium and aluminium. Give a reason for each choice.

metal A

metal B

metal C

(b) Using 'moles', explain why two of the metals form the same volume of hydrogen but the third metal forms a larger volume.

3 A diagram of the apparatus which could be used to investigate the rate of reaction between magnesium and an excess of an acid is drawn below.

(a) The magnesium kept rising to the surface. In one experiment, this was prevented by twisting the magnesium around a piece of copper. In a second experiment, the magnesium was held down by a plastic net fastened to the beaker.

(i) Suggest a reason why magnesium, which is denser than water, floated to the surface.

(ii) Iron, zinc and copper have similar densities. Why was copper a better choice than iron or zinc to weigh down the magnesium?

(c) The common ore of tin is Sn(IV) oxide and an ore of copper is malachite, CuCO$_3$·Cu(OH)$_2$.

(ii) Malachite is heated to form copper oxide and two other chemicals. Name these chemicals.
4 The reactivity series of metals given below contains both familiar and unfamiliar elements. For most of the unfamiliar elements, which are marked *, their common oxidation states are given.

<table>
<thead>
<tr>
<th>*barium</th>
<th>Ba (+2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>*lanthanum</td>
<td>La (+3)</td>
</tr>
<tr>
<td>magnesium</td>
<td></td>
</tr>
<tr>
<td>zinc</td>
<td>Cr (+3), (+6)</td>
</tr>
<tr>
<td>iron</td>
<td></td>
</tr>
<tr>
<td>*copper</td>
<td>(+2)</td>
</tr>
</tbody>
</table>

Choose metal(s) from the above list to answer the following questions.

(i) Which two metals would not react with dilute hydrochloric acid?

(ii) Which two unfamiliar metals (*) would react with cold water?

(iii) What is the oxidation state of barium?

(iv) Name an unfamiliar metal (*) whose oxide cannot be reduced by carbon.

(v) Why should you be able to predict that metals such as iron and chromium have more than one oxidation state?

---

5 Their hydroxides are heated. If the compound decomposes, complete the word equation. If it does not decompose, write “no reaction”.

Potassium hydroxide → ........................................................................... [2]

Calcium hydroxide → ........................................................................... [2]

6 Complete the equations for the decomposition of their nitrates.

2KNO₃ → ........................................................................... + ..................[4]

2Ca(NO₃)₂ → ........................................................................... + ..................[4]

6 The reactivity series lists metals in order of reactivity.

(a) To find out which is the more reactive metal, zinc or tin, the following experiment could be carried out:

![Experiment Diagram]

This experiment could be carried out with other metals and the results recorded in a table. Then the order of reactivity can be deduced.

(i) The order was found to be:

<table>
<thead>
<tr>
<th>Most Reactive</th>
<th>Least Reactive</th>
</tr>
</thead>
<tbody>
<tr>
<td>manganese</td>
<td>silver</td>
</tr>
<tr>
<td>zinc</td>
<td>tin</td>
</tr>
</tbody>
</table>
Complete the table of results from which this order was determined.

<table>
<thead>
<tr>
<th></th>
<th>tin Sn</th>
<th>manganese Mn</th>
<th>silver Ag</th>
<th>zinc Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>tin(II) nitrate</td>
<td></td>
<td>R</td>
<td>NR</td>
<td>R</td>
</tr>
<tr>
<td>manganese(II) nitrate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>silver(I) nitrate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>zinc nitrate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(ii) Write the ionic equation for the reaction between tin atoms and silver(I) ions.

(iii) The following is a redox reaction.

\[ \text{Mn} + \text{Sn}^{2+} \rightarrow \text{Mn}^{2+} + \text{Sn} \]

Indicate on the equation the change which is oxidation. Give a reason for your choice.

(iv) Explain why experiments of this type cannot be used to find the position of aluminium in the reactivity series.

Some reactions of metals W, X, Y and Z are given below.

<table>
<thead>
<tr>
<th>metal</th>
<th>reaction with water</th>
<th>reaction with dilute hydrochloric acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>A few bubbles form slowly in cold water.</td>
<td>Vigorous reaction. Gas given off.</td>
</tr>
<tr>
<td>Y</td>
<td>No reaction.</td>
<td>No reaction.</td>
</tr>
<tr>
<td>Z</td>
<td>Does not react with cold water. Hot metal reacts with steam.</td>
<td>Steady fusing.</td>
</tr>
</tbody>
</table>

(a) Arrange these metals in order of reactivity.

most reactive .................................................. [2]

least reactive .................................................. [2]

(b) Which of these metals could be

(i) magnesium, .................................................. [1]

(ii) copper? .................................................. [1]

5 (a) Titanium is produced by the reduction of its chloride. This is heated with magnesium in an inert atmosphere of argon.

\[ \text{TiCl}_4 + 2\text{Mg} \rightarrow \text{Ti} + 2\text{MgCl}_2 \]

(i) Explain why it is necessary to use argon rather than air.

(ii) Name another metal that would reduce titanium chloride to titanium.

(b) Both metals react with water.

(i) Write a word equation for the reaction of zinc and water and state the reaction conditions.

word equation .................................................. [1]

conditions .................................................. [2]
(ii) Write an equation for the reaction of strontium with water and give the reaction condition.

\[ \text{equation} \quad \text{condition} \]  [2]  [1]

(b) Aluminium reacts very slowly with aqueous copper(II) sulphate.

\[ 2Al(s) + 3CuSO_4(aq) \rightarrow Al_2(SO_4)_3(aq) + 3Cu(s) \]  [2]

(i) Which of the two metals has the greater tendency to form ions?

...  [1]

(ii) Describe what you would see when this reaction occurs.

...  [1]

(iii) Explain why aluminium reacts so slowly.

...  [1]

6 The position of aluminium in the reactivity series of metals is shown below.

magnesium  aluminium  zinc  copper

(a) Aluminium is extracted by the electrolysis of its molten oxide.

\[ \text{waste gases} \quad \text{carbon anode (+)} \quad \text{mixture of aluminium oxide and cryolite} \quad \text{aluminium} \]  [1]

\[ \text{carbon cathode (-)} \quad 900 \, ^\circ \text{C} \quad \text{electrolyte} \quad \text{dilute sulphuric acid} \]

\[ \text{voltmeter} \quad \text{tin electrode} \quad \text{zinc electrode} \]

(i) Predict how the voltage of the cell would change if the tin electrode was replaced with a silver one.

\[ \text{[1]} \]

(ii) Which electrode would go into the solution as positive ions? Give a reason for your choice.

\[ \text{[1]} \]

(iii) State how you can predict the direction of the electron flow in cells of this type.

\[ \text{[1]} \]
7 (a) (i) Write a symbol equation for the action of heat on zinc hydroxide.

(ii) Describe what happens when solid sodium hydroxide is heated strongly.

(b) What would be observed when copper(II) nitrate is heated?

---

4 In the following list of ionic equations, the metals are in order of reactivity.

Zn → Zn²⁺ + 2e⁻, reactivity of metals increases
Sn → Sn²⁺ + 2e⁻
Hg → Hg²⁺ + 2e⁻
Ag → Ag⁺ + e⁻

(a) (i) In the space at the top of the series, write an ionic equation that includes a more reactive metal.

(ii) Define oxidation in terms of electron transfer.

(iii) Explain why the positive ions are likely to be oxidising agents.

---

(iii) Which positive ion(s) can oxidise mercury metal (Hg)?

---

4 Nitrogen dioxide, NO₂, is a dark brown gas.

(a) Most metal nitrates decompose when heated to form the metal oxide, nitrogen dioxide and oxygen.

(i) Write a symbol equation for the decomposition of lead(II) nitrate.

\[
\text{Pb(NO}_3\text{)}_2 \rightarrow \ ...
\]

(ii) Potassium nitrate does not form nitrogen dioxide on heating. Write the word equation for its decomposition.

---

5 The first three elements in Period 6 of the Periodic Table of the Elements are caesium, barium and lanthanum.

(c) All three metals react with cold water. Complete the word equation for these reactions.

metal + water → ...

---

(d) Copper is an unreactive metal. Its compounds are easily reduced to the metal or decomposed to simpler compounds. Complete the following equations.

(i) ...CuO + ... → ...Cu + ...

(ii) Copper(II) hydroxide + (heat)

(iii) \[\text{Cu(NO}_3\text{)}_2 \rightarrow\]

---

[1]
Topic Chem 10.2 Q# 28/ iGCSE Chemistry/2002/w/Paper 3/ Q1

(c) The results of an investigation into the action of heat on copper(II) sulphate-5-water, a blue crystalline solid, are given below:

The formula is CuSO₄·5H₂O and the mass of one mole is 250 g.

A 5.0 g sample of the blue crystals is heated to form 3.2 g of a white powder. With further heating this decomposes into a black powder and sulphur trioxide.

(i) Name the white powder..............................................................[1]

(ii) What is observed when water is added to the white powder? ..............................................................[1]

(iii) Name the black powder..............................................................[1]

(iv) Calculate the mass of the black powder. Show your working.
...........................................................................................................[3]

Topic Chem 10.3 Q# 30/ iGCSE Chemistry/2015/s/Paper 31/

2 Iron from the Blast Furnace is impure. It contains about 5% of impurities, mainly carbon, sulfur, silicon and phosphorus, which have to be removed when this iron is converted into steel.

(b) Explain how the addition of oxygen and calcium oxide removes these impurities. Include an equation for a reaction of oxygen and a word equation for a reaction of calcium oxide in this process.
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Topic Chem 10.3 Q# 31/ iGCSE Chemistry/2014/w/Paper 31/

4 Iron is extracted from the ore hematite in the Blast Furnace.

(a) The coke reacts with the oxygen in the air to form carbon dioxide.

\[ C + O_2 \rightarrow CO_2 \]

(i) Explain why carbon monoxide is formed higher in the Blast Furnace.
...........................................................................................................
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(ii) Write an equation for the reduction of hematite, Fe₂O₃, by carbon monoxide.

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

(b) (i) Limestone decomposes to form two products, one of which is calcium oxide. Name the other product.
.................................................................................................................. [1]

(ii) Calcium oxide reacts with silicon(IV) oxide, an acidic impurity in the iron ore, to form slag. Write an equation for this reaction.
.................................................................................................................. [2]

(iii) Explain why the molten iron and the molten slag form two layers and why molten iron is the lower layer.
.................................................................................................................. [2]

(iv) Suggest why the molten iron does not react with the air.
.................................................................................................................. [1]

(a) (i) Alumina is obtained from the main ore of aluminium. Name this ore.
.................................................................................................................. [1]

(ii) Explain why it is necessary to use a mixture, alumina and cryolite, rather than just alumina.
.................................................................................................................. [2]

(iii) Copper can be extracted by the electrolysis of an aqueous solution. Suggest why the electrolysis of an aqueous solution cannot be used to extract aluminium.
.................................................................................................................. [2]

(b) The ions which are involved in the electrolysis are Al³⁺ and O²⁻. The products of this electrolysis are given on the diagram. Explain how they are formed. Use equations where appropriate.
.................................................................................................................. [4]
Topic Chem 10.3 Q# 34/ iGCSE Chemistry/2011/s/Paper 31/

3 Iron from the blast furnace is impure. It contains about 4% carbon and 0.5% silicon. Most of this impure iron is used to make mild steel, an alloy of iron containing less than 0.25% carbon.

(a) A jet of oxygen is blown through the molten iron in the presence of a base, usually calcium oxide. Explain how the percentage of carbon is reduced and how the silicon is removed. 

(b) Titanium is a transition element. It is isolated by the following reactions.

\[ \text{titanium ore} \rightarrow \text{titanium(IV) oxide} \rightarrow \text{titanium(IV) chloride} \rightarrow \text{titanium} \]

\[ \text{TiO}_2 \rightarrow \text{TiCl}_4 \rightarrow \text{Ti} \]

(a) Why is it usually necessary to include a number in the name of the compounds of transition elements? 

(b) Titanium(IV) chloride is made by heating the oxide with coke and chlorine.

\[ \text{TiO}_2 + 2\text{C} \rightarrow \text{TiCl}_4 + \text{O}_2 \]

\[ 2\text{C} + \text{O}_2 \rightarrow 2\text{CO} \]

Explain why the presence of coke ensures the maximum yield of the metal chloride.

(c) Explain why the change, titanium(IV) chloride to titanium, is reduction.

Topic Chem 10.3 Q# 35/ iGCSE Chemistry/2011/s/Paper 31/

4 A major ore of zinc is zinc blende, ZnS. A by-product of the extraction of zinc from this ore is sulfur dioxide which is used to make sulfuric acid.

(a) (i) Zinc blende is heated in air. Zinc oxide and sulfur dioxide are formed. Write the balanced equation for this reaction.

(b) (ii) Zinc oxide is reduced to zinc by heating with carbon. Name two other reagents which could reduce zinc oxide.

(c) (iii) The zinc obtained is impure. It is a mixture of metals. Explain how fractional distillation could separate this mixture. zinc bp = 908°C, cadmium bp = 765°C, lead bp = 1751°C

Topic Chem 10.3 Q# 36/ iGCSE Chemistry/2010/w/Paper 31/ Q2

(c) The common ore of tin is tin(IV) oxide and an ore of copper is malachite, CuCO₃ Cu(OH)₂.

(i) Write a word equation for the reduction of tin(IV) oxide by carbon.

(ii) How is zinc blende changed into zinc oxide? 

(iii) Write a balanced equation for the reduction of zinc oxide to zinc by carbon.
Q3

(b) (i) Name a reagent that can reduce iron(III) oxide to iron.

(ii) Write a symbol equation for the reduction of iron(III) oxide, Fe$_2$O$_3$, to iron.

(d) Iron from the blast furnace is impure. Two of the impurities are carbon and silicon. These are removed by blowing oxygen through the molten iron and adding calcium oxide.

(i) Explain how the addition of oxygen removes carbon.

(ii) Explain how the addition of oxygen and calcium oxide removes silicon.

Q4

(b) Some of the zinc oxide was mixed with an excess of carbon and heated to 1000 °C. Zinc distils out of the furnace.

2ZnO + C $\rightarrow$ 2Zn + CO$_2$

C + CO$_2$ $\rightarrow$ 2CO

(ii) Why is it necessary to use an excess of carbon?

6 Aluminium is extracted by the electrolysis of a molten mixture that contains alumina, which is aluminium oxide, Al$_2$O$_3$.

(a) The ore of aluminium is bauxite. This contains alumina, which is amphoteric, and iron(III) oxide, which is basic. The ore is heated with aqueous sodium hydroxide. Complete the following sentences.

The ________________ dissolves to give a solution of ________________.

The ________________ does not dissolve and can be removed by ________________.

(b) Complete the labelling of the diagram.

(c) The ions that are involved in the electrolysis are Al$^{3+}$ and O$^{2-}$.

(i) Write an equation for the reaction at the cathode.

(ii) Explain how carbon dioxide is formed at the anode.
(c) Iron is extracted in a blast furnace. The list below gives some of the substances used or formed in the extraction.

- carbon monoxide
- coke
- iron ore
- limestone
- slag

(i) Which substance is a mineral containing largely calcium carbonate? [1]

(ii) Which substance is formed when impurities in the ore react with calcium oxide? [1]

(iii) Which substance is also called hematite? [1]

(d) State two functions of the coke used in the blast furnace. [2]

(b) The major ore of zinc is zinc blende, ZnS.

(i) Describe how zinc is extracted from zinc blende. [1]

(ii) Give a use of zinc. [1]

(iii) Oxygen is produced at the positive electrode (anode). Name another gas which is given off at this electrode. [1]

(i) Name the main ore of aluminium. [1]

(ii) Why does the molten electrolyte contain cryolite? [1]

(iii) Zinc blende is the common ore of zinc. It is usually found mixed with an ore of lead and traces of silver.

(a) Describe how zinc blende is changed into zinc oxide. [2]
(ii) Write an equation for the reduction of zinc oxide by carbon.

(iii) The boiling point of lead is 1740 °C and that of zinc is 907 °C. Explain why, when both oxides are reduced by heating with carbon at 1400 °C, only lead remains in the furnace.

(i) The temperature in the furnace rises to 2000 °C. Write an equation for the exothermic reaction that causes this high temperature.

(ii) In the furnace, the ore is reduced by carbon monoxide. Explain how this is formed.

(c) The formation of slag removes an impurity in the ore. Write a word equation for the formation of the slag.

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.

(a) Complete the following equation.

\[
\text{Fe}_2\text{O}_3 + C \rightarrow \text{ } + \text{ }
\]

(b) In 1705 Abraham Darby showed that iron ore could be reduced using coke in a blast furnace.

Aluminium is produced by the electrolysis of an electrolyte that contains aluminium oxide.

(i) Write an ionic equation for the reduction of the aluminium ion at the cathode.

(ii) Name the main ore of aluminium.

(iii) Complete the following description of the electrolyte by filling the spaces.

The electrolyte is a \______________ mixture of aluminium oxide and \______________ which is maintained at 900 °C.
(iv) Explain why the gas given off at the anode is a mixture of oxygen and carbon dioxide.

Topic Chem 10.3 Q# 4/ GCSE Chemistry/2001/w/Paper 3/Q4 (a)

(ii) Describe how zinc is extracted from zinc blende.

Topic Chem 10.3 Q# 52/ GCSE Chemistry/2001/w/Paper 3/3

4 (a) Zinc is made by reducing zinc oxide. In 1695 Hornberg obtained zinc from calamine, zinc carbonate. At present zinc is extracted from the ore, zinc blende.

(i) Suggest a way of changing calamine into zinc oxide.

Topic Chem 10.4 Q# 33/ GCSE Chemistry/2015/s/Paper 31/3

2 Iron from the Blast Furnace is impure. It contains about 6% of impurities, mainly carbon, sulfur, silicon and phosphorus, which have to be removed when this iron is converted into steel.

(b) Mild steel is the most common form of steel. Mild steel contains a maximum of 0.3% of carbon.

High carbon steel contains 2% of carbon. It is less malleable and much harder than mild steel.

(i) Give a use of mild steel.

(ii) Suggest a use of high carbon steel.

(iii) Explain why metals are malleable.

Topic Chem 10.4 Q# 54/ GCSE Chemistry/2014/s/Paper 31/Q5

(b) Suggest an explanation why high carbon steel is less malleable and harder than mild steel.

Topic Chem 10.4 Q# 55/ GCSE Chemistry/2015/s/Paper 31/Q3

(c) The uses of a metal are determined by its properties.

(i) Foods which are acidic can be supplied in aluminium containers.

Explain why the acid in the food does not react with the aluminium.

Topic Chem 10.4 Q# 56/ GCSE Chemistry/2011/s/Paper 31/Q3

(b) (i) Why are steel alloys used in preference to iron?

(ii) State a use of the following alloys.

mild steel

stainless steel

Topic Chem 10.4 Q# 57/ GCSE Chemistry/2010/w/Paper 31/Q3c

(iv) Give one use of copper, other than making alloys.
Topic Chem 10.4 Q# 58/ GCSE Chemistry/2010/w/Paper 31/

7 Titanium is a transition element. It is isolated by the following reactions.

\[ \text{titanium ore} \rightarrow \text{titanium(IV) oxide} \rightarrow \text{titanium(IV) chloride} \rightarrow \text{titanium} \]

\[ \text{TiO}_2 \quad \text{TiCl}_4 \quad \text{Ti} \]

(d) Complete the table which shows some of the properties of titanium and its uses. The first line has been completed as an example.

<table>
<thead>
<tr>
<th>property</th>
<th>related use</th>
</tr>
</thead>
<tbody>
<tr>
<td>soluble in molten steel</td>
<td>making steel titanium alloys</td>
</tr>
<tr>
<td>resistant to corrosion, especially in sea water</td>
<td>making aircraft and space vehicles</td>
</tr>
</tbody>
</table>

Topic Chem 10.4 Q# 59/ GCSE Chemistry/2008/w/Paper 31/ Q3

(c) (i) Give two reasons why copper is used.

ir electric wiring. ..................................................................................................................................................

ir cooking utensils. ..................................................................................................................................................

(ii) Give another use of copper.

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

Topic Chem 10.4 Q# 60/ GCSE Chemistry/2007/w/Paper 3/ Q4

(d) Give two uses of zinc

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

2. ........................................................................................................................................................................

13.11.1 ESSENTIAL EXAM QUESTIONS Paper 3/4 268marks T10

Q# 1/ GCSE Chemistry/2003/w/Paper 3/ Q3 (b) (ii) different size atom NOT shape prevents layers from moving

Q# 2/ GCSE Chemistry/2002/w/Paper 3/ Q4a

(ii) regular array
different sizes
delocalised or mobile or free electrons

Q# 3/ GCSE Chemistry/2015/w/Paper 31/

Question | Answer | Marks
--- | --- | ---
Zn | reacts with air to form a bluish-grey oxide | 1

Q# 4/ GCSE Chemistry/2013/w/Paper 31/ (b) potassium hydrogen (1) and potassium hydroxide (1) zinc hydrogen (1) and zinc oxide (1) copper no reaction (1)

Q# 5/ GCSE Chemistry/2013/s/Paper 31/ 5 (a) (i) any metal above zinc Mg \( \rightarrow \text{Mg}^{2+} + 2e^- \)

(ii) \( \text{Zn} + 2\text{Ag}^+ \rightarrow \text{Zn}^{2+} + 2\text{Ag} \)

Note: not balanced only [1]

(iii) because they can accept or gain electrons / change into atoms or can be reduced

(iv) Ag or silver charge not essential but if given must be correct

(v) Ag” or Cu” or silver and copper charge not essential but if given must be correct

Q# 6/ GCSE Chemistry/2013/s/Paper 31/ (b) Cu Sn C0 Zn (i.e. all 4 in correct order) relates order to voltage

one relevant comment from:

higher reactivity metals are the negative electrodes / copper is least reactive because it is the positive electrolyte because copper would have the lowest voltage / copper cell \( \eta = 0 \) / the bigger the difference in reactivity, the bigger the voltage / zinc has highest voltage because it is most reactive / more reactive metals have higher voltage

Q# 7/ GCSE Chemistry/2012/s/Paper 31/ (b) (i) CuO and NO\(_2\) and O\(_2\):

accept: names or correct formula

(ii) \( 2\text{NaNO}_3 \rightarrow 2\text{NaNO}_2 + \text{O}_2 \)

accept: \( \text{NaNO}_3 \rightarrow \text{NaNO}_2 + 1/2 \text{O}_2 \)

not balanced = [1]
Q#8/IGCSE Chemistry/2012/s/Paper 31/Q5

(c) Na / Cu

(d) Cu; Ag

accept: ions Cu²⁺ and Ag⁺

Q#9/IGCSE Chemistry/2011/w/Paper 31/

7 (a) (i) any Group 1 metal
accept: LiOH
(ii) Cu(OH)₂ → CuO + H₂O
note: products only = 1
(iii) reactivity of metals / metals have different reactivities

(b) (i) zinc oxide, nitrogen dioxide, oxygen
note: two correct = 1
(ii) 2KNO₃ → 2KNO₂ + O₂
note: unbalanced = 1, correct word equation = 1

Q#10/IGCSE Chemistry/2011/s/Paper 31/

7 (a) metal A is magnesium
cond most reactive or fastest reaction
metal B is aluminium
cond faster reaction after removal of oxide layer / it would give more hydrogen / aluminium more reactive than zinc
metal C is zinc
zinc least reactive

NOTE MAX [5]

If you encounter different reasoning which is correct, please award the appropriate marks.

(b) for magnesium and zinc same volume of hydrogen

because both have valency of 2 / 1 mole of metal gives 1 mole of hydrogen / 1 mole of metal reacts with 2 moles of acid
bigger volume for aluminium because its valency is 3 / 1 mole of metal gives 1.5 moles of hydrogen / 1 mole of metal reacts with 3 moles of acid

If you encounter different reasoning which is correct, please award the appropriate marks.
accept balanced equations
accept ionic charges as alternative to valency

Q#11/IGCSE Chemistry/2011/w/Paper 31/Q2

(ii) water

carbon dioxide

q#12/IGCSE Chemistry/2010/s/Paper 31/Q1b

(iii) protected by oxide layer

Q#13/IGCSE Chemistry/2010/s/Paper 31/

3 (a) (i) bubbles / effervescence / hydrogen / gas pushes up / lifts metal
(ii) does not react with acid / zinc and iron react with acid
not just unreactive

Q#14/IGCSE Chemistry/2009/s/Paper 31/

4 (i) Cu and Pd
(ii) Ba and La
(iii) +2 or +2 or Ba²⁺
(iv) Ba or La
(v) it is a transition metal or a d block element

[Total: 7]

Q#15/IGCSE Chemistry/2008/w/Paper 31/6 (b)

(ii) potassium hydroxide → no reaction
calcium hydroxide → calcium oxide and water
ACCEPT metal oxide
(iii) 2KNO₃ → 2KNO₂ + O₂
[1] for formula of either product
2Ca(NO₃)₂ → 2CaO + 4NO₂ + O₂
[1] for formulae of any TWO products

Q#16/IGCSE Chemistry/2008/w/Paper 31/

6 (a) (i)

<table>
<thead>
<tr>
<th>aqueous solution</th>
<th>tin</th>
<th>manganese</th>
<th>silver</th>
<th>zinc</th>
</tr>
</thead>
<tbody>
<tr>
<td>tin(II) nitrate</td>
<td>R</td>
<td>R</td>
<td>NR</td>
<td>R</td>
</tr>
<tr>
<td>manganese(II) nitrate</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>R</td>
</tr>
<tr>
<td>silver(I) nitrate</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>zinc nitrate</td>
<td>NR</td>
<td>R</td>
<td>NR</td>
<td>R</td>
</tr>
</tbody>
</table>

[1] for each row
ignore anything written in blank space

(ii) Sn + 2Ag⁺ → Sn²⁺ + 2Ag
all species correct [1]
accept equation with Sn²⁺

(iii) Mn to Mn²⁺ need both species
electron loss or oxidation number increases

(iv) covered with oxide layer
makes it unreactive or protects or aluminium oxide unreactive
Q# 17/ IGCSE Chemistry/2008/s/Paper 3/1
5 (a) (i) The air would react with the magnesium or titanium.
OR argon would not react with the metals.
NOT argon is inert.
(ii) any metal higher than magnesium in reactivity series
[1]

Q# 18/ IGCSE Chemistry/2006/s/Paper 3/1
2 (a) X
W
Z
Y
For most reactive X and least Y [1] ONLY
All other responses [0]

(b) magnesium
W
[1]
copper
Y
[1]

Q# 19/ IGCSE Chemistry/2005/s/3/Q5
(d) (i) zinc + water = zinc oxide + hydrogen
heat,[1] steam [1]
(ii) Sr + 2H₂O = Sr(OH)₂ + H₂
Not balanced [1]
cold water [1]

Q# 20/ IGCSE Chemistry/2005/s/3/Q6
(d) (i) 2Al(OH)₃ = Al₂O₃ + 3H₂O
Not balanced [1]
(ii) Aluminium nitrate = aluminium oxide + nitrogen dioxide + oxygen
only TWO correct products [1]

Q# 21/ IGCSE Chemistry/2005/s/3/Q6
(b) (i) aluminum
[1]
(ii) solution goes colourless or copper formed
or a brown solid forms or blue colour disappears
or bubbles
NOT goes clear or copper formed
(iii) covered with an oxide layer
[1]

Q# 22/ IGCSE Chemistry/2004/w/Paper 3/4
(b) (i) increase
[1]
(iii) zinc
COND and a correct reason - such as it loses electrons more easily or
it is more reactive
Need both zinc and reason for the mark.
(iii) from the more reactive to the less reactive NOT just from zinc to lead
[1]
Q# 28/ iGCSE Chemistry/2002/w/Paper 3/ Q1
(c) (i) copper sulphate or anhydrous copper sulphate
    accept “unhydrated”
    NOT formula
    [1]
(i) goes blue or becomes hot or steam
    [1]
(ii) copper oxide
    [1]
(iv) 5/250 = 0.02 moles
    [1]
Mr = 80
    [1]
80 x 0.02 = 1.6 g
    [1]
NB (iv) to be marked consec to (iii)
Correct answer no working ONLY [1]
Q# 29/ iGCSE Chemistry/2002/w/Paper 3/ Q1
1 (i) Any metal above aluminium Na, K, Ca, Mg etc
    [1]
(ii) If (i) is correct then word equation
    [1]
(iii) cause to (i) symbol equation
    If not balanced ONLY [1]
Q# 30/ iGCSE Chemistry/2015/s/Paper 3/1
1 (a) CuSO₄ + Ba(OH)₂ → Cu(OH)₂ + BaSO₄
    [2]
(b) CuSO₄ + Na₂CO₃ → CuCO₃ + Na₂SO₄
    [2]
(c) CuSO₄ + Ba₂+ → Cu²⁺ + Ba²⁺
    [2]
(d) CuSO₄ + Na⁺ → Cu⁺ + Na⁺
    [2]

Question | Answer | Marks | Guidance
---|---|---|---
2 (a) | M₄ forming an oxide (all elements or all impurities become oxides); | 1 | (a) elements or all impurities react with oxygen.
M₂/acid oxides | CaO + CO₂ → CaCO₃ | 1 | A formula/acid monoxide.
M₃/acid oxides | SiO₂ + Na₂O → Na₂SiO₃ | 1 | A formula.
M₄/acid oxides | SiO₂ + CaO → CaSiO₃ | 1 | Water insoluble.
M₅/acid oxides | SiO₂ + ZnO → Zn₂SiO₄ | 1 | Used in the glass industry.
M₆/acid oxides | SiO₂ + Al₂O₃ → Al₂SiO₃ | 1 | Used in the glass industry.

Q# 31/ iGCSE Chemistry/2014/s/Paper 3/1
4 (a) (i) insufficient/limited oxygen
    2C + O₂ → 2CO
    coke/coal reacts with carbon dioxide
    2C + CO₂ → 2CO
    [1]
(ii) Fe₂O₃ + 3CO → 2Fe + 3CO₂
    species (1) balancing (1)
    [2]
(b) (i) carbon dioxide
    CaO + CO₂ → CaCO₃
    [1] each side correct
    [2]
(iii) molten iron higher density (than slag)
    [2]
(iv) No oxygen in contact with iron or layer of slag prevents hot iron reacting with oxygen/air or (all) oxygen reacts with carbon (so no oxygen left to react with iron)
    [1]
Q# 32/ iGCSE Chemistry/2014/s/Paper 3/1
5 (a) M1: (zinc sulfide) heated/roasted/burnt in air (1)
M₂: zinc oxide formed (1)
M₃: zinc oxide reduced (1)
M₄: (by adding) coke or carbon (1)
M₅: Balanced equation (any one of) (1)
2ZnO + 3CO → 2Zn + 3CO₂
2ZnO + C → 2Zn + CO₂
ZnO + CaO → Zn + CO₂
ZnO + CO → Zn + CO₂

Q# 33/ iGCSE Chemistry/2011/w/Paper 3/1
3 (a) (i) bauxite
    [1]
    (ii) lowers melting point
   melt, reduces amount of energy needed / reduces cost / more economic/makes process viable / conserves energy
    [1]
(iii) aluminium more reactive than copper / aluminium higher in reactivity series / hydrogen not aluminium formed at cathode
    [1]
(b) Al³⁺ + 3e⁻ → Al
    2O₂ → O₃ + 4e⁻
    [7]
    note: not balanced = 1
oxygen reacts with carbon (emode) to form carbon dioxide / C + O₂ → CO₂
note: if rate of an electrode reaction are not awarded then allow aluminium ions accept electrons / are reduced
oxide ion loses electrons / is oxidised
max - 1
Q#34/ iGCSE Chemistry/2011/s/Paper 31/

3  (a) any four max 4
    carbon forms carbon dioxide / carbon monoxide
    this is a gas if it escapes / blown out / diffuse
    [1]
    silicon forms silicon(IV) oxide / silica
    / silicon(IV) oxide present in impure iron
    silicon(IV) oxide reacts with calcium oxide to form slag or calcium silicate
    slag removed from surface
    accept reclaimed, syphoned, poured off
    not tapped
    accept correct formula or equations
    max [4]
    not calcium oxide reacts with silicon

Q#35/ iGCSE Chemistry/2011/s/Paper 31/

4  (e) (i) 2ZnO + O2 → 2ZnO + 2SO2
    not balanced only [1]
    [2]
    (ii) two reagents from named metal(s) more reactive than zinc/carbon monoxide
    not hydrogen
    they have different boiling points
    cadmium will distill first then zinc leaving lead/lead distill last
    [1]
    [1]

Q#36/ iGCSE Chemistry/2010/w/Paper 31/ Q2

(c) (i) tin(IV) oxide + carbon → tin + carbon dioxide
    not carbon monoxide as a reductant
    accept carbon monoxide as a product
    not tin(IV)
    accept correct symbol equation
    [1]

Q#37/ iGCSE Chemistry/2010/w/Paper 31/ Q2

7  (a) a transition element has more than one oxidation state or valency
    accept different oxidation states
    [1]
    (b) by removing oxygen concentration of O2 decreases
    prevents the back reaction / equilibrium shifts to right
    [1]
    [1]
    (c) oxidation number reduced from (+4) to (0)
    accept accepts electrons or accepts four electrons
    if number given must be 4
    [1]

Q#38/ iGCSE Chemistry/2009/w/Paper 31/ Q2

3  (a) (i) heat or roast or burn in air
    need both points for mark
    [1]
    (ii) ZnO + C → Zn + CO
        or 2ZnO + C → 2Zn + CO2
        unbalanced ONLY [1]

Q#39/ iGCSE Chemistry/2008/w/Paper 31/ Q3

(b) (i) hydrogen or carbon or carbon monoxide or methane
    or more reactive metal NOT Group I
    [1]
    (ii) any correct equation
        only error not balanced [1]

Q#40/ iGCSE Chemistry/2008/w/Paper 31/ Q3

(d) (i) forms carbon dioxide/carbon monoxide (which escapes)
    [1]
    (ii) forms silicon(IV) oxide or silicon oxide or silica
    OR CaO reacts with SiO2
    to form slag or calcium silicate
    ignore an incorrect formula if a correct name "slag" given
    NOT Si + O2 + CaO form slag, this gains mark for slag only
    [1]

Q#41/ iGCSE Chemistry/2007/w/Paper 3/ Q4 (b)

(iii) to get maximum yield of zinc or reduce all zinc oxide
    NOTE the above mark is awarded for why add excess carbon moves equilibrium to right or to favour the products or removes CO2 from equilibrium
    NOTE this mark is awarded for how does the addition of excess carbon give max yield of zinc
    NOTE Allow any coherent explanation flexibly based on the above ideas
    EXAMPLES: moves equilibrium to right [1] because carbon dioxide removed [1]
    to get maximum yield of zinc [1] as equilibrium moves to right [1]
    NOT just to make CO from CO2

Q#42/ iGCSE Chemistry/2008/w/Paper 31/ Q3

6  (a) alumina or aluminium oxide
    sodium aluminate
    iron(III) oxide
    filtration or centrifuge NOT conditional
    [1]
    [1]
    (b) from left to right:
        carbon cathode or carbon negative electrode
        900 to 1000°C
        aluminium
        molten
        [1]
        [1]
        [1]
        (c) (i) Al3+ + 3e = Al
            not balanced [1]
            Al3+(aq) = 0
            [2]
            (ii) oxygen is formed NOT oxide
                reacts with carbon anode
                [1]
Q#43/ IGCSE Chemistry/2006/s/Paper 3/ Q1
(c) (i) limestone
(ii) slag
(iii) iron ore
Q#44/ IGCSE Chemistry/2006/s/Paper 3/ Q1
(d) to burn or provide heat
to make carbon monoxide
Q#45/ IGCSE Chemistry/2005/w/Paper 3/ Q5
(b)(i) heat zinc blende in air to form oxide
reduce oxide with carbon
(ii) galvanising
sacrificial protection
alloys
batteries
roofing
Any ONE
Q#46/ IGCSE Chemistry/2005/s/Paper 3/
6 (a) (i) bauxite
(ii) to reduce melting point or improve conductivity
or as a solvent or reduce the working temperature
(iii) carbon dioxide or monoxide or fluorine
Q#47/ IGCSE Chemistry/2003/w/Paper 3/
3 (a) (i) heat or roast
in air
(ii) Either correct equation
ZnO + C = Zn + CO
2ZnO + C = 2Zn + CO
2
Not balanced ONLY [1]
NOT carbon monoxide as a reductant
(ii) bp of lead above 1400 °C it remains
bp of zinc below 1400 °C
boils away or forms vapour
Any TWO
OR lead does not boil
zinc boils
Q#48/ IGCSE Chemistry/2003/s/Paper 3/
1 (a) A correct equation either CO or CO2 as product
If not balanced but otherwise correct [1] ONLY
(b)(i) C + O2 → CO2 NOT word equation
(ii) (higher in furnace) no oxygen left
carbon dioxide reacts with carbon (to give carbon monoxide)
OR incomplete combustion of carbon
OR either equation gains both marks
CO2 + C = 2CO or 2C + O2 = 2CO
OR carbon dioxide reacts
with carbon
(c) limestone + sand → slag
OR calcium carbonate + silicon (IV) oxide → calcium silicate (+ carbon dioxide)
For knowing that impurity is sand [1] ONLY
Accept calcium oxide and silicon oxide
Accept lime
Q#49/ IGCSE Chemistry/2003/s/Paper 3/ Q1
(iii) blow air/oxygen through carbon becomes carbon dioxide
carbon dioxide escapes as gas
silicon and phosphorus become oxides
calcium oxide or calcium carbonate
forms slag
Any FOUR NOT blast furnace
Q#50/ IGCSE Chemistry/2002/s/Paper 3/ Q4/IGCSE Chemistry/Q1
(b) (i) Al+3 + 3e → Al
For Al3+ ONLY [1] anywhere in equation
(ii) bauxite
(iii) molten or liquid or fused or homogeneous
cryolite
(iv) oxygen from oxide or formed at anode or
implied it is formed
carbon (anode) to form carbon dioxide
Q#51/ IGCSE Chemistry/2001/w/Paper 3/Q4 (a)
(ii) zinc sulphide or roast or burn or sulphur dioxide formed
zinc oxide
reduce with carbon or dissolve zinc oxide in sulphuric acid and electrolyse
NOT electrolysis of blende or oxide
NOT electrolysis of blende or oxide
Q52/ IGCSE Chemistry/2001/w/Paper 3/
4 (a) (i) roast (ignore air) or roasting NOT burn

Q53/ IGCSE Chemistry/2015/s/Paper 31/

13.12 FUNDAMENTAL Assessed Activity 1 Keyword Test

<table>
<thead>
<tr>
<th>Topic #</th>
<th>English</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>2124</td>
<td>blast furnace</td>
<td></td>
</tr>
<tr>
<td>3786</td>
<td>alloy steels</td>
<td></td>
</tr>
<tr>
<td>3955</td>
<td>ore</td>
<td></td>
</tr>
<tr>
<td>7323</td>
<td>alloys</td>
<td></td>
</tr>
<tr>
<td>8380</td>
<td>galvanising</td>
<td></td>
</tr>
<tr>
<td>8993</td>
<td>reactivity series of metals</td>
<td></td>
</tr>
<tr>
<td>9278</td>
<td>carbon steel</td>
<td></td>
</tr>
<tr>
<td>9448</td>
<td>basic oxygen process</td>
<td></td>
</tr>
</tbody>
</table>
13.13 ESSENTIAL Assessed Activity 2 Topic 10 Paper 2 16 marks

Q# 14/ iGCSE Chemistry/2017/m/Paper 2

26 Which statement about all metals is correct?
   A They are attracted to a magnet.
   B They are weak and brittle.
   C They may be used to form alloys.
   D They react with water.

27 Which substance produces sulfur dioxide when roasted in air?
   A bauxite
   B cryolite
   C hematite
   D zinc blende

28 Which metal carbonate does not produce carbon dioxide when it is heated with a Bunsen burner?
   A copper(II) carbonate
   B magnesium carbonate
   C sodium carbonate
   D zinc carbonate

29 Two experiments are carried out.

   In experiment 1, copper is heated with steam.
   In experiment 2, copper(II) oxide is heated with carbon.

Which row describes what happens in experiments 1 and 2?

<table>
<thead>
<tr>
<th></th>
<th>experiment 1</th>
<th>experiment 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>no reaction</td>
<td>no reaction</td>
</tr>
<tr>
<td>B</td>
<td>no reaction</td>
<td>reaction</td>
</tr>
<tr>
<td>C</td>
<td>reaction</td>
<td>no reaction</td>
</tr>
<tr>
<td>D</td>
<td>reaction</td>
<td>reaction</td>
</tr>
</tbody>
</table>

Q# 15/ iGCSE Chemistry/2016/w/Paper 2

25 Basic oxides and oxygen are used to convert iron into steel.

Which statement is not correct?
   A Carbon is converted into carbon dioxide.
   B Silicon is converted into silicon(IV) oxide.
   C The basic oxides react with acidic impurities to form slag.
   D The oxygen reacts with the iron to produce hematite.

26 The results of two experiments are given.

   1 Cobalt displaces manganese from an aqueous solution of a manganese salt.
   2 Manganese displaces silver from an aqueous solution of a silver salt.

Three more experiments are carried out.

   3 Cobalt is added to an aqueous solution of a silver salt.
   4 Manganese is added to an aqueous solution of a cobalt salt.
   5 Silver is added to an aqueous solution of a cobalt salt.

In which experiments does a reaction take place?
   A 3 only   B 3 and 4   C 4 and 5   D 5 only

27 Cryolite, Na₃AlF₆, is added to aluminium oxide in the electrolytic extraction of aluminium.

What is the reason for this?
   A to decrease the melting point of the electrolyte
   B to protect the anodes
   C to produce more aluminum
   D to stop the aluminium reacting with air
26 Different forms of steel contain different proportions of carbon.

Steel P contains a high proportion of carbon.

Steel Q contains a low proportion of carbon.

Which statement is correct?

A  P is stronger and more brittle than Q.
B  P is stronger and less brittle than Q.
C  P is less strong and more brittle than Q.
D  P is less strong and less brittle than Q.

Q# 16/IGCSE Chemistry/2016/w/Paper 21/  

25 Impurities in iron obtained from the blast furnace include carbon, phosphorus and silicon.

Which impurities are removed from the molten iron as gases when it is made into steel?

A  carbon and phosphorus
B  carbon and silicon
C  carbon only
D  phosphorus and silicon

26 Y displaces X from its aqueous sulfate.

X does not displace W from its aqueous sulfate.

X displaces Z from its aqueous sulfate.

What is the order of reactivity of elements W, X, Y and Z?

<table>
<thead>
<tr>
<th>most reactive</th>
<th>least reactive</th>
</tr>
</thead>
<tbody>
<tr>
<td>A  W X Y Z</td>
<td>B  W Y X Z</td>
</tr>
<tr>
<td>C  Z X Y W</td>
<td>D  Z W Y X</td>
</tr>
</tbody>
</table>

27 Which statement about the industrial extraction of aluminium from aluminium oxide is correct?

A  Aluminium is extracted by heating its oxide with carbon.
B  Aluminium is extracted using electrolysis and is collected at the anode.
C  Aluminium is extracted using platinum electrodes and direct current.
D  Molten cryolite is used as a solvent for aluminium oxide.

28 The alloy brass is a mixture of copper and another metal.

Brass is used to make the pins of electrical plugs.

Copper is used to make electrical wiring.

Which row about brass is correct?

<table>
<thead>
<tr>
<th>hardness</th>
<th>electrical conductivity</th>
<th>other metal</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>harder than copper</td>
<td>better than copper</td>
</tr>
<tr>
<td>B</td>
<td>harder than copper</td>
<td>worse than copper</td>
</tr>
<tr>
<td>C</td>
<td>softer than copper</td>
<td>better than copper</td>
</tr>
<tr>
<td>D</td>
<td>softer than copper</td>
<td>worse than copper</td>
</tr>
</tbody>
</table>

Q# 17/IGCSE Chemistry/2016/w/Paper 21/  

25 Impure iron from the blast furnace is converted to steel as shown.

Which statement about the process is correct?

A  Acidic oxides are added to remove alkaline impurities.
B  Coke is added as a reducing agent.
C  Oxygen is blown in to oxidise the impure iron.
D  The steel produced contains less carbon than the impure iron.

26 The ionic equations represent the reactions between four metals, P, Q, R and S, and solutions of the salts of the same metals.

- $P + Q^{2+}$ → no reaction
- $R + P^{2+}$ → $R^{2+} + P$
- $Q + S^{2+}$ → $Q^{2+} + S$
- $S + R^{2+}$ → $S^{2+} + R$
- $S + Q^{2+}$ → no reaction
What is the correct order of reactivity of the metals?

<table>
<thead>
<tr>
<th>most</th>
<th>least</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>P</td>
</tr>
<tr>
<td>B</td>
<td>Q</td>
</tr>
<tr>
<td>C</td>
<td>Q</td>
</tr>
<tr>
<td>D</td>
<td>S</td>
</tr>
</tbody>
</table>

27 Aluminium is extracted by electrolysis.

From which ore is aluminium extracted and at which electrode is aluminium deposited during electrolysis?

<table>
<thead>
<tr>
<th>ore</th>
<th>electrode</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>bauxite</td>
</tr>
<tr>
<td>B</td>
<td>bauxite</td>
</tr>
<tr>
<td>C</td>
<td>cryolite</td>
</tr>
<tr>
<td>D</td>
<td>cryolite</td>
</tr>
</tbody>
</table>

28 Zinc oxide can be reacted with carbon to produce zinc metal.

Which equation for this reaction is correct?

A $2\text{ZnO} + \text{C} \rightarrow \text{2Zn} + \text{CO}$

B $2\text{ZnO} + 2\text{C} \rightarrow \text{2Zn} + 2\text{CO}_2$

C $\text{ZnO} + \text{C} \rightarrow \text{Zn} + \text{CO}$

D $\text{ZnO} + 2\text{C} \rightarrow \text{Zn} + 2\text{CO}_2$

13.14 ESSENTIAL Assessed Activity 3 28 marks Topic 10 Paper 3/4

7 One way of establishing a reactivity series is by displacement reactions.

(a) A series of experiments was carried out using the metals lead, magnesium, zinc and silver. Each metal was added in turn to aqueous solutions of the metal nitrates.

The order of reactivity was found to be:

```
lead → magnesium → zinc → silver
```

(i) Complete the table.

<table>
<thead>
<tr>
<th>metal</th>
<th>aqueous solution</th>
<th>lead (II) nitrate</th>
<th>magnesium nitrate</th>
<th>zinc nitrate</th>
<th>silver nitrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pb</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>X</td>
</tr>
<tr>
<td>Mg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zn</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ag</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(ii) Displacement reactions are redox reactions.

On the following equation, draw a ring around the reducing agent and an arrow to show the change which is oxidation.

```
\text{Zn} + \text{Pb}^{2+} \rightarrow \text{Zn}^{2+} + \text{Pb}
```

[i]

(iii) Complete the following ionic equation.

```
\text{Zn} + 2\text{Ag}^+ \rightarrow \text{...} + \text{...}
```

[2]
(b) Another way of determining the order of reactivity of metals is by measuring the voltage and polarity of simple cells. The polarity of a cell is shown by which metal is the positive electrode and which metal is the negative electrode. An example of a simple cell is shown below.

(i) Mark on the above diagram the direction of the electron flow. \[1\]

(ii) Explain, in terms of electron transfer, why the more reactive metal is always the negative electrode.

(iii) The following table gives the polarity of cells using the metals zinc, lead, copper and manganese.

<table>
<thead>
<tr>
<th>cell</th>
<th>electrode 1</th>
<th>polarity</th>
<th>electrode 2</th>
<th>polarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>zinc</td>
<td>-</td>
<td>lead</td>
<td>+</td>
</tr>
<tr>
<td>B</td>
<td>manganese</td>
<td>+</td>
<td>lead</td>
<td>-</td>
</tr>
<tr>
<td>C</td>
<td>copper</td>
<td>-</td>
<td>lead</td>
<td>+</td>
</tr>
</tbody>
</table>

What information about the order of reactivity of these four metals can be deduced from the table? \[2\]

(iv) What additional information is needed to establish the order of reactivity of these four metals using cells? \[1\]

---

Topic Chem 10.3 Q# 2/

6 The position of aluminium in the reactivity series of metals is shown below.

(a) Aluminium is extracted by the electrolysis of its molten oxide.

(i) Name the main ore of aluminium. \[1\]

(ii) Why does the molten electrolyte contain cryolite? \[1\]

(iii) Oxygen is produced at the positive electrode (anode). Name another gas which is given off at this electrode. \[1\]

---

Topic Chem 10.3 Q# 3/

3 Zinc blende is the common ore of zinc. It is usually found mixed with an ore of lead and traces of silver.

(a) (i) Describe how zinc blende is changed into zinc oxide. \[2\]
(ii) Write an equation for the reduction of zinc oxide by carbon.

\[ \text{Fe}_2\text{O}_3 + C \rightarrow \text{Fe} + \text{CO}_2 \]

(iii) The boiling point of lead is 1740°C and that of zinc is 907°C. Explain why, when both oxides are reduced by heating with carbon at 1400°C, only lead remains in the furnace.

(i) The temperature in the furnace rises to 2000°C. Write an equation for the exothermic reaction that causes this high temperature.

(ii) In the furnace, the ore is reduced by carbon monoxide. Explain how this is formed.

(c) The formation of slag removes an impurity in the ore. Write a word equation for the formation of the slag.

---

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.

(a) Complete the following equation.

\[ \text{Fe}_2\text{O}_3 + C \rightarrow \text{Fe} + \text{CO}_2 \]

(b) In 1705 Abraham Darby showed that iron ore could be reduced using coke in a blast furnace.

---

13.15 Exceptional Additional Activities, Further Reading and Exploring Beyond the Syllabus

Is hydrogen a metal or a non-metal?

For articles and information that explores this idea go to this webpage:

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

---

A diagram of Jupiter showing a model of the planet's interior, with a rocky core overlaid by a deep layer of liquid metallic hydrogen (shown as magenta) and an outer layer predominantly of molecular hydrogen. Jupiter's true interior composition is uncertain. For instance, the core may have shrunk as convection currents of hot liquid metallic hydrogen mixed with the molten core and carried its contents to higher levels in the planetary interior. Furthermore, there is no clear physical boundary between the hydrogen layers—with increasing depth the gas increases smoothly in temperature and density, ultimately becoming liquid. Features are shown to scale except for the aurorae and the orbits of the Galilean moons.

Are neutron stars metals or non-metals? Why have all of the non-metals been discovered? Could there be a third type of element other than metals and non-metals yet to be discovered?
### 14.1 End of Paper 6 Alternative to Practical Unit Goals Checklist

<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>Yes/No</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>Yes/No</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>Yes/No</td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Ask your teacher one question about something to do with science every lesson</td>
<td>Yes/No</td>
<td>EXTENSION</td>
</tr>
<tr>
<td>Notes and follow up notes</td>
<td>Complete set of class note</td>
<td>Yes/No</td>
<td>FUNDAMENTAL</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Attempted</td>
<td>Yes/No</td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Completed</td>
<td>Yes/No</td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Cornell Notetaking Completed to an exemplary standard</td>
<td>Yes/No</td>
<td>EXCEPTIONAL</td>
</tr>
<tr>
<td></td>
<td>Attempted the Mind Map for this topic</td>
<td>Yes/No</td>
<td>ESSENTIAL</td>
</tr>
<tr>
<td></td>
<td>Completed the Mind Map for this topic</td>
<td>Yes/No</td>
<td>EXTENSION</td>
</tr>
<tr>
<td>Textbook</td>
<td>Read ahead before the topic has been started</td>
<td>Yes/No</td>
<td>EXTENSION</td>
</tr>
<tr>
<td></td>
<td>Highlighted key ideas and translated new words</td>
<td>Yes/No</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>Yes/No</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>Yes/No</td>
<td>EXTENSION</td>
</tr>
</tbody>
</table>

**Post Exam Questions**

- Attempted more than 25% of the exam questions in this workbook
- Completed and marked all questions here
- Used the resources available online to answer additional questions not found in this workbook
- Used the resources available online to answer additional questions not found in the Review and Reflection section
- Completed the word list activity using the word list at the front of each topic as little as possible
- Complete 2 assessed activities, either in class or as homework
- Complete 2 assessed activities and scored over 70% on average
- Complete 2 assessed activities and scored over 80% on average
- Scored 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)
- Scored 30% higher than your current average
- Scored 15% or more than your previous end of topic average
- Scored over 90%

**Reflection**

- You completed this goal setting table
- 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
- You have given an answer for every question in the Review and Reflection section at the end of this topic
- You have given good and thoughtful answers for every question in the Review and Reflection section at the end of this topic

**Assessed Activities**

- Complete the word list activity using the word list at the front of each topic as little as possible
- Complete 2 assessed activities, either in class or as homework
- Complete 2 assessed activities and scored over 70% on average
- Complete 2 assessed activities and scored over 80% on average
- Completed, marked and additional key ideas where you have located the most difficult marks added to your notebook

**End of Topic Test**

- Scored 30% higher than your current average
- Scored 15% or more than your previous end of topic average
- Scored over 90%
- Scored over 95%

---

#### 14.2 ESSENTIAL EXAM QUESTIONS Paper 6 Essay type questions by topic 124marks

**PAPER 6 - Question types**

Percentage of all marks awarded for each question type from w2001 to w2015 (red crosses) and from m2016 to w2017 (green triangles)
Topic 1

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.

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?

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

(c) The label on the paint tin states

“Touch-dry in three hours”

(i) How could you check this value?

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

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.
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 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)

---

Topic 5

026

ELECTROPLATING A COPPER KEY

Electroplating is when a metal is coated with another metal using electricity.

To electropate a metal a very clean surface is needed.

Describe an experiment to nickel plate a copper key. You are provided with the following items.

6 V bulb and holder
6 V battery and connecting wires
250 cm³ beaker
steel wool/sandpaper
copper key
distilled water
nickel rod
solid nickel(II) sulphate, NiSO₄

---

You can use a labelled diagram to help you answer the question.

---

Topic 6

076

7 When cement powder is added to water a reaction takes place.

(a) Describe an experiment to show that this reaction is exothermic.
7 Diesel is a liquid fuel obtained from crude oil. Biodiesel is a fuel made from oil obtained from the seeds of plants such as sunflowers.

Using the apparatus below plan an experiment to investigate which of these two fuels produces more energy.

![Diagram](image)

---

8 Is manganese(IV) oxide a catalyst?

A catalyst is a substance that speeds up a chemical reaction and remains unchanged.

Hydrogen peroxide, \( \text{H}_2\text{O}_2 \), breaks down to form oxygen. This reaction is very slow without a catalyst. Describe an experiment to show that manganese(IV) oxide is a catalyst for this reaction.

You are provided with the following items.

- Hydrogen peroxide solution
- Manganese(IV) oxide
- Measuring cylinder
- Balance
- Beaker
- Filtration apparatus
- Splints/Bunsen burner
- Distilled water
8 An aqueous solution of hydrogen peroxide decomposes very slowly to form oxygen. The speed of decomposition can be increased by using a catalyst. Two possible catalysts are the solid’s copper(II) oxide and chromium(III) oxide.

Plan an investigation to find out which of these two oxides is the better catalyst for this decomposition.

The space below can be used for a diagram.

6 Beach sand is a mixture of sand and broken shells (calcium carbonate). Calcium carbonate reacts with dilute hydrochloric acid to form a solution of calcium chloride.

Plan an investigation to find out the percentage of shell material in a given sample of beach sand.

(a) What is meant by the term concentrated?

(b) Predict the pH of the lemon drink.
(c) Describe an experiment to show that two different yellow colourings are present in the drink.

6 The diagram shows two bottles of liquid oven cleaner.

The oven cleaners contain sodium hydroxide solution. Plan an investigation to show which oven cleaner contains the highest concentration of sodium hydroxide.

7 Some plants do not grow well in acidic soil. A farmer gives you a small sample of soil from a corner of one of his fields.

(a) Plan an investigation to find out the pH of the soil sample.

You are provided with Universal Indicator solution and common laboratory apparatus.

(b) Why would further experiments be necessary to inform the farmer which plants should be grown in each of his fields?

7 A solution of magnesium sulphate can be made by reacting magnesium oxide with warm sulphuric acid.

(a) Describe how you could make a solution of magnesium sulphate starting with magnesium oxide powder and dilute sulphuric acid.
6 Acid base indicators

Indicators are used to identify acids and bases.
Indicators can be obtained from berries and other fruits.

(a) Plan an experiment to obtain an aqueous solution of an indicator from some berries.

(b) Plan an experiment to use the indicator solution to show that it is an effective indicator.

7 Malachite is a naturally occurring form of copper carbonate. Outline how a sample of copper metal could be obtained from large lumps of malachite in the laboratory.
Copper is one of the least reactive metals.
Your answer should include any chemicals used and conditions.
**FASTGROW FERTILISER**

Fertilisers are used to increase the growth of plants. Fertilisers have to dissolve in water if they are to be used by plants.

Plan an experiment to find the solubility, in g/100 cm³, of FASTGROW fertiliser at 30 °C.

---

**STOP RUST!**

Solutions of chemicals known as corrosion inhibitors are added to the water in steel radiators to reduce rust. You are provided with three different bottles of liquid corrosion inhibitors, R, S and T, and some steel nails.

Plan an experiment to test if these inhibitors prevent the corrosion of steel and which of these inhibitors is the most effective.

---

**Topic 12**

6 Sulphur dioxide gas is a common pollutant formed when fossil fuels burn in air. Sulphur dioxide can be detected by using an acidic solution of potassium dichromate(VI). The dichromate solution changes colour from orange to green when a certain amount of sulphur dioxide has reacted with it.

Plan an experiment to investigate which of three different samples of coal produces most sulphur dioxide.

---

**Topic 13**

6 Which is the more pure - limestone or marble?

Calcium carbonate is found in limestone and in marble. All carbonates react with hydrochloric acid to form chlorides. Calcium carbonate is insoluble in water but calcium chloride is water soluble.

Most impurities in limestone and marble are insoluble. Plan an experiment to find out which of limestone and marble contain most insoluble impurities. You are provided with common laboratory apparatus.

---
14.3 MARK SCHEMES ESSENTIAL EXAM QUESTIONS Paper 6 Essay type questions by topic

124 marks

Topic 1 Mark Scheme

04w6

7 chromotography (1) apply ink/spot to paper (1)
organic solvent/water (1) rises up paper (1)
check height/position of spot (1) compare to find ink from banknote (1) (6)

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

06w6

6 (a) point sample + water(1) filter(1) solid residue(1) max 2
(b) solid + organic solvent(1) add to paper(1)
chromotography(1) use of solvent(1) description of spots(1)
max 4 N.B. use of water = max 1 for chromatography
(c) (i) apply point, start timer(1) method of choosing dry, note time(1)
no painting = 0
(ii) correct method(1) e.g. hair dryer/fan/increase temperature.
NOT catalyst. (2)

09w6

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

(b) NB marks can be obtained from a diagram
chromotography 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)
If water used as solvent (max 3)
If paper dipped into extract (max 3)
If method would not work (max 2)

11w6

6 measured volume of seawater (1)
using measuring cylinder (1)
into evaporating dish/beaker (1)
pre-weighed (1)
evaporate/heat (1)
to dryness/constant mass (1)
re-weigh (1)
indication of calculation method (1)
max 6

would not work = max 0

Topic 7 Mark Scheme

05/6

8 Add known mass of manganese oxide

Tn (measured until mass of hydrogen peroxide)
Bubbles
Test gas with glowing splint
Result
Filter
Dry solid
Reweigh and compare
(max 6)

05/6

8 same amount/measured volume of peroxide (1)
add known mass of metal oxide (1)
t/m (1), measure volume of oxygen (1)
repeat with other oxides (1) compare/conclusion (1)
method will not work = 0

Topic 8 Mark Scheme

03/6

6 Known mass of beach sand (1)
add excess (1) dilute hydrochloric acid (1)
filter (1), wash (1), dry (1) residue
and weigh sand (1) working out result (1)
max 5 of B

05/6

6 (a) no little water present/little water implied (1)
(b) any value less than 7 (1)
(c) chromatography (1) apply to paper (1) use of solvent (1)
description of two yellow spots (1)
paper in drink = max 2

05/6

6 (a) soil sample + water (1)

stir heat (1)
filter (1)
add Universal indicator (1)
chart (1)
(b) more samples (1)
different parts of field (1)

06/6

6 Measured volume of oven cleaner (1)
Add indicator/coloured indicator (1)
Add named acid (1), from a burette/pipette (1)
Until colour change/end point (1), measure/record volume of acid (1)
Repeat with other cleaner (1), compare (1)

Max 6

07/6

7 (a) initial temperature of acid water or cement (1)
add cement (1)
using thermometer in beaker etc. (1)
measure temperature (1)
temperature rise (2) max 4

N.B.
no water = 0
no cement = 0
use of heat = 0
wrong chemicals = 0
would not work = 0

(b) sodium hydroxide (1) white precipitate (1)
or flame test (1) red (1)

[Total: 6]

08/6

7 (a) heat/warm the acid (1)
add excess oxide or description of no more solid reacting (1)
filter/decant (1)

(b) heat equalised & to crystallising point or description of e.g. using glass rod/leave it to evaporate (1)
cool to form crystals (1)
filter off crystals (1)
method of drying crystals e.g. pressed filter papers/oven at low temperature (1)

[Total: 6]

09/6

6 (a) add water (1)
Use/measure (1)
filter/decant or pipette off liquid/sieve (1)

(b) add indicator solution to acid (and note colour) (1)
add indicator solution to alkali or named alkali (and note colour) (1) not base conclusion e.g. colours should be different owts (1)
10s6

1. Crush malachite (1) using pestle and mortar (1) add named acid (1) solution red (1) obtain copper (1) or fine powder (1) max 6

or first two steps (2) displacements (1) until goes pink (1) obtain copper (1) or first four steps (1) electrolysis solution (1) copper deposited or electrodes (1) NB if malachite anode used allow max 3 even if would not work.

11s6

1. Known mass of salt (1)
   Add known volume of water (1)

2. Warm to 30°C (1)
   Stir (1)
   Filter (1)
   Evaporate to dryness (1)

3. Dry and weigh residue (1)
   Wash and redissolve (1) max 6

4. Conclusion (1)

12s6

6. Steel nail (1) in test tube/suitable glass container (1)
   Known volume of water (1) water (1) no water = max 3
   Known volume of inhibitor added (1)
   Observations after suitable time (1) note: minimum time = 1 day
   Repeat using other inhibitors (1)
   Observed comparison of results (1)

[Total: 7]

13s6

6. Weigh coal sample (1) same amount
   Burn coal (1)
   Pass gas or diagram to show (1)
   Through acid (1)
   Use of timer (1)
   Record time for colour change (1)
   Repeat compare with other samples (1)

Max 6
14.5 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?

14.6 Exceptional Additional Activities, Further Reading and Exploring Beyond the Syllabus

Empiricism. What is it and what are the alternatives? Will we ever discover a better way to understand the universe than through science? Is empiricism a good idea?

This touches on very deep but fundamental philosophical ideas about what it means to know, and why it might matter that you know things in different ways. For instance, it is important that you know who your family members are, but it is more important that you think about them in a different way than how you think about your clothes, or a tree or seeing a sunset. Another way of exploring how we understand things is to look at neurobiology and what the mind is.

For a variety of different opinions about this larger topic go here: https://www.smashingsciencecn.org/igcse-chem-additional-resources

Above are two very different views on thought and reason, both extremely famous. Click on them to find out more!
## APPENDIX – Glossary of the Complete iGCSE Syllabus

### 15.1 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><strong>atomic number (Z)</strong></td>
<td>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（2）**原子核中的原子序数；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><strong>chemical bonding</strong></td>
<td>the strong forces that hold atoms (or ions) together in the various structures that chemical substances can form – metallic bonding, covalent bonding and ionic bonding (electrovalent bonding)</td>
<td><strong>化学键</strong>将化学物质可形成的各种结构中的原子（或离子）保持在一起的强键 <strong>金属键</strong>、共价键和离子（电价键）</td>
</tr>
<tr>
<td><strong>compound</strong></td>
<td>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><strong>covalent bond</strong></td>
<td>a chemical bond formed by the sharing of one or more pairs of electrons between two atoms</td>
<td><strong>共价键</strong>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><strong>density</strong></td>
<td>expresses the relationship between the mass of a substance and the volume it occupies: density = mass / volume</td>
<td><strong>密度</strong>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><strong>diatomic molecule</strong></td>
<td>a molecule containing two atoms, for example hydrogen, H2</td>
<td><strong>双原子分子</strong>一种包含两个原子的分子，例如，H2</td>
</tr>
<tr>
<td><strong>electrical conductor</strong></td>
<td>a substance that conducts electricity but is not chemically changed in the process</td>
<td><strong>电导体</strong>在过程中不会发生化学变化的物质</td>
</tr>
<tr>
<td><strong>electron (arrangement) configuration</strong></td>
<td>a shorthand method of describing how electrons are organised by energy levels of an atom</td>
<td><strong>电子（排列）构型</strong>是描述电子按照原子能级组织的简便方法</td>
</tr>
<tr>
<td><strong>electron</strong></td>
<td>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><strong>电子</strong>是质量可忽略且电荷为-1的亚原子粒子；它存在于所有原子中，位于原子核以外的能级</td>
</tr>
<tr>
<td><strong>electrostatic force of attraction</strong></td>
<td>a strong pulling force between particles with opposite charges – such forces are involved in</td>
<td><strong>静电引力</strong>在带相反电荷的粒子之间产生的强大的拉力-这种力与</td>
</tr>
<tr>
<td><strong>element</strong></td>
<td>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><strong>元素</strong>一种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><strong>energy levels (of electrons)</strong></td>
<td>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-电子从靠近原子核的最低开始填充这些能级（或壳层）</td>
</tr>
<tr>
<td><strong>giant ionic structure</strong></td>
<td>a regular arrangement of positive metal ions held together by the electrostatic forces of attraction between positive and negative ions</td>
<td><strong>巨大离子结构</strong>通过正负离子之间的静电吸引力被晶格保持在一起的结构</td>
</tr>
<tr>
<td><strong>giant metallic lattice</strong></td>
<td>a regular arrangement of positive metal ions held together by the mobile “sea” of electrons moving between the ions</td>
<td><strong>巨大的金属晶格</strong>正离子的规则排列通过在离子之间移动的电子“海”中电子之间的静电吸引力保持在一起</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>English</th>
<th>Chinese</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>giant molecular structure</strong> substance where large numbers of atoms are joined by covalent bonds forming a strong lattice structure</td>
<td>巨大的分子结构物质，其中大量原子通过共价键连接而形成坚固的晶格结构</td>
</tr>
<tr>
<td><strong>insulator</strong> substance that does not conduct electricity</td>
<td>不导电的绝缘体物质</td>
</tr>
<tr>
<td><strong>intermolecular forces</strong> the weak attractive forces which act between molecules</td>
<td>分子间作用力作用于分子之间的微弱吸引力</td>
</tr>
<tr>
<td><strong>ionic (electrovalent) bond</strong> a strong electrostatic force of attraction between oppositely charged ions</td>
<td>离子（电价）键在带相反电荷的离子之间形成强大的静电吸引力</td>
</tr>
<tr>
<td><strong>ions</strong> charged particles made from an atom, or groups of atoms (polyatomic ions), by the loss or gain of electrons</td>
<td>离子通过电子的丢失或获得而由一个原子或一组原子（多原子离子）形成的粒子带电</td>
</tr>
<tr>
<td><strong>lattice</strong> a regular three-dimensional arrangement of atoms, molecules or ions in a crystalline solid</td>
<td>将晶体、固体中原子、分子或离子的规则三维排列成晶格</td>
</tr>
<tr>
<td><strong>malleable</strong> a word used to describe the property that metals can be bent and beaten into sheets</td>
<td>可塑性的单词，用来描述金属可以弯曲并打成薄片的特性</td>
</tr>
<tr>
<td><strong>mass number (A)</strong> the total number of protons and neutrons present in the nucleus of an atom</td>
<td>质量数（A）原子核中存在的质子和中子总数</td>
</tr>
<tr>
<td><strong>malleable</strong> a word used to describe the property that metals can be bent and beaten into sheets</td>
<td>可塑性的单词，用来描述金属可以弯曲并打成薄片的特性</td>
</tr>
<tr>
<td><strong>metallic bond</strong> an electrostatic force of attraction between the mobile 'sea' of electrons and the regular array of positive metal ions within a solid metal</td>
<td>金属键是电子的移动“海洋”与固态金属中规则的正金属离子阵列之间的静电吸引力</td>
</tr>
<tr>
<td><strong>molecule</strong> a group of atoms held together by covalent bonds</td>
<td>分子通过共价键结合在一起的一组原子</td>
</tr>
<tr>
<td><strong>neutron</strong> an uncharged subatomic particle present in the nucleus of an atom – a neutron has a mass of 1 relative to a proton</td>
<td>中子原子核中存在的不带电荷的亚原子粒子—中子相对于质子的质量比为1</td>
</tr>
<tr>
<td><strong>non-metals</strong> a class of chemical elements that are typically poor conductors of heat and electricity</td>
<td>非金属-一类化学元素，通常是热和电的不良导体</td>
</tr>
<tr>
<td><strong>nucleon number (A)</strong> the total number of protons and neutrons present in the nucleus of an atom</td>
<td>核子数（A）原子核中存在的质子和中子总数</td>
</tr>
<tr>
<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</td>
<td>原子核（原子的）原子的中心区域，由质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><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><strong>proton number</strong> another name for atomic number</td>
<td>质子数原子数的别称</td>
</tr>
<tr>
<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变</td>
</tr>
<tr>
<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><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><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><strong>valence</strong> the combining power of an atom or group of atoms: in ionic compounds the valency of an atom is equal to its charge; in a covalent molecule the valency of an atom is the number of bonds that a atom makes</td>
<td>共价化合物的电子在离子化合物中相同的电荷；在共价化合物中，原子的化合价是原子形成的键的数量</td>
</tr>
<tr>
<td><strong>balanced chemical (symbol) equation</strong> a summary of a chemical reaction using chemical formulae – the total number of any of the atoms involved in the same on both the reactant and product sides of the equation</td>
<td>平衡化学（符号）方程式，使用化学反应进行化学反应的摘要-涉及的任何原子总是在方程式中的反应物和产物两侧相同</td>
</tr>
<tr>
<td><strong>chemical reaction</strong> 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><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>
<td>溶度衡量溶质溶解在溶剂中的百分数，溶液可以是稀溶液（高比例的溶剂），也可以是浓溶液（高比例的溶质）</td>
</tr>
<tr>
<td><strong>empirical formula</strong> 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><strong>formula (chemical)</strong> 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><strong>hydrated salts</strong> 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离子化合物</td>
</tr>
</tbody>
</table>
4 ionic equation the simplified equation for a reaction involving ionic substances: only those ions which take part in the reaction are shown.

4 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.

4 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).

4 molar mass the mass, in grams, of one mole of a substance.

4 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).

4 mole the measure of amount of substance in chemistry: one mole of a substance has a mass equal to its relative atomic mass or its relative molecular mass. A mole of a substance contains 6.02 × 10²³ (Avogadro constant) atoms, molecules or formula units depending on the substance considered.

4 molecular formula a formula which shows the actual number of atoms of each element present in a molecule of the compound.

4 molecular mass another, less precise, name for relative molecular mass.

4 percentage purity 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

4 percentage yield 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

4 products (in a chemical reaction) the substance(s) produced by a chemical reaction.

4 reactants (in a chemical reaction) the chemical substances that react together in a chemical reaction.

4 relative formula mass (Mr) the sum of all the relative atomic masses of the atoms present in a 'formula unit' of a substance.

4 relative molar mass (Mr) the sum of all the relative atomic masses of the atoms present in a molecule.

4 spectator ions these are present in a chemical reaction but take no part in it. They are not included in ionic equations.

4 standard atom 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

4 standard solution a solution whose concentration is known precisely: it is used to find the concentration of another solution by titration.

4 structural formula 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.

4 symbol (chemical) a single letter, or group of letters, that represents an element in a chemical formula.

4 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.

4 water of crystallisation water included in the structure of certain salts as they crystallise: for example, copper(ii) sulphate pentahydrate (CuSO₄·5H₂O) contains five molecules of water of crystallisation per mole of copper(ii) sulphate.

4 word equation a summary of a chemical reaction using the chemical names of the reactants and products.
halides compounds formed between an element and a halogen; for example, sodium iodide

halogens elements in Group VII of the Periodic Table – generally the most reactive group of non-metals

main-group elements the elements in the outer groups of the Periodic Table (Groups I to VII and 0)

metals a class of chemical elements (and alloys) which have a characteristic shiny appearance and are good conductors of heat and electricity

metals and metalloids some of the properties of metals and some of non-metals; for example, boron and silicon

nonmetal elements elements in Group 0 – a group of very unreactive gases

periodic table a table of elements arranged in order of increasing proton number (atomic number) to show the similarities of the chemical elements with related electron configurations

Periodic Table a table of elements arranged in order of increasing atomic number (atomic number) to show the similarities of the chemical elements with related electron configurations

Periodic Table a table of elements arranged in order of increasing proton number (atomic number) to show the similarities of the chemical elements with related electron configurations

transition metals elements from the central region of the Periodic Table – they are hard, strong, dense metals that form compounds which are often coloured

decomposition (see also thermal decomposition) a type of chemical reaction where a compound breaks down into simpler substances

dehydration a chemical reaction in which water is removed from a compound

drying agent a chemical substance that absorbs water; anhydrous calcium chloride and concentrated sulfuric acid are two examples

fluorination or "scrubber" a tower in which the waste gases from a coal- or oil-fired power station are treated to remove acidic gases such as sulfur dioxide

lime a white solid known chemically as calcium oxide (CaO), produced by heating limestone; it can be used to counteract soil acidity, to manufacture calcium hydroxide (slaked lime) and is also used as a drying agent

limestone a form of calcium carbonate (CaCO₃)

limestone water a solution of calcium hydroxide in water; it is an alkali and is used in the test for carbon dioxide gas

thermal decomposition the breakdown of a compound due to heating

addition polymer a polymer formed by an addition reaction – the monomer molecules must contain a C(=O) double bond

addition reaction a reaction in which a simple molecule adds across the carbon–carbon double bond of an alkene

alcohols (alkanols) a series of organic compounds containing the functional group ROH and the general formula CH₃OH + 1OH

alkanes a series of hydrocarbons with the general formula CnH₂n+2; they are saturated compounds as they have only single bonds between carbon atoms in their structure

alkenes a series of hydrocarbons with the general formula CnH₂n; they are unsaturated molecules as they have a C=C double bond somewhere in the chain

amidase (or peptide link) the link between monomers in a protein or myosin, formed by a condensation reaction between a carboxylic acid group on one monomer and an amine group on the next monomer

amino acids naturally occurring organic compounds which possess both an amino (-NH₂) group and an acid (-COOH) group in the molecule; there are 20 naturally occurring amino acids and they are polymerised in cells to make proteins

biodegradable plastics these are designed to be degraded (decomposed) by bacteria

carbohydrates a group of naturally occurring organic compounds containing carbon, hydrogen and oxygen; the ratio of hydrocarbon to oxygen atoms in the molecules is always 2:1 and they have the general formula Cₓ(H₂O)y

miscellaneous other compounds (as defined by IUPAC)

alkali metal a group of elements (alkali metals) in Group I of the Periodic Table

alkaline earth metals a group of elements (alkaline earth metals) in Group II of the Periodic Table

alkene a series of hydrocarbons with the general formula CₙH₂ₙ; they are unsaturated compounds as they have only single bonds between carbon atoms in their structure

alkane a series of hydrocarbons with the general formula CₙH₂ₙ+2; they are saturated compounds as they have only single bonds between carbon atoms in their structure

alkyl group an alkane group containing one or more carbon atoms

alkane group a class of chemical elements (and alloys) which have a characteristic shiny appearance and are good conductors of heat and electricity

alkene group a class of chemical elements (and alloys) which have a characteristic shiny appearance and are good conductors of heat and electricity

alkane a hydrocarbon which has only single carbon–carbon bonds

alkene an unsaturated hydrocarbon with one or more double carbon–carbon bonds
<table>
<thead>
<tr>
<th>English</th>
<th>Chinese</th>
</tr>
</thead>
<tbody>
<tr>
<td>compounds which contain</td>
<td>化合物，特别是碳氢化合物，它们由碳和氢组成。</td>
</tr>
<tr>
<td>Topic</td>
<td>English</td>
</tr>
<tr>
<td>-------</td>
<td>---------</td>
</tr>
<tr>
<td>15.2</td>
<td>EXTENSION Keywords</td>
</tr>
</tbody>
</table>

- 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* you do.
<table>
<thead>
<tr>
<th>Topic #</th>
<th>English</th>
<th>Chinese</th>
</tr>
</thead>
<tbody>
<tr>
<td>x11</td>
<td>nitrogen fixation the direct use of atmospheric nitrogen in the formation of important compounds of nitrogen; most plants cannot fix nitrogen directly, but bacteria present in the root nodules of certain plants are able to take nitrogen from the atmosphere to form essential protein molecules</td>
<td>固氮直接利用大气中的氮来形成重要的氮化合物；大多数植物不能直接固定氮，但是某些植物根瘤中存在的细菌能够从大气中吸收氮以形成必需的蛋白质分子</td>
</tr>
<tr>
<td>x11</td>
<td>photodegradable plastics polymers designed to degrade under the influence of sunlight</td>
<td>可光降解的塑料聚合物，旨在在日光的影响下分解</td>
</tr>
<tr>
<td>x12</td>
<td>Frasch process the process of obtaining sulfur from sulfur beds below the Earth’s surface; superheated water is pumped down a shaft to liquefy the sulfur, which is then brought to the surface</td>
<td>Frasch处理从地球表面以下的硫层中获取硫的过程；过热水沿井下泵抽，以使硫液化，然后将硫带到地面</td>
</tr>
<tr>
<td>x14</td>
<td>anaerobic decay breakdown of organic matter which takes place in the absence of air by living things</td>
<td>生物在没有空气的情况下发生有机物的厌氧衰减分解</td>
</tr>
<tr>
<td>x14</td>
<td>detergent a soap-like substance, which is used with water to remove dirt and grease from clothes, dishes and other objects</td>
<td>洗涤剂，类似与肥皂的物质，可与水一起使用，以去除衣服、餐具和其他物品上的污垢和油脂</td>
</tr>
<tr>
<td>x14</td>
<td>drug any substance, natural or synthetic, that alters the way in which the body works</td>
<td>服用任何会改变人体工作方式的天然或合成物质</td>
</tr>
<tr>
<td>x14</td>
<td>rancid a term used to describe oxidised organic material (food) – usually involving a bad smell</td>
<td>腐烂的术语，用于描述氧化的有机物质（食物）– 通常涉及难闻的气味</td>
</tr>
<tr>
<td>x14</td>
<td>saponification the name given to the hydrolysis of fats or vegetable oils by hot, concentrated sodium hydroxide solution to produce soap</td>
<td>皂化：通过加热的浓氢氧化钠溶液水解脂肪或植物油以产生肥皂的名称</td>
</tr>
<tr>
<td>x14</td>
<td>soaps substances formed by saponification</td>
<td>皂化皂化物质</td>
</tr>
<tr>
<td>x14</td>
<td>synthesis (see also photosynthesis) a chemical reaction in which a compound is made from its elements</td>
<td>合成（另见光合作用）一种化学反应，其中由其元 素制成化合物</td>
</tr>
</tbody>
</table>
# 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 Number</th>
<th>P1,3, 6 2001-15</th>
<th>P4 2016-18</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7.7</td>
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<td>8.3</td>
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<td>3.1</td>
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</tr>
<tr>
<td>11</td>
<td>7.4</td>
<td>7.1</td>
</tr>
<tr>
<td>12</td>
<td>1.7</td>
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<td>0.0</td>
</tr>
<tr>
<td>14</td>
<td>12.4</td>
<td>20.2</td>
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</tbody>
</table>

### ALL PAPERS Topic Number

<table>
<thead>
<tr>
<th>Paper 2</th>
<th>Paper 4</th>
<th>Paper 6</th>
<th>Totals</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative value %</td>
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<td>50</td>
<td>20</td>
<td>100</td>
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<tr>
<td>Number of marks</td>
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<td>160</td>
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<tr>
<td>Value of each mark/% of iGCSE</td>
<td>0.75</td>
<td>0.63</td>
<td>0.50</td>
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</tr>
<tr>
<td>Time/min</td>
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<td>75</td>
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<tr>
<td>Time per mark/sec</td>
<td>68</td>
<td>56</td>
<td>60</td>
<td>61</td>
</tr>
<tr>
<td>Portion of syllabus examined</td>
<td>C &amp; S</td>
<td>C &amp; S</td>
<td>Core</td>
<td></td>
</tr>
</tbody>
</table>

C = Core  S = Supplement

## 15.4 Topics in Rank Order

<table>
<thead>
<tr>
<th>Topic</th>
<th>Rank ALL Papers</th>
<th>Rank P3: A* Focus</th>
<th>All Syllabus Word Count RANK</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
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<tr>
<td>6</td>
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<td>13</td>
<td>13</td>
</tr>
</tbody>
</table>

Greener = Better; “Words per %...” refers to the words in the syllabus versus weighted marks awarded since w2001

15.5  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 (ANALYSIED 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.**

<table>
<thead>
<tr>
<th>Multiple Choice Paper (B4 2016=P1, after=P2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of all marks awarded for each topic from s2002-w12 and marks per topic for the new P2 (green triangle) s16 to s19</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Topic Number</th>
<th>1</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<th>8</th>
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<th>14</th>
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</thead>
<tbody>
<tr>
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<td>15.0</td>
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<td>P1 2002-12</td>
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<td>12.1</td>
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<td>2.1</td>
<td>12.7</td>
</tr>
</tbody>
</table>
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.)
### 15.5.1 Raw Data Info Used to Make the Graphs

<table>
<thead>
<tr>
<th>Topic</th>
<th>P1 % of Marks</th>
<th>P1 # of Questions</th>
<th>P1 Average marks per Q</th>
<th>P3 % of Marks</th>
<th>P3 # of Questions</th>
<th>P3 Average marks per Q</th>
<th>P6 % of Marks</th>
<th>P6 # of Questions</th>
<th>P6 Average marks per Q</th>
<th>ALL % of Marks (Weighted)</th>
<th>ALL # of Questions</th>
<th>ALL Average marks per Q</th>
<th>Rank Order</th>
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**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.
15.6 Words per topic statistics from the syllabus

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| All Syllabus Word Count RANK | 8    | 2    | 9    | 7    | 11   | 3    | 6    | 10   | 5    | 4    | 12   | 13   | 1    |

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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]
15.7 Papers Used to create the revision resources I use

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