Cambridge Assessment International Education

Interactive

Learner Guide

# Cambridge International AS & A Level Chemistry 9701

For examination from 2022

Cambridge Pathway

# Contents

# About this guide

This guide explains what you need to know about your Cambridge International AS & A Level Chemistry 9701 course and examinations.

This guide will help you to:

- understand what skills you should develop by taking this Cambridge International AS & A Level course
- understand how you will be assessed
- understand what we are looking for in the answers you write
- plan your revision programme
- revise, by providing revision tips and an interactive revision checklist (Section 5).

Following a Cambridge International AS & A Level programme will help you to develop abilities that universities value highly, including a deep understanding of your subject; higher order thinking skills (analysis, critical thinking, problem solving); presenting ordered and coherent arguments; and independent learning and research.

Studying Cambridge International AS & A Level Chemistry will help you to develop a set of transferable skills, including handling data, practical problem-solving and applying the scientific method. You should develop relevant attitudes, such as concern for accuracy and precision, objectivity, integrity, enquiry, initiative and inventiveness.

# Section 1: Syllabus content - what you need to know

This section gives you an outline of the syllabus content for this course. There are five components that can be combined in specific ways (see Section 3). Talk to your teacher to make sure you know which components you will be taking.

| Content section | Assessment component | Topics included |
|---|---|---|
| AS Level subject content | Paper 1 | AS Level subject content:<br>Physical chemistry: topics 1-8<br>Inorganic chemistry: topics 9-12<br>Organic chemistry: topics 13-21<br>Analysis: topic 22 |
| AS Level subject content | Paper 2 | AS Level subject content:<br>Physical chemistry: topics 1-8<br>Inorganic chemistry: topics 9-12<br>Organic chemistry: topics 13-21<br>Analysis: topic 22 |
| Advanced practical skills | Paper 3 | A laboratory-based practical paper focusing on the experimental skills:<br>Manipulation, measurement and observation.<br>Presentation of data and observations.<br>Analysis, conclusions and evaluations |
| A Level subject content | Paper 4 | A Level subject content:<br>Physical chemistry: topics 23-26<br>Inorganic chemistry: topics 27-28<br>Organic chemistry: topics 29-36<br>Analysis: topic 22 |
| Planning, Analysis and Evaluation | Paper 5 | Questions based on the skills of:<br>Planning<br>Analysis<br>Evaluation<br>The questions may be outside the syllabus content. |

Make sure you always check the latest syllabus, which is available from our public website. This will also explain the different combinations of components you can take.

## Prior knowledge

It is recommended that you have completed a course in Chemistry or Co-ordinated Science equivalent to Cambridge IGCSE™ or Cambridge O Level before you begin this course.

## Key concepts

Key concepts are essential ideas that help you to develop a deep understanding of your subject and make links between different aspects of the course. The key concepts for Cambridge International AS & A Level Chemistry are:

- **Atoms and forces**

  Matter is built from atoms interacting and bonding through electrostatic forces. The structure of matter affects its physical and chemical properties, and influences how substances react chemically.

- **Experiments and evidence**

  Chemists use evidence gained from observations and experiments to build models and theories of the structure and reactivity of materials. Theories are tested by further experiments and an appreciation of accuracy and reliability is gained.

- **Patterns in chemical behaviour and reactions**

  Patterns in chemical behaviour can be identified and used to predict the properties of substances. By applying these patterns, useful new substances can be designed and synthetic routes created.

- **Chemical bonds**

  The understanding of how chemical bonds are made and broken by the movement of electrons allows us to predict patterns of reactivity. Appreciation of the strength of chemical bonds leads to the understanding of a material's properties and its uses.

- **Energy changes**

  The energy changes that take place during chemical reactions can be used to predict the extent, feasibility and rate of such reactions. An understanding is gained of why and how chemical reactions happen.

# Section 2: How you will be assessed

Cambridge International AS Level Chemistry makes up the first half of the Cambridge International A Level course in chemistry and provides a foundation for the study of chemistry at Cambridge International A Level.

## About the examinations

There are three routes for Cambridge International AS & A Level Chemistry qualifications:

- AS Level only. Papers 1, 2 and 3
- A Level. Papers 1, 2, 3, 4 and 5, staged over two years.
  Year 1 AS Level Papers 1, 2 and 3. Year 2 A Level Papers 4 and 5
- A Level. Papers 1, 2, 3, 4 and 5, where candidates take all components in the same exam series.

These are summarised in the table. Find out from your teacher which papers you will be taking.

| Route | Paper 1 | Paper 2 | Paper 3 | Paper 4 | Paper 5 |
|---|---|---|---|---|---|
| 1 **AS Level only** (Candidates take all AS components in the same exam series) | ✓ | ✓ | ✓ | | |
| 2 **A Level** (staged over two years) Year 1 AS Level* | ✓ | ✓ | ✓ | | |
| Year 2 Complete the A Level | | | | ✓ | ✓ |
| 3 **A Level** (Candidates take all components in the same exam series) | ✓ | ✓ | ✓ | ✓ | ✓ |

## About the papers

The table gives you further information about the examination papers:

| Component | Time and marks | Questions | Percentage of total mark |
|---|---|---|---|
| Paper 1 | 1 hour 15 minutes<br>40 marks | 40 multiple-choice questions.<br>Questions are based on the AS Level syllabus content. | 31% of the AS Level<br>15.5% of the A Level |
| Paper 2 | 1 hour 15 minutes<br>60 marks | Structured questions.<br>Questions are based on the AS Level syllabus content. | 46% of the AS Level<br>23% of the A Level |
| Paper 3 | 2 hours<br>40 marks | Practical work and structured questions.<br>Questions are based on the experimental skills in the Practical assessment section of the syllabus. | 23% of the AS Level<br>11.5% of the A Level |
| Paper 4 | 2 hours<br>100 marks | Structured questions.<br>Questions are based on the A Level syllabus content; knowledge of material from the AS Level syllabus will be required. | 38.5% of the A Level |
| Paper 5 | 1 hour 15 minutes<br>30 marks | Questions based on the experimental skills of planning, analysis and evaluation. The context of the questions may be outside the syllabus content. | 11.5% of the A Level |

In all the papers you are required to answer all the questions.

# Section 3: What skills will be assessed?

The examiners take account of the following skills areas (**assessment objectives**) in the examinations:

- AO1 Knowledge and understanding
- AO2 Handling, applying and evaluating information
- AO3 Experimental skills and investigations

| Assessment objectives (AO) | What does the AO mean? |
|---|---|
| **AO1** Knowledge and understanding | Demonstrate knowledge and understanding of:<br>• scientific phenomena, facts, laws, definitions, concepts and theories<br>• scientific vocabulary, terminology and conventions (including symbols, quantities and units)<br>• scientific instruments and apparatus, including techniques of operation and aspects of safety<br>• scientific quantities and their determination<br>• scientific and technological applications with their social, economic and environmental implications<br>• reasoned explanations for phenomena, patterns and relationships |
| **AO2** Handling, applying and evaluating information | Handle, apply and manipulate information in words or using other forms of presentation (e.g. symbols, graphical of numerical) to:<br>• locate, select, organise and present information from a variety of sources<br>• translate information from one form to another<br>• manipulate numerical and other data<br>• use information to identify patterns, report trends and draw conclusions<br>• give reasoned explanations for phenomena, patterns and relationships<br>• make predictions and construct arguments to support hypotheses<br>• make sense of new situations<br>• evaluate hypotheses<br>• demonstrate an awareness of the limitations of chemical theories and models<br>• solve problems |
| **AO3** Experimental skills and investigations | Demonstrate the ability to:<br>• plan experiments and investigations<br>• collect, record and present observations, measurements and estimates<br>• analyse and interpret experimental data to reach conclusions<br>• evaluate methods and quality of experimental data, and suggest improvements to experiments |

It is important that you know the different weightings (%) of the assessment objectives, as this affects how the examiner will assess your work.

## Weighting for assessment objectives

The approximate weightings allocated to each of the assessment objectives are summarised below:

| Assessment objective | Weighting at AS Level % | Weighting at A Level % |
|---|---|---|
| AO1 Knowledge and understanding | 40 | 40 |
| AO2 Handling, applying and evaluating information | 40 | 40 |
| AO3 Experimental skills and investigations | 20 | 20 |
| **Total** | 100 | 100 |

## Assessment objectives as a percentage of each component

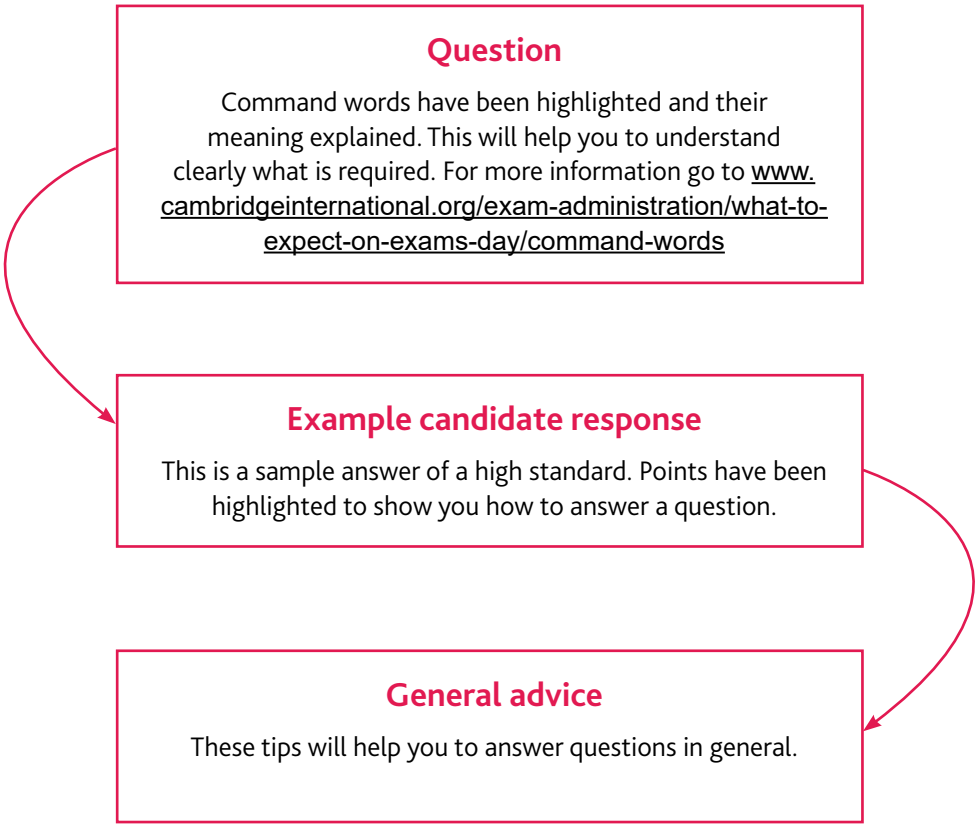
| Assessment objective | Weighting in AS Level % | | | | |
|---|---|---|---|---|---|
| | **Paper 1** | **Paper 2** | **Paper 3** | **Paper 4** | **Paper 5** |
| AO1 Knowledge and understanding | 50 | 50 | 0 | 50 | 0 |
| AO2 Handling, applying and evaluating information | 50 | 50 | 0 | 50 | 0 |
| AO3 Experimental skills and investigations | 0 | 0 | 100 | 0 | 100 |
| **Total** | 100 | 100 | 100 | 100 | 100 |

# Section 4: Example candidate response

This section takes you through an example question and candidate response. It will help you to see how to identify the command words within questions and to understand what is required in your response. Understanding the questions will help you to know what you need to do with your knowledge. For example, you might need to state something, calculate something, find something or show something.

All information and advice in this section is specific to the example question and response being demonstrated. It should give you an idea of how your responses might be viewed by an examiner but it is not a list of what to do in all questions. In your own examination, you will need to pay careful attention to what each question is asking you to do.

This section is structured as follows:



## Question

**3** Calcium and its compounds have a large variety of applications.

**(a)** Calcium metal reacts readily with most acids.

When calcium metal is placed in dilute sulfuric acid, it reacts vigorously at first.

After a short time, a layer of calcium sulfate forms on the calcium metal and the reaction stops. Some of the calcium metal and dilute sulfuric acid remain unreacted.

Suggest an explanation for these observations.

.....

.....

.....

.....

[1]

**Suggest** – apply knowledge and understanding to situations where there are a range of valid responses in order to make proposals/put forward considerations

**(b)** Calcium ethanedioate is formed when calcium reacts with ethanedioic acid, HOOCCOOH. Calcium ethanedioate contains one cation and one anion.

**(i)** State the full electronic configuration of the cation in calcium ethanedioate.

.....

.....

[1]

**State** – express in clear terms

**(ii)** Deduce the charge on the cation.

.....

.....

[1]

**Deduce** – conclude from available information

**(iii)** Draw the fully displayed formula of ethanedioic acid.

[1]

**Draw** – represent the structure or diagram. Here the structure of an ethanedioic acid molecule must be drawn as the displayed formula (rather than structural or skeletal)

**(c)** Calcium chlorate(I), $Ca(ClO)_2$, is used as an alternative to sodium chlorate(I), $NaClO$, in some household products.

**(i)** The chlorate(I) ion is formed when cold aqueous sodium hydroxide reacts with chlorine.

Write an ionic equation for this reaction. State symbols are **not** required.

.....

.....

[1]

**Write** – use knowledge of this reaction to summarise the reaction occurring as an ionic equation in the space provided

**(ii)** The chlorate(I) ion is unstable and decomposes when heated as shown.

$$3ClO^- \rightarrow 2Cl^- + ClO_3^-$$

This reaction can be described as a disproportionation reaction.

Describe what is meant by disproportionation reaction.

.....

**Describe** – state the points of a topic / give characteristics and main features

.....

..... [1]

**(iii)** Deduce the oxidation number of chlorine in each species for the equation in **(c)(ii)**.

Complete the boxes.

**Deduce** – conclude from available information

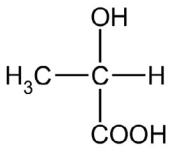
$3ClO^- \rightarrow 2Cl^- + ClO_3^-$

oxidation number of chlorine | +1 | | |

[1]

**(d)** Calcium carbonate reacts with 2-hydroxypropanoic acid to form product **Y**.

2-hydroxypropanoic acid




**Y**

$Ca(CH_3CH(OH)COO)_2$

**Fig. 3.1**

**(i)** Identify the **two** other products of the reaction of 2-hydroxypropanoic acid with calcium carbonate.

.....

**Identify** – name / select / recognise.
The two products can be identified as either names and/or formulae because the question does not ask specifically for the names or the formulae of the two products.

Two possible methods of making 2-hydroxypropanoic acid are shown in Fig. 3.2.

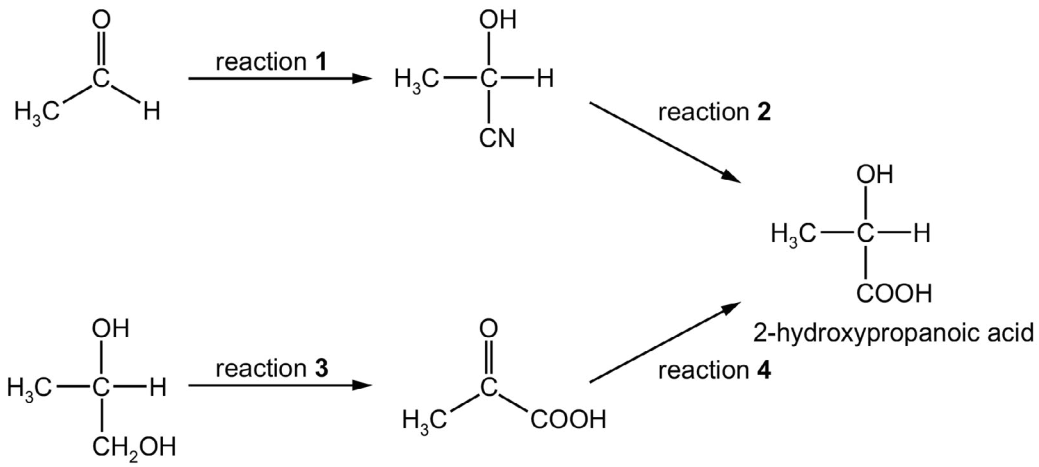



**Fig. 3.2**

**(ii)** State suitable reagents and conditions for reactions **1** and **3**.

reaction **1** .....

reaction **3** .....

**State** – express in clear terms
The reagents lists can be shown as either names or formulae because the question has not specifically asked for either the names or the formulae.

**(iii)** Deduce the type of reaction that occurs in reaction **2**.

..... [1]

**Deduce** – conclude from available information

**(iv)** The reagent for reaction **4** is $NaBH_4$.

Identify the role of $NaBH_4$ in this reaction.

..... [1]

**Identify** – name / select / recognise

**(v)** 2-hydroxypropanoic acid has a chiral centre.

State what is meant by chiral centre.

.....

.....

..... [1]

**State** – express in clear terms

[Total: 15]

## Example candidate response

**3** Calcium and its compounds have a large variety of applications.

**(a)** Calcium metal reacts readily with most acids.

When calcium metal is placed in dilute sulfuric acid, it reacts vigorously at first.

After a short time, a layer of calcium sulfate forms on the calcium metal and the reaction stops. Some of the calcium metal and dilute sulfuric acid remain unreacted.

Suggest an explanation for these observations.

*The layer of calcium sulfate acts as a barrier, so sulfuric acid cannot reach calcium to react.* [1]

(a) Here the candidate gives a plausible explanation of the observations described and the mark is awarded.
1/1

**(b)** Calcium ethanedioate is formed when calcium reacts with ethanedioic acid, HOOCCOOH. Calcium ethanedioate contains one cation and one anion.

**(i)** State the full electronic configuration of the cation in calcium ethanedioate.

$1s^2 2s^2 2p^6 3s^2 3p^6$ [1]

(b)(i) Understanding of the term cation is required to state the electronic configuration of the calcium ion. Calcium is a group 2 element so the ion will have two fewer electrons compared to a calcium atom. The two electrons in the outermost energy shell are lost.
1/1

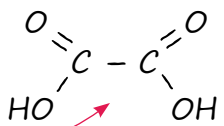
**(ii)** Deduce the charge on the cation.

+2 [1]

(ii) The candidate correctly deduced that when a calcium atom loses two electrons it will make an ion with a charge of +2.
1/1

**(iii)** Draw the fully displayed formula of ethanedioic acid.

(iii) A displayed formula shows the relative placing of the atoms AND the bonds between them.
In this answer the bond is not shown between the O and H of the OH group so the mark is not awarded.
0/1




[1]

**(c)** Calcium chlorate(I), $Ca(ClO)_2$, is used as an alternative to sodium chlorate(I), $NaClO$, in some household products.

**(i)** The chlorate(I) ion is formed when cold aqueous sodium hydroxide reacts with chlorine.

Write an ionic equation for this reaction. State symbols are **not** required.

$Cl_2 + 2OH^- \rightarrow Cl^- + ClO^- + H_2O$ [1]

(c)(i) The correct ionic equation is described for the reaction of chlorine with cold aqueous sodium hydroxide.
The sodium ions are ignored even though they are present in the solution because they are not involved in the reaction; they are spectator ions.
1/1

**(ii)** The chlorate(I) ion is unstable and decomposes when heated as shown.

$$3ClO^- \rightarrow 2Cl^- + ClO_3^-$$

This reaction can be described as a disproportionation reaction.

Describe what is meant by disproportionation reaction.

a reaction where the species like Cl+' in ClO– is both oxidised and reduced [1]

(ii) This is a correct description of the term disproportionation.
1/1

**(iii)** Deduce the oxidation number of chlorine in each species for the equation in **(c)(ii)**.

Complete the boxes.

$3ClO^- \rightarrow 2Cl^- + ClO_3^-$

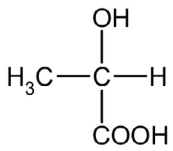
oxidation number of chlorine | +1 | −1 | +5 |

[1]

(iii) Here the oxidation numbers of chlorine in both products have been worked out correctly.
1/1

**(d)** Calcium carbonate reacts with 2-hydroxypropanoic acid to form product **Y**.

2-hydroxypropanoic acid




**Y**

$Ca(CH_3CH(OH)COO)_2$

**Fig. 3.1**

**(i)** Identify the **two** other products of the reaction of 2-hydroxypropanoic acid with calcium carbonate.

*$CO_2$ + water* ..... [1]

(d)(i) Either a correct name OR correct formula can be used to identify each of the two products.
1/1

Two possible methods of making 2-hydroxypropanoic acid are shown in Fig. 3.2.

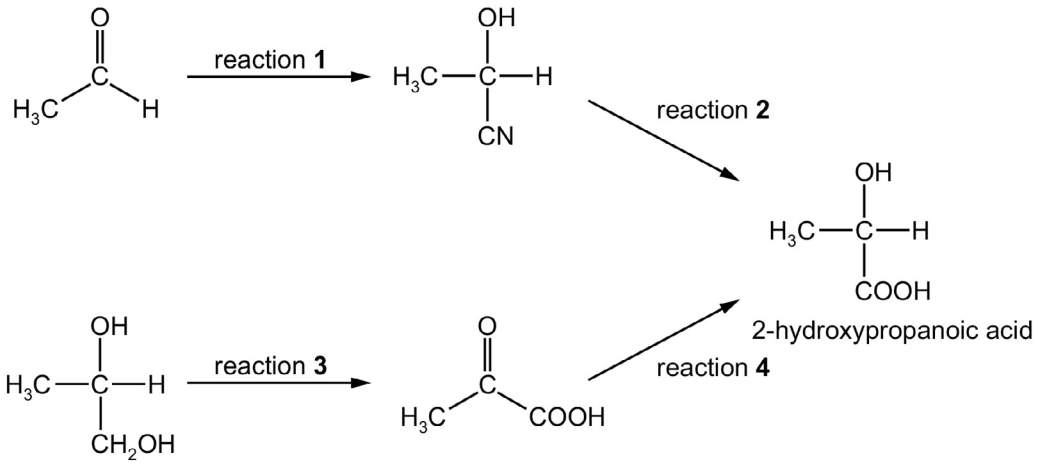



**Fig. 3.2**

**(ii)** State suitable reagents and conditions for reactions **1** and **3**.

reaction **1** *Heat HCN and KCN(aq)* .....

reaction **3** *add acidified $K_2Cr_2O_7$ and heat under reflux* .....

[4]

(ii) In this question the reagent is the chemical name or formula which is added to the organic substance.

The conditions give the additional details which are required for each of the reaction to occur, e.g addition of a specific catalyst (reaction 1 – potassium cyanide) and in acid conditions with potassium dichromate (VI) and reflux.

Both answers are correct.
4/4

**(iii)** Deduce the type of reaction that occurs in reaction **2**.

*hydrolysis / hydration* ..... [1]

(iii) When two or more answers are given and only one answer is required, an incorrect answer contradicts a correct answer and no mark is awarded.

Here 'hydrolysis' is the correct answer – but no mark is awarded because reaction 2 is not a hydration reaction.
0/1

**(iv)** The reagent for reaction **4** is $NaBH_4$.

Identify the role of $NaBH_4$ in this reaction.

*reduction* ..... [1]

(iv) The role of NaBH4 is as a reducing agent because it reduces the carbonyl group to a hydroxy group.

Reduction describes the change which occurs to the carbonyl group but does not answer the question.
0/1

**(v)** 2-hydroxypropanoic acid has a chiral centre.

State what is meant by chiral centre.

*a carbon atom surrounded by 4 different groups*

..... [1]

[Total: 15]

(v) A chiral centre contains 4 different groups bonded to it. Use of the term 'surrounded' rather than 'bonded' is ambiguous so the mark is not awarded.
0/1

Total: 11/15

## General advice

Read all the information given in a question carefully before you start to answer the specific question parts.

Read each question part carefully, noticing the command words and key instructions. You may want to underline them to help.

Make sure your answer is relevant to the question.

Make sure that you cross out an answer which you do not want to be marked.

Always show your working as part of your solution to a calculation question.

Allow a few minutes at the end of the examination to check your work.

# Section 5: Revision

This advice will help you revise and prepare for the examinations. It is divided into general advice and specific advice for each of the papers.

**Use the tick boxes ☐ to keep a record of what you have done, what you plan to do or what you understand.**

## General advice

### Before the examination

- ☐ Find out when the examinations are and plan your revision so you have enough time for each topic. A revision timetable will help you.
- ☐ Find out how long each paper is and how many questions you have to answer.
- ☐ Know the meaning of the command words used in questions and how to apply them to the information given. Highlight the command words in past papers and check what they mean. There is a list in the syllabus available on the syllabus page of the Cambridge International website.
- ☐ Make revision notes; try different styles of notes. Discover what works best for you.
- ☐ Work for short periods then have a break. Revise small sections of the syllabus at a time.
- ☐ Build your confidence by practising questions on each of the topics.
- ☐ Make sure you practise lots of past examination questions so that you are familiar with the format of the examination papers. You could time yourself when doing a paper so that you know how quickly you need to work in the real examination.
- ☐ Look at mark schemes to help you to understand how the marks are awarded for each question.
- ☐ Familiarise yourself with the mathematical requirements you may be expected to use in the examination. Details of this can be found on the mathematical requirements page in the syllabus available on the Cambridge International website.
- ☐ Make sure that you are familiar with the way organic structures should be represented. Details of this can be found on the expected conventions for representing organic structures pages in the syllabus available on the Cambridge International website.
- ☐ Familiarise yourself with the Periodic Table of Elements and the table of important values, constants and standards that will be found at the back of the question paper so that you are aware of all the data available to you in the examination. Details of this can be found in the Data section in the syllabus available on the Cambridge International website. Any other data required to answer specific questions will be given in the question.

### During the examination

- ☐ Read the instructions carefully and answer **all** the questions.
- ☐ Check the number of marks for each question or part question. This helps you to judge how long you should be spending on the response. You don't want to spend too long on some questions and then run out of time at the end.
- ☐ Do not leave out questions or parts of questions. Remember, no answer means no mark.
- ☐ You do not have to answer the questions in the order they are printed in the answer booklet. You may be able to do a later question more easily then come back to an earlier one for another try.
- ☐ Read each question very carefully. Misreading a question can cost you marks:
  - Identify the command words – you could underline or highlight them.
  - Identify the other key words and perhaps underline them too.
  - Identify data and perhaps underline them too.
  - Try to put the question into your own words to understand what it is really asking.
- ☐ Read all parts of a question before starting your answer. Think carefully about what is needed for each part.

- [ ] **Answer the question set**. This is very important!
  - Use your knowledge and understanding.
  - Do not just try all the methods you know. Only use the ones you need to answer the question.
- [ ] Make sure that you have answered everything that a question asks. Sometimes one sentence asks two things, e.g. 'Show that … and hence find …'. It is easy to concentrate on the first request and forget about the second one.
- [ ] Always show your working. Marks are usually awarded for using correct steps in the method even if you make a mistake somewhere.
- [ ] Don't cross out any working until you have replaced it by trying again. Even if you know it's not correct you may still be able to get method marks. If you have made two or more attempts, make sure you cross out all except the one you want marked.
- [ ] Make sure all your numbers are clear, for example make sure your '1' doesn't look like a '7' and a 's' does not look like a '5'.
- [ ] If you need to change a word or a number, or even a sign (+ to – for example), it is better to cross out your work and rewrite it. Don't try to write over the top of your previous work as it will be difficult to read and you may not get the marks.

### Advice for all papers

- [ ] Use correct chemical formulae when referring to specific species.
- [ ] Check all equations are balanced. Include state symbols when appropriate, i.e when asked for or when an equation is describing a specific process where the state of each species is key to the definition, e.g standard enthalpy change of combustion.
- [ ] Learn all key definitions and explanations stated in the syllabus.
- [ ] Always use specific relevant vocabulary when answering a question.
- [ ] Show key steps in reasoning and explanations.
- [ ] Show working in calculations.
- [ ] In a calculation question include relevant units in your answer where appropriate.
- [ ] Make sure that the units of your answer match the units that are asked for in the question.
- [ ] Use the correct number of significant figures for calculated quantities (this should be the same as or one more than the smallest number of significant figures in the provided or experimentally determined data), unless instructed otherwise.

### Advice for Paper 1

- [ ] If you are not certain of the correct answer put a cross against the choices which you know do not answer the question. Then, decide from the remaining choices the one you believe is most likely to be correct.
- [ ] Look at the question carefully. Sometimes some of the choices given are correct statements but they do not answer the question so are not the correct answer.
- [ ] In a calculation question note down your working out on the question paper rather than carry out the calculation in your head.

### Advice for Papers 2 and 4

- [ ] Read the details of each question carefully.
- [ ] Use the space on the paper and the number of marks to be awarded for a question as a guide to the length of answer required.
- [ ] Use appropriate, precise vocabulary in your answers.

### Advice for Paper 3

- [ ] Be familiar with the range of experiments you have looked at during this course including quantitative analysis (titrations, rate experiments, gravimetric experiments, thermometric experiments, gas volume experiments) and qualitative analysis (including the qualitative analysis notes you will have access to in the examination.)

- ☐ Follow the instructions on the paper so that you carry out the correct experiment(s).
- ☐ Record measurements to a suitable level of precision which is compatible with the measuring instrument, e.g. record burette readings to the nearest 0.05 $cm^3$.
- ☐ Record all observations and measurements of raw data to the same level of detail.
- ☐ Be familiar with recording results in tables with appropriate headings and units.
- ☐ Familiarise yourself with the vocabulary often used when describing test tube reactions, e.g. precipitate, slight, dense, soluble, insoluble, solution, excess, and effervescence.

  State all observations including 'no observable change' if there is no obvious change occurs.

  Give precise colour descriptions.

  Where fine discrimination is required, terms such as 'pale' or 'dark' should be used, and comparisons made such as 'darker brown than at three minutes' or 'paler green than with 0.2 mol $dm^{3}$'.
- ☐ Be able to present data appropriately in a graph and draw straight lines or smooth curves of best fit. Consider scale of both axes, labelling of axes, plotting the points accurately and practise drawing lines of best fit.

## Advice for Paper 5

- ☐ Be familiar with the range of experiments you have looked at during the practical course including quantitative analysis (titrations, rate experiments, gravimetric experiments, thermometric experiments, gas volume experiments) and qualitative analysis so that you can draw on this experience to help you answer the questions on this paper.
- ☐ Read all the information that you are given in the examination carefully. All information that you are not required to know but is needed in order to answer the question will be given.
- ☐ Be aware of the details that need to be included if asked to design an experimental investigation of a given problem, including diagrams, flow charts tables and equations.
- ☐ Be familiar with expressing a prediction in the form of a written hypothesis linking independent and dependent variables, or in the form of a graph showing the expected outcome.
- ☐ Use previous experiments to revise how experimental data can be analysed, evaluated and how conclusions can be drawn. (Include drawing lines of best fit on graphs, recognising and explaining anomalous results.)

## Revision checklists

The tables below can be used as a revision checklist: **It doesn't contain all the detailed knowledge you need to know, just an overview.** For more detail see the syllabus and talk to your teacher.

The table headings are explained below:

| Topic | You should be able to | R | A | G | Comments |
|---|---|---|---|---|---|
| These topics are listed in the syllabus. | The second column lists the different sections of each topic described in the syllabus.<br><br>The actual details within these sections can be found as learning outcomes in a copy of the syllabus. | You can use the tick boxes to show when you have revised an item and how confident you feel about it.<br><br>R = RED means you are really unsure and lack confidence; you might want to focus your revision here and possibly talk to your teacher for help<br><br>A = AMBER means you are reasonably confident but need some extra practice<br><br>G = GREEN means you are very confident.<br><br>As your revision progresses, you can concentrate on the RED and AMBER items in order to turn them into GREEN items. You might find it helpful to highlight each topic in red, orange or green to help you prioritise. | | | You can use the 'Comments' column to:<br><br>• add more information about the details for each point<br>• add formulae or notes<br>• include a reference to a useful resource<br>• highlight areas of difficulty or things that you need to talk to your teacher about or look up in a textbook. |

## Papers 1 and 2 (and assumed knowledge for Paper 4)

| Topic | You should be able to | R | A | G | Comments |
|---|---|---|---|---|---|
| 1. Atomic structure | • Particles in the atom and atomic radius | ☐ | ☐ | ☐ | |
| | • Isotopes | ☐ | ☐ | ☐ | |
| | • Electrons, energy levels and atomic orbitals | ☐ | ☐ | ☐ | |
| | • Ionisation energy | ☐ | ☐ | ☐ | |
| 2. Atoms, molecules and stoichiometry | • Relative masses of atoms and molecules | ☐ | ☐ | ☐ | |
| | • The mole and the Avogadro constant | ☐ | ☐ | ☐ | |
| | • Formulae | ☐ | ☐ | ☐ | |
| | • Reacting masses and volumes (of solutions and gases) | ☐ | ☐ | ☐ | |
| 3. Chemical bonding | • Electronegativity and bonding | ☐ | ☐ | ☐ | |
| | • Ionic bonding | ☐ | ☐ | ☐ | |
| | • Metallic bonding | ☐ | ☐ | ☐ | |
| | • Covalent bonding and coordinate (dative covalent) bonding | ☐ | ☐ | ☐ | |
| | • Shapes of molecules | ☐ | ☐ | ☐ | |
| | • Intermolecular forces, electronegativity and bond properties | ☐ | ☐ | ☐ | |
| | • Dot-and-cross diagrams | ☐ | ☐ | ☐ | |

| Topic | You should be able to | R | A | G | Comments |
|---|---|---|---|---|---|
| 4. States of matter | • The gaseous state: ideal and real gases and $pV = nRT$<br>• Bonding and structure | ☐<br>☐ | ☐<br>☐ | ☐<br>☐ | |
| 5. Chemical energetics | • Enthalpy change, $\Delta H$<br>• Hess's Law | ☐<br>☐ | ☐<br>☐ | ☐<br>☐ | |
| 6. Electrochemistry | • Redox processes: electron transfer and changes in oxidation number (oxidation state) | ☐ | ☐ | ☐ | |
| 7. Equilibria | • Chemical equilibria: reversible reactions, dynamic equilibrium<br>• Brønsted–Lowry theory of acids and bases | ☐<br>☐ | ☐<br>☐ | ☐<br>☐ | |
| 8. Reaction kinetics | • Rate of reaction<br>• Effect of temperature on reaction rates and the concept of activation energy<br>• Homogeneous and heterogeneous catalysts | ☐<br>☐<br>☐ | ☐<br>☐<br>☐ | ☐<br>☐<br>☐ | |
| 9. The Periodic Table: chemical periodicity | • Periodicity of physical properties of the elements in Period 3<br>• Periodicity of chemical properties of the elements in Period 3<br>• Chemical periodicity of other elements | ☐<br>☐<br>☐ | ☐<br>☐<br>☐ | ☐<br>☐<br>☐ | |
| 10. Group 2 | • Similarities and trends in the properties of the Group 2 metals, magnesium to barium, and their compounds | ☐ | ☐ | ☐ | |
| 11. Group 17 | • Physical properties of the Group 17 elements<br>• The chemical properties of the halogen elements and the hydrogen halides<br>• Some reactions of the halide ions<br>• The reactions of chlorine | ☐<br>☐<br>☐<br>☐ | ☐<br>☐<br>☐<br>☐ | ☐<br>☐<br>☐<br>☐ | |

| Topic | You should be able to | R | A | G | Comments |
|---|---|---|---|---|---|
| 12. Nitrogen and sulfur | • Nitrogen and sulfur | ☐ | ☐ | ☐ | |
| 13. An introduction to AS Level organic chemistry | • Formulae, functional groups and the naming of organic compounds<br>• Characteristic organic reactions<br>• Shapes of organic molecules; σ and π bonds<br>• Isomerism: structural and stereoisomerism | ☐<br>☐<br>☐<br>☐ | ☐<br>☐<br>☐<br>☐ | ☐<br>☐<br>☐<br>☐ | |
| 14. Hydrocarbons | • Alkanes<br>• Alkenes | ☐<br>☐ | ☐<br>☐ | ☐<br>☐ | |
| 15. Halogen compounds | • Halogenoalkanes | ☐ | ☐ | ☐ | |
| 16. Hydroxy compounds | • Alcohols | ☐ | ☐ | ☐ | |
| 17. Carbonyl compounds | • Aldehydes and ketones | ☐ | ☐ | ☐ | |
| 18. Carboxylic acids and derivatives | • Carboxylic acids<br>• Esters | ☐<br>☐ | ☐<br>☐ | ☐<br>☐ | |
| 19. Nitrogen compounds | • Primary amines<br>• Nitriles and hydroxynitriles | ☐<br>☐ | ☐<br>☐ | ☐<br>☐ | |
| 20. Polymerisation | • Addition polymerisation | ☐ | ☐ | ☐ | |
| 21. Organic synthesis | • Organic synthesis | ☐ | ☐ | ☐ | |
| 22. Analytical techniques | • Infra-red spectroscopy<br>• Mass spectrometry | ☐<br>☐ | ☐<br>☐ | ☐<br>☐ | |

## Paper 4

| Topic | You should be able to | R | A | G | Comments |
|---|---|---|---|---|---|
| 23. Chemical energetics | • Lattice energy and Born-Haber cycles | ☐ | ☐ | ☐ | |
| | • Enthalpies of solution and hydration | ☐ | ☐ | ☐ | |
| | • Entropy change, $\Delta S$ | ☐ | ☐ | ☐ | |
| | • Gibbs free energy change, $\Delta G$ | ☐ | ☐ | ☐ | |
| 24. Electrochemistry | • Electrolysis | ☐ | ☐ | ☐ | |
| | • Standard electrode potentials $E^{\ominus}$; standard cell potentials $E^{\ominus}$ and the Nernst equation | ☐ | ☐ | ☐ | |
| 25. Equilibria | • Acids and bases | ☐ | ☐ | ☐ | |
| | • Partition coefficients | ☐ | ☐ | ☐ | |
| 26. Reaction kinetics | • Simple rate equations, orders of reaction and rate constants | ☐ | ☐ | ☐ | |
| | • Homogeneous and heterogeneous catalysts | ☐ | ☐ | ☐ | |
| 27. Group 2 | • Similarities and trends in the properties of the Group 2 metals, magnesium to barium, and their compounds | ☐ | ☐ | ☐ | |
| 28. Chemistry of transition elements | • General physical and chemical properties of the first row of transition elements, titanium to copper | ☐ | ☐ | ☐ | |
| | • General characteristic chemical properties of the first set of transition elements, titanium to copper | ☐ | ☐ | ☐ | |
| | • Colour of complexes | ☐ | ☐ | ☐ | |
| | • Stereoisomerism in transition element complexes | ☐ | ☐ | ☐ | |
| | • Stability constants, $K^{stab}$ | ☐ | ☐ | ☐ | |

| You should be able to | Ways to practise skills | R | A | G | Comments |
|---|---|---|---|---|---|
| 29. An introduction to A Level organic chemistry | • Formulae, functional groups and the naming of organic compounds<br>• Characteristic organic reactions<br>• Shapes of aromatic organic molecules; σ and π bonds<br>• Isomerism: optical | ☐ | ☐ | ☐ | |
| 30. Hydrocarbons | • Arenes | ☐ | ☐ | ☐ | |
| 31. Halogen compounds | • Halogen compounds | ☐ | ☐ | ☐ | |
| 32. Hydroxy compounds | • Alcohols<br>• Phenol | ☐ | ☐ | ☐ | |
| 33. Carboxylic acids and derivatives | • Carboxylic acids<br>• Esters<br>• Acyl chlorides | ☐ | ☐ | ☐ | |
| 34. Nitrogen compounds | • Primary and secondary amines<br>• Phenylamine and azo compounds<br>• Amides<br>• Amino acids | ☐ | ☐ | ☐ | |
| 35. Polymerisation | • Condensation polymerisation<br>• Predicting the type of polymerisation<br>• Degradable polymers | ☐ | ☐ | ☐ | |

| Topic | You should be able to | R | A | G | Comments |
|---|---|---|---|---|---|
| 36. Organic synthesis | • Organic synthesis | ☐ | ☐ | ☐ | |
| 37. Analytical techniques | • Thin-layer chromatography | ☐ | ☐ | ☐ | |
| | • Gas / liquid chromatography | ☐ | ☐ | ☐ | |
| | • Carbon-13 NMR spectroscopy | ☐ | ☐ | ☐ | |
| | • Proton ($^1$H) NMR spectroscopy | ☐ | ☐ | ☐ | |

## Paper 3

| You should be able to | Ways to practise skills | R | A | G | Comments |
|---|---|---|---|---|---|
| Manipulation, measurement and observation | • set up apparatus and follow instructions | ☐ | ☐ | ☐ | |
| | • collect an appropriate quantity of data using the apparatus | ☐ | ☐ | ☐ | |
| | • make observations and make accurate and consistent measurements | ☐ | ☐ | ☐ | |
| | • make decisions related to the measurements and observations collected, e.g. decide how many tests or observations to perform, identify where repeated readings are appropriate, etc. | ☐ | ☐ | ☐ | |
| Presentation of data and observations | • present numerical data, values or observations in a single table of results with appropriate headings and units | ☐ | ☐ | ☐ | |
| | • record all raw readings of a quantity to the same degree of precision and use a degree of precision compatible with the measuring instrument used | ☐ | ☐ | ☐ | |
| | • record all observations to the same level of detail | ☐ | ☐ | ☐ | |
| | • show working in calculations and key steps in reasoning and use the correct number of significant figures for calculated quantities | ☐ | ☐ | ☐ | |
| | • present data on a graph, when appropriate | ☐ | ☐ | ☐ | |
| Analysis, conclusions and evaluations | • describe the patterns and trends shown by data in tables and graphs | ☐ | ☐ | ☐ | |

| You should be able to | Ways to practise skills | R | A | G | Comments |
|---|---|---|---|---|---|
| | • describe and summarise the key points of a set of observations | | | | |
| | • calculate quantities from data, or calculate the mean from repeated values, or make other appropriate calculations | | | | |
| | • find an unknown value by using coordinates, a point of intersection or intercepts on a graph | | | | |
| | • determine the gradient of a straight-line graph, using two points that are more than half of the length of the axes apart | | | | |
| | • extrapolate the line of a graph | | | | |
| | • draw conclusions from an experiment, considering whether experimental data supports a given hypothesis, and making further predictions | | | | |
| | • draw conclusions from interpretations of observations, data and calculated values | | | | |
| | • make scientific explanations of data, observations and conclusions described | | | | |
| | • identify sources of error and suggest improvements | | | | |

## Paper 5

| You should be able to | Ways to practise skills | R | A | G | Comments |
|---|---|---|---|---|---|
| Planning | • identify a safe and efficient procedure that when followed would lead to a reliable result | | | | |
| | • identify the steps necessary to carry out the procedure | | | | |
| | • identify apparatus that is suitable for carrying out each step of the procedure | | | | |
| | • show an understanding of the risks of a proposed experiment | | | | |
| | • identify the independent and the dependent variable in an experiment | | | | |
| | • express the aim of an experiment in terms of a prediction, and express this in words or in the form of a predicted graph | | | | |
| | • identify any variables that are to be controlled | | | | |

| Topic | You should be able to | R | A | G | Comments |
|---|---|---|---|---|---|
| | • show an understanding of how and why the procedure suggested will be effective | ☐ | ☐ | ☐ | |
| Method | • describe the method to be used when carrying out the experiment to its full conclusion | ☐ | ☐ | ☐ | |
| | • describe the arrangement of apparatus, and the steps in the procedure to be followed in order to collect all relevant data | ☐ | ☐ | ☐ | |
| | • suggest the use of appropriate measuring instruments so that the data are recorded to a suitable precision | ☐ | ☐ | ☐ | |
| | • suggest appropriate volumes and concentrations of reagents | ☐ | ☐ | ☐ | |
| | • describe precautions that should be taken to keep risks to a minimum | ☐ | ☐ | ☐ | |
| | • describe how to vary the independent variable and how the dependent variable is to be measured, and describe how each of the other key variables might be controlled | ☐ | ☐ | ☐ | |
| | • explain how any control experiments might be used to verify that it is the independent variable that is affecting the dependent variable and not some other factor | ☐ | ☐ | ☐ | |
| | • describe the outcome of steps in the procedure where these are relevant to the overall experiment | ☐ | ☐ | ☐ | |
| | • draw up appropriately headed tables for data to be recorded and describe how the data might be used in order to reach a conclusion | ☐ | ☐ | ☐ | |
| | • describe standard laboratory practice when carrying out quantitative determinations | ☐ | ☐ | ☐ | |
| Analysis, conclusions and evaluations | • identify the calculations and means of data presentation that are necessary to be able to draw conclusions from provided data | ☐ | ☐ | ☐ | |
| | • use calculations to enable simplification or explanation of data, including calculation of mean, percentage and percentage gain or loss | ☐ | ☐ | ☐ | |
| | • use tables and graphs to draw attention to the key points in quantitative data, including the variability of data | ☐ | ☐ | ☐ | |
| | • analyse data to draw appropriate conclusions | ☐ | ☐ | ☐ | |

| You should be able to | Ways to practise skills | R | A | G | Comments |
|---|---|---|---|---|---|
| | • plot an appropriate graph from provided or calculated data | ☐ | ☐ | ☐ | |
| | • plot a graph of $y$ against $x$ and use the graph to find the values of $m$ and $c$ in an equation of the form $y = mx + c$ | ☐ | ☐ | ☐ | |
| | • suggest appropriate axes from a range of data values | ☐ | ☐ | ☐ | |
| | • calculate the percentage error of a measurement | ☐ | ☐ | ☐ | |
| | • calculate quantities from raw data | ☐ | ☐ | ☐ | |
| | • draw a conclusion from an investigation, providing a detailed description of the key features of the data and analyses, and considering whether experimental data support the conclusion reached | ☐ | ☐ | ☐ | |
| | • make detailed scientific explanations of the data, analyses and conclusion described | ☐ | ☐ | ☐ | |
| | • make further predictions and suggest improvements | ☐ | ☐ | ☐ | |
| | • conclude whether errors in experimentally obtained data could be accounted for by a measurement error or by other factors | ☐ | ☐ | ☐ | |
| | • identify anomalous values in provided data, suggest possible explanations for anomalous readings and suggest appropriate means of dealing with such anomalies | ☐ | ☐ | ☐ | |
| | • identify the extent to which provided readings have been adequately replicated and the benefit of this | ☐ | ☐ | ☐ | |
| | • describe the adequacy of the range of data provided | ☐ | ☐ | ☐ | |
| | • use provided information to assess the extent to which selected variables have been effectively controlled | ☐ | ☐ | ☐ | |
| | • identify and explain the weaknesses of the experimental procedure used | ☐ | ☐ | ☐ | |
| | • suggest and explain the effect that a change in the concentrations of reagents or the conditions used for the experiment might have on the results obtained | ☐ | ☐ | ☐ | |

| Topic | You should be able to | R | A | G | Comments |
|---|---|---|---|---|---|
| | • suggest the consequences that the incorrect use of apparatus might have on the results obtained | ☐ | ☐ | ☐ | |
| | • explain that data that obey a line of best fit are reliable because there are no anomalous points | ☐ | ☐ | ☐ | |
| | • comment on the validity of data with regards to their suitability to prove or disprove a prediction | ☐ | ☐ | ☐ | |
| | • identify instances where additional readings being taken during the experiment would be advantageous in order to give a more comprehensive range of values | ☐ | ☐ | ☐ | |
| | • draw together all available information to make judgements about the reliability of the investigation and the trustworthiness of its outcomes | ☐ | ☐ | ☐ | |
| | • comment on the quality of data and state whether or not the data support a prediction | ☐ | ☐ | ☐ | |
| | • use evaluations and provided information to make informed judgements on the confidence with which conclusions may be drawn | ☐ | ☐ | ☐ | |

# Section 6: Useful resources

The resources listed below will help you to revise and study for your Cambridge International AS & A Level Chemistry course.

These resources have not been through the Cambridge quality assurance process but have been found suitable for use with various parts of the syllabus. This list includes website links providing direct access to internet resources. Cambridge is not responsible for the accuracy or content of information contained in these resources. The inclusion of a link to an external website should not be understood to be an endorsement of that website or the site's owners (or their products/services).

www.youtube.com/channel/UCPtWS4fCi25YHw5SPGdPz0g
This link takes you to a series of video tutorials that explain some of the concepts found in A Level Chemistry. There are many videos to choose from including, 'The Mole', 'Calculations Using the Ideal Gas Equation', 'Kp-Gas Equilibria' and 'Nomenclature (branched molecules).'

www.periodicvideos.com/
For general interest and background knowledge this site, produced by the University of Nottingham, shows short videos about specific elements in the Periodic Table.

https://chemguide.co.uk/
This site contains details relevant to UK AS & A Level Chemistry courses and presently a section specific to the previous Cambridge International AS & A Level Chemistry courses. This has useful revision topics on Isomerism and Organic mechanisms, including a topic on 'Using curly arrows in reaction mechanisms'.

You can also find a resource list, including endorsed resources to support Cambridge International AS & A Level Chemistry on our public website [here]

Endorsed resources have been written to be closely aligned to the syllabus they support, and have been through a detailed quality assurance process. All textbooks endorsed by Cambridge International for this syllabus are the ideal resource to be used alongside this Learner Guide.

In addition to reading the syllabus, you should refer to the past and specimen papers.

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