

GCSE

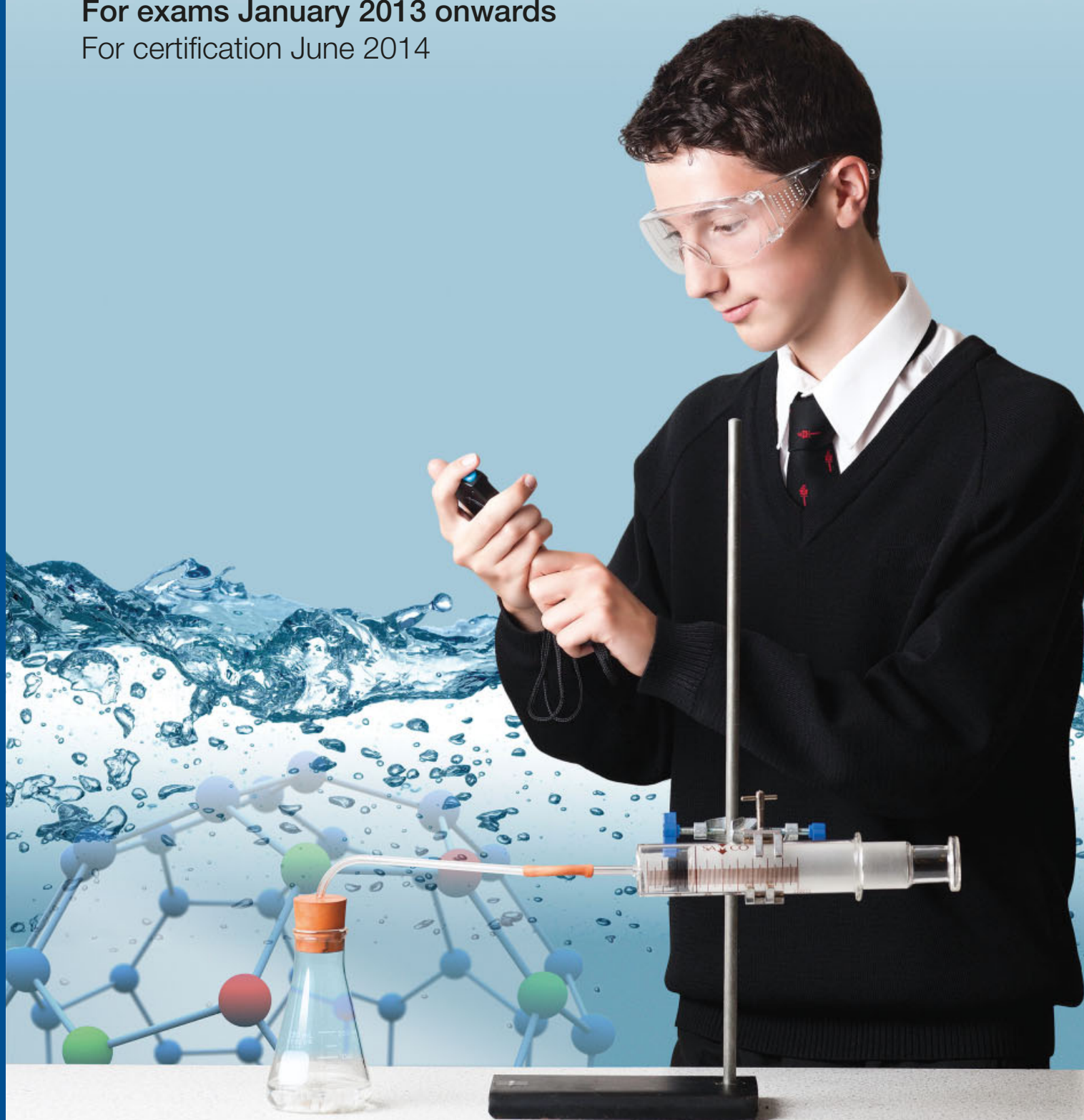
Specification

Chemistry M (modular)

For schools outside England

For exams January 2013 onwards

For certification June 2014





GCSE

Specification

Chemistry M (modular)

4602

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Introduction

1.1 Why choose AQA?

We, AQA, are the United Kingdom's favourite awarding body and more candidates get their academic qualifications from us than from any other body. But why are we so popular?



We understand the different requirements of each subject by working with teachers. Our GCSEs:

- help candidates to achieve their full potential
- are relevant for today's challenges
- are manageable for schools and colleges
- are easy for candidates of all levels of ability to understand
- lead to accurate results, delivered on time
- are affordable and value for money.

We provide a wide range of support services for teachers, including:

- access to subject departments
- training for teachers, including practical teaching strategies and methods that work, presented by senior examiners
- individual support for Controlled Assessment
- 24-hour support through our website and online with **Ask AQA**
- past question papers and mark schemes
- a wide range of printed and electronic resources for teachers and candidates
- free online results analysis, with Enhanced Results Analysis.

We are an educational charity focused on the needs of the learner. All our income is spent on improving the quality of our specifications, examinations and support services. We don't aim to profit from education, we want you to.

If you are already a customer we thank you for your support. If you are thinking of joining us we look forward to welcoming you.

1.2 Why choose GCSE Chemistry M (modular)?

GCSE Chemistry M (modular) enables you to provide a Key Stage 4 chemistry course for learners of any ability, whether they intend to study science further or not. The specification has three chemistry teaching and learning units and a Controlled Assessment unit. The model of Controlled Assessment, Investigative Skills Assignment (ISA), is straightforward and the previous version proved popular with teachers. This course provides a firm foundation for progression to AS and A level Chemistry. GCSE Chemistry M (modular) is identical in subject content to GCSE Chemistry but is assessed in a modular way. Examinations in GCSE Chemistry M (modular) are not available in England.

During the development of our specifications, we have been careful to ensure natural progression from KS3 and we have paid attention to the Assessing Pupils' Progress (APP) approach developed by QCDA and the National Strategies. In Unit 4, we have signposted the assessment focus threads to match those used in KS3.

When our science AS and A-levels were developed for first teaching from September 2008, we were very careful to ensure that there was no 'gap' so that learners could easily progress from KS4. We used the same model of internal assessment (ISAs). Research into the outcomes of learners at GCSE and A-level has shown that we were successful in ensuring a smooth transition. A-levels are due to be redeveloped to follow from this GCSE development, and we will continue to ensure our portfolio of specifications offers good progression routes.

GCSE Chemistry M (modular) is one of many qualifications that AQA offers for Key Stage 4. AQA's range, which includes GCSEs, Diplomas and Entry Level qualifications, enables teachers to select and design appropriate courses for all learners.

In addition to this specification and the associated specimen papers, we offer a wide range of related support and resources for teachers, much of it free. This includes:

- Preparing to Teach meetings
- on-line schemes of work
- ideas for practical work including worksheets and technician guidance
- practice tests for homework
- our Enhanced Results Analysis service.

This support is accessible through a web-based portal called *The Science Lab*.

1.3 How do I start using this specification?

To ensure you receive all the teaching and examination material, it is important that the person responsible for making the decision to teach AQA informs both AQA and their Examinations Officer.

Step One

To confirm you will be teaching this specification please sign up to teach and complete the online form. You will then receive your free GCSE Sciences welcome pack(s) that contains teaching and support material.

Step Two

Inform your Examinations Officer of your choice to ensure you receive all your examination material. Your Exams Officer will make sure that your centre is registered with AQA and will complete the *Intention to Enter and Estimated Entries* when required to do so.

If your centre has not used AQA for any examinations in the past, please contact our centre approval team at centreapproval@aqa.org.uk

1.4 How can I find out more?

You can choose to find out more about this specification or the services that AQA offers in a number of ways.

Ask AQA

We provide 24-hour access to useful information and answers to the most commonly asked questions at www.aqa.org.uk/askaqa

If the answer to your question is not available, you can submit a query through **Ask AQA** and we will respond within two working days.

Speak to your subject team

You can talk directly to the GCSE Sciences subject team about this specification on **01483 477 756** or e-mail science-gcse@aqa.org.uk

Teacher Support

Details of the full range of our Teacher Support and CPD courses are available on our website at www.aqa.org.uk/qual/cpd

There is also a link to our fast and convenient online booking system for all of our courses at coursesandevents.aqa.org.uk/training

Latest information online

You can find out more including the latest news, how to register to use Enhanced Results Analysis, support and downloadable resources on our website at www.aqa.org.uk

Specification at a Glance

Unit 1: Chemistry 1

Written paper – **1 hour**

60 marks – **25 %**

Structured and closed questions

At least one question assessing Quality of Written Communication in a science context.



Unit 2: Chemistry 2

Written paper – **1 hour**

60 marks – **25 %**

Structured and closed questions

At least one question assessing Quality of Written Communication in a science context.



Unit 3: Chemistry 3

Written paper – **1 hour**

60 marks – **25 %**

Structured and closed questions

At least one question assessing Quality of Written Communication in a science context.



Unit 4: Controlled Assessment

Investigative Skills Assignment – two written assessments plus one or two lessons for practical work and data processing

50 marks – **25 %**

Controlled Assessment:

- we set the ISAs and send you all the information before the course starts
- you choose which of several ISAs to do and when
- your candidates do the ISA test in class time
- you mark their tests using marking guidance from us
- we moderate your marks.

Examinations in this subject are not available in England

Subject Content

3.1 Introduction to Subject Content

The subject content of this specification is presented in five sections:

- How Science Works
- the three sections of substantive content, Chemistry 1, Chemistry 2, Chemistry 3
- and the Controlled Assessment (Unit 4).

It is intended that the How Science Works content is integrated and delivered not only through the Controlled Assessment but also through the context of the content of **Chemistry 1**, **Chemistry 2** and **Chemistry 3**.

The organisation of each sub-section of the substantive content is designed to facilitate this approach. Each of the sub-sections of Chemistry 1, Chemistry 2 and Chemistry 3 starts with the statement:

‘Candidates should use their skills, knowledge and understanding to:’.

This introduces a number of activities, for example:

- **evaluate the impact on the environment of burning hydrocarbon fuels.**

These activities are intended to enable candidates to develop the skills, knowledge and understanding of How Science Works.

Other aspects of the skills, knowledge and understanding of How Science Works will be better developed through investigative work and it is expected that teachers will adopt a practical enquiry approach to the teaching of many topics.

The subject content is presented in two columns. The left-hand column lists the content that needs to be delivered. The right-hand column contains guidance and expansion of the content to aid teachers in delivering it and gives further details on what will be examined.

At the end of each section there is a list of ideas for investigative practical work that could be used to help candidates develop their practical enquiry skills to understand and engage with the content.

Opportunities to carry out practical work should be provided in the context of each section. These opportunities should allow candidates to:

- use their knowledge and understanding to pose scientific questions and define scientific problems
- plan and carry out investigative activities, including appropriate risk management, in a range of contexts
- collect, select, process, analyse and interpret both primary and secondary data to provide evidence
- evaluate their methodology, evidence and data.

In the written papers, questions will be set that examine How Science Works in chemistry contexts.

Examination questions will use examples that are both familiar and unfamiliar to candidates. All applications will use the knowledge and understanding developed through the substantive content.

Tiering of subject content

In this specification there is additional content for Higher Tier candidates. This is denoted in the subject content in **bold type** and annotated as **HT only** in Sections 3.3 to 3.5.



3.2 How Science Works

This section is the content underpinning the science that candidates need to know and understand. Candidates will be tested on How Science Works in **both** the written papers and the Controlled Assessment.

The scientific terms used in this section are clearly defined by the ASE in *The Language of Measurement: Terminology used in school science investigations* (Association for Science Education, 2010). Teachers should ensure that they, and their candidates, are familiar with these terms. Definitions of the terms will **not** be required in assessments, but candidates will be expected to use them correctly.

The thinking behind the doing

Science attempts to explain the world in which we live. It provides technologies that have had a great impact on our society and the environment. Scientists try to explain phenomena and solve problems using evidence. The data to be used as evidence must be repeatable, reproducible and valid, as only then can appropriate conclusions be made.

A scientifically literate person should, amongst other things, be equipped to question, and engage in debate on, the evidence used in decision-making.

The repeatability and the reproducibility of evidence refers to how much we trust the data. The validity of evidence depends on these, as well as on whether the research answers the question. If the data is not repeatable or reproducible the research cannot be valid.

To ensure the repeatability, reproducibility and validity of evidence, scientists consider a range of ideas that relate to:

- how we observe the world
- designing investigations so that patterns and relationships between variables may be identified
- making measurements by selecting and using instruments effectively
- presenting and representing data
- identifying patterns, relationships and making suitable conclusions.

These ideas inform decisions and are central to science education. They constitute the 'thinking behind the doing' that is a necessary complement to the subject content of biology, chemistry and physics.

Fundamental ideas

Evidence must be approached with a critical eye. It is necessary to look closely at how measurements have been made and what links have been established. Scientific evidence provides a powerful means of forming opinions. These ideas pervade all of How Science Works.

- It is necessary to distinguish between opinion based on valid, repeatable and reproducible evidence and opinion based on non-scientific ideas (prejudices, whim or hearsay).
- Scientific investigations often seek to identify links between two or more variables. These links may be:
 - causal, in that a change in one variable causes a change in another
 - due to association, in that changes in one variable and a second variable are linked by a third variable
 - due to chance occurrence.
- Evidence must be looked at carefully to make sure that it is:
 - repeatable
 - reproducible
 - valid.

Observation as a stimulus to investigation

Observation is the link between the real world and scientific ideas. When we observe objects, organisms or events we do so using existing knowledge. Observations may suggest hypotheses that can be tested.

- A hypothesis is a proposal intended to explain certain facts or observations.
- A prediction is a statement about the way something will happen in the future.
- Observations can lead to the start of an investigation, experiment or survey. Existing models can be used creatively to suggest explanations for observations (hypotheses). Careful observation is necessary before deciding which variables are the most important. Hypotheses can then be used to make predictions that can be tested.
- Data from testing a prediction can support or refute the hypothesis or lead to a new hypothesis.
- If the hypotheses and models we have available to us do not completely match our data or observations, we need to check the validity of our observations or data, or amend the models.



Designing an investigation

An investigation is an attempt to determine whether or not there is a relationship between variables. Therefore it is necessary to identify and understand the variables in an investigation. The design of an investigation should be scrutinised when evaluating the validity of the evidence it has produced.

- An independent variable is one that is changed or selected by the investigator. The dependent variable is measured for each change in the independent variable.
- For a measurement to be valid it must measure only the appropriate variable.
- A fair test is one in which only the independent variable affects the dependent variable, as all other variables are kept the same. These are called control variables.
- When using large-scale survey results, it is necessary to select data from conditions that are similar.
- Control groups are often used in biological and medical research to ensure that observed effects are due to changes in the independent variable alone.
- Care is needed in selecting values of variables to be recorded in an investigation. A trial run will help identify appropriate values to be recorded, such as the number of repeated readings needed and their range and interval.

- An accurate measurement is one that is close to the true value.
- The design of an investigation must provide data with sufficient precision to form a valid conclusion.

Making measurements

When making measurements we must consider such issues as inherent variation due to variables that have not been controlled, human error and the characteristics of the instruments used. Evidence should be evaluated with the repeatability and validity of the measurements that have been made in mind.

- There will always be some variation in the actual value of a variable, no matter how hard we try to repeat an event.
- The resolution of an instrument refers to the smallest change in a value that can be detected.
- Even when an instrument is used correctly, human error may occur; this could produce random differences in repeated readings or a systematic shift from the true value.
- Random error can result from inconsistent application of a technique. Systematic error can result from consistent misapplication of a technique.
- Any anomalous values should be examined to try to identify the cause and, if a product of a poor measurement, ignored.

Presenting data

To explain the relationship between two or more variables, data may be presented in such a way as to make the patterns more evident. There is a link between the type of graph used and the type of variable represented. The choice of graphical representation depends upon the type of variable represented.

- The range of the data refers to the maximum and minimum values.
- The mean (or average) of the data refers to the sum of all the measurements divided by the number of measurements taken.
- Tables are an effective means of displaying data but are limited in how they portray the design of an investigation.
- Bar charts can be used to display data in which one of the variables is categorical.
- Line graphs can be used to display data in which both the independent and dependent variables are continuous.
- Scattergrams can be used to show an association between two variables.

Using data to draw conclusions

The patterns and relationships observed in data represent the behaviour of the variables in an investigation. However, it is necessary to look at patterns and relationships between variables with the limitations of the data in mind in order to draw conclusions.

- Patterns in tables and graphs can be used to identify anomalous data that require further consideration.
- A line of best fit can be used to illustrate the underlying relationship between variables.
- Conclusions must be limited by, and not go beyond, the data available.

Evaluation

In evaluating a whole investigation the repeatability, reproducibility and validity of the data obtained must be considered.

Societal aspects of scientific evidence

A judgement or decision relating to social-scientific issues may not be based on evidence alone, as other societal factors may be relevant.

- Evidence must be scrutinised for any potential bias of the experimenter, such as funding sources or allegiances.
- Evidence can be accorded undue weight, or dismissed too lightly, simply because of its political significance. If the consequences of the evidence could provoke public or political disquiet, the evidence may be downplayed.
- The status of the experimenter may influence the weight placed on evidence; for instance, academic or professional status, experience and authority.
- Scientific knowledge gained through investigations can be the basis for technological developments.
- Developments in science and technology have ethical, social, economic or environmental consequences, which should always be taken into account when evaluating the impacts of any new developments.

- Advancements in science can have ethical implications. The effects of these must be taken into account in a balanced way to facilitate decision making.
- Decisions are made by individuals and by society on issues relating to science and technology.

Limitations of scientific evidence

Science can help us in many ways but it cannot supply all the answers.

- We are still finding out about things and developing our scientific knowledge.
- There are some questions that we cannot answer, maybe because we do not have enough repeatable, reproducible and valid evidence.
- There are some questions that science cannot answer directly. These tend to be questions where beliefs, opinions and ethics are important.



3.3 Unit 1: Chemistry 1

Throughout this unit candidates will be expected to write word equations for reactions specified. **Higher Tier candidates will also be expected to write and balance symbol equations for reactions specified throughout the unit.**

C1.1 The fundamental ideas in chemistry

Atoms and elements are the building blocks of chemistry. Atoms contain protons, neutrons and electrons. When elements react they produce compounds.

C1.1.1 Atoms

- a) All substances are made of atoms. A substance that is made of only one sort of atom is called an element. There are about 100 different elements. Elements are shown in the periodic table. The groups contain elements with similar properties.

Additional guidance:

Candidates should understand where metals and non-metals appear in the periodic table.

- b) Atoms of each element are represented by a chemical symbol, eg O represents an atom of oxygen, and Na represents an atom of sodium.

Additional guidance:

Knowledge of the chemical symbols for elements other than those named in the specification is **not** required.

- c) Atoms have a small central nucleus, which is made up of protons and neutrons and around which there are electrons.

- d) The relative electrical charges are as shown:

Name of particle	Charge
Proton	+1
Neutron	0
Electron	-1

- e) In an atom, the number of electrons is equal to the number of protons in the nucleus. Atoms have no overall electrical charge.

- f) All atoms of a particular element have the same number of protons. Atoms of different elements have different numbers of protons.

Additional guidance:

- g) The number of protons in an atom of an element is its atomic number. The sum of the protons and neutrons in an atom is its mass number.

Candidates will be expected to calculate the number of each sub-atomic particle in an atom from its atomic number and mass number.

- h) Electrons occupy particular energy levels. Each electron in an atom is at a particular energy level (in a particular shell). The electrons in an atom occupy the lowest available energy levels (innermost available shells). Candidates may answer questions in terms of either energy levels or shells.

Additional guidance:

Candidates should be able to represent the electronic structure of the first 20 elements of the periodic table in the following forms:

**C1.1.2 The periodic table**

- a) Elements in the same group in the periodic table have the same number of electrons in their highest energy level (outer electrons) and this gives them similar chemical properties.
- b) The elements in Group 0 of the periodic table are called the noble gases. They are unreactive because their atoms have stable arrangements of electrons.

Additional guidance:

Knowledge is limited to the reactions of Group 1 elements with water and oxygen.

Candidates are **not** required to know of trends within each group in the periodic table, but should be aware of similarities between the elements within a group.

Candidates should know that the noble gases have eight electrons in their outer energy level, except for helium, which has only two electrons.

C1.1.3 Chemical reactions

- a) When elements react, their atoms join with other atoms to form compounds. This involves giving, taking or sharing electrons to form ions or molecules. Compounds formed from metals and non-metals consist of ions. Compounds formed from non-metals consist of molecules. In molecules the atoms are held together by covalent bonds.
- b) Chemical reactions can be represented by word equations or by symbol equations.
- c) No atoms are lost or made during a chemical reaction so the mass of the products equals the mass of the reactants.

Additional guidance:

Further details of the types of bonding are **not** required.

Candidates should know that metals lose electrons to form positive ions, whereas non-metals gain electrons to form negative ions. Knowledge of such transfers is limited to single electrons.

Candidates should be able to write word equations for reactions in the specification. The ability to interpret given symbol equations in terms of numbers of atoms is required.

Higher Tier candidates should be able to balance symbol equations.

Knowledge and understanding of masses in chemical reactions is limited to conservation of mass. Calculations based on relative atomic masses are **not** required but candidates should be able to calculate the mass of a reactant or product from information about the masses of the other reactants and products in the reaction.

Suggested ideas for practical work to develop skills and understanding include the following:

- modelling of atoms (using physical models or computer simulations) to illustrate chemical reactions at the atomic level
- precipitation reactions, such as lead nitrate with potassium iodide, to show conservation of mass.

C1.2 Limestone and building materials

Rocks provide essential building materials. Limestone is a naturally occurring resource that provides a starting point for the manufacture of cement and concrete.

Candidates should use their skills, knowledge and understanding to:

- consider and evaluate the environmental, social and economic effects of exploiting limestone and producing building materials from it
- evaluate the developments in using limestone, cement and concrete as building materials, and their advantages and disadvantages over other materials.

Additional guidance:

Candidates should know that limestone is needed for buildings and that the positive benefits of using this material should be considered against the negative aspects of quarrying.

Knowledge of building materials is limited to limestone, cement and concrete.

Knowledge of particular developments is **not** required, but information may be supplied in examination questions for candidates to evaluate.

Knowledge of the properties of other building materials is **not** required, but candidates may be provided with information about materials such as timber, stone, glass and steels in the examination so that they can make comparisons about their uses.

C1.2.1 Calcium carbonate

- Limestone, mainly composed of the compound calcium carbonate (CaCO_3), is quarried and can be used as a building material.
- Calcium carbonate can be decomposed by heating (thermal decomposition) to make calcium oxide and carbon dioxide.

- The carbonates of magnesium, copper, zinc, calcium and sodium decompose on heating in a similar way.

Additional guidance:

Knowledge and understanding of metal carbonates is limited to metal carbonates decomposing on heating to give carbon dioxide and the metal oxide.

Candidates should be aware that not all carbonates of metals in Group 1 of the periodic table decompose at the temperatures reached by a Bunsen burner.

- Calcium oxide reacts with water to produce calcium hydroxide, which is an alkali that can be used in the neutralisation of acids.

Knowledge of the common names quicklime and slaked lime is **not** required.

e) A solution of calcium hydroxide in water (limewater) reacts with carbon dioxide to produce calcium carbonate. Limewater is used as a test for carbon dioxide. Carbon dioxide turns limewater cloudy.

f) Carbonates react with acids to produce carbon dioxide, a salt and water. Limestone is damaged by acid rain.

g) Limestone is heated with clay to make cement. Cement is mixed with sand to make mortar and with sand and aggregate to make concrete.

Additional guidance:

Candidates should be familiar with using limewater to test for carbon dioxide gas.

The reaction of carbonates with acids is limited to the reactions of magnesium, copper, zinc, calcium and sodium.

Suggested ideas for practical work to develop skills and understanding include the following:

- investigation of the limestone cycle: decomposition of CaCO_3 to give CaO , reaction with water to give Ca(OH)_2 , addition of more water and filtering to give limewater and use of limewater to test for CO_2
- thermal decomposition of CaCO_3 to show limelight
- honeycomb demonstration: heat sugar syrup mixture to 150°C and add sodium bicarbonate
- making concrete blocks in moulds, investigation of variation of content and carrying out strength tests
- design and carry out an investigation of trends in the thermal decomposition of metal carbonates
- investigation of the reaction of carbonates with acids.

C1.3 Metals and their uses

Metals are very useful in our everyday lives. Ores are naturally occurring rocks that provide an economic starting point for the manufacture of metals. Iron ore is used to make iron and steel. Copper can be easily extracted but copper-rich ores are becoming scarce so new methods of extracting copper are being developed. Aluminium and titanium are useful metals but are expensive to produce. Metals can be mixed together to make alloys.

Candidates should use their skills, knowledge and understanding to:

- consider and evaluate the social, economic and environmental impacts of exploiting metal ores, of using metals and of recycling metals
- evaluate the benefits, drawbacks and risks of using metals as structural materials.

Additional guidance:

Candidates should know that metal ores are obtained by mining and that this may involve digging up and processing large amounts of rock.

Knowledge and understanding of obtaining, using and recycling metals is limited to the metals named in the subject content.

Knowledge and understanding of the uses and properties of metals and alloys is limited to those specified in the subject content. Information may be given in examination questions so that candidates can evaluate their uses.

C1.3.1 Extracting metals

- a) Ores contain enough metal to make it economical to extract the metal. The economics of extraction may change over time.
- b) Ores are mined and may be concentrated before the metal is extracted and purified.
- c) Unreactive metals such as gold are found in the Earth as the metal itself but most metals are found as compounds that require chemical reactions to extract the metal.

Additional guidance:

Knowledge of specific examples is **not** required. Data may be provided in examination questions for candidates to analyse.

Knowledge of specific examples other than those given below is **not** required.

- d) Metals that are less reactive than carbon can be extracted from their oxides by reduction with carbon, for example iron oxide is reduced in the blast furnace to make iron.
- e) Metals that are more reactive than carbon, such as aluminium, are extracted by electrolysis of molten compounds. The use of large amounts of energy in the extraction of these metals makes them expensive.
- f) Copper can be extracted from copper-rich ores by heating the ores in a furnace (smelting). The copper can be purified by electrolysis. The supply of copper-rich ores is limited.

Additional guidance:

Knowledge and understanding is limited to the reduction of oxides using carbon.

Knowledge of reduction is limited to the removal of oxygen.

Knowledge of the details of the extraction of other metals is **not** required. Examination questions may provide further information about specific processes for candidates to interpret or evaluate.

Details of the blast furnace are **not** required.

Knowledge of the details of industrial methods of electrolysis is **not** required.

Details of industrial smelting processes are **not** required.

- copper is extracted from its ores by chemical processes that involve heat or electricity

- copper-rich ores are being depleted and traditional mining and extraction have major environmental impacts.

- g) New ways of extracting copper from low-grade ores are being researched to limit the environmental impact of traditional mining.

Copper can be extracted by phytomining, or by bioleaching.

Additional guidance:

Candidates should know and understand that:

- phytomining uses plants to absorb metal compounds and that the plants are burned to produce ash that contains the metal compounds
- bioleaching uses bacteria to produce leachate solutions that contain metal compounds.

Further specific details of these processes are **not** required.

- h) Copper can be obtained from solutions of copper salts by electrolysis or by displacement using scrap iron.

Candidates should know that during electrolysis positive ions move towards the negative electrode. They do **not** need to describe this in terms of oxidation and reduction, or to understand half equations.

- i) Aluminium and titanium cannot be extracted from their oxides by reduction with carbon. Current methods of extraction are expensive because:

- there are many stages in the processes
- large amounts of energy are needed.

Candidates do **not** need to know the details of methods used to extract these metals, but should be able to comment on and evaluate information that is given about the chemical processes that can be used.

- j) We should recycle metals because extracting them uses limited resources and is expensive in terms of energy and effects on the environment.

Candidates are **not** required to know details of specific examples of recycling, but should understand the benefits of recycling in the general terms specified here.

C1.3.2 Alloys

- a) Iron from the blast furnace contains about 96 % iron. The impurities make it brittle and so it has limited uses.

Additional guidance:

Knowledge of uses of blast furnace iron is limited to blast furnace iron being used as cast iron because of its strength in compression.

- b) Most iron is converted into steels. Steels are alloys since they are mixtures of iron with carbon. Some steels contain other metals. Alloys can be designed to have properties for specific uses. Low-carbon steels are easily shaped, high-carbon steels are hard, and stainless steels are resistant to corrosion.

Knowledge and understanding of the types of steel and their properties is limited to those specified in the subject content. Information about the composition of specific types of steel may be given in examination questions so that candidates can evaluate their uses.

- c) Most metals in everyday use are alloys. Pure copper, gold, iron and aluminium are too soft for many uses and so are mixed with small amounts of similar metals to make them harder for everyday use.

Candidates should be familiar with these specified examples but examination questions may contain information about alloys other than those named in the subject content to enable candidates to make comparisons.

C1.3.3 Properties and uses of metals

a) The elements in the central block of the periodic table are known as transition metals. Like other metals they are good conductors of heat and electricity and can be bent or hammered into shape. They are useful as structural materials and for making things that must allow heat or electricity to pass through them easily.

b) Copper has properties that make it useful for electrical wiring and plumbing.

Additional guidance:

Knowledge of the properties of specific transition metals other than those named in this unit is **not** required.

Candidates should know and understand that copper:

- is a good conductor of electricity and heat
- can be bent but is hard enough to be used to make pipes or tanks
- does not react with water.

c) Low density and resistance to corrosion make aluminium and titanium useful metals.

Suggested ideas for practical work to develop skills and understanding include the following:

- comparing less reactive metals (gold, silver, copper) with more reactive metals, eg in acid
- heating metal oxides with carbon to compare reactivity, eg CuO, PbO, Fe₂O₃
- heating copper carbonate with charcoal to produce copper
- displacement reactions, eg CuSO₄(aq) + Fe (using temperature sensors to investigate differences in metal reactivity)
- investigation of the physical properties of metals and alloys, eg density / thermal and electrical conductivity
- electrolysis of copper sulfate solution using copper electrodes
- ignition tube demonstration of blast furnace – potassium permanganate, mineral wool plug, iron oxide mixed with carbon
- investigation of phytomining: growing brassica plants in compost with added copper sulfate or spraying brassica plants (eg cabbage leaves) with copper sulfate solution, ashing the plants (fume cupboard), adding sulfuric acid to the ash, filtering and obtaining the metal from the solution by displacement or electrolysis.

C1.4 Crude oil and fuels

Crude oil is derived from an ancient biomass found in rocks. Many useful materials can be produced from crude oil. Crude oil can be fractionally distilled. Some of the fractions can be used as fuels. Biofuels are produced from plant material. There are advantages and disadvantages to their use as fuels. Fuels can come from renewable or non-renewable resources.

Candidates should use their skills, knowledge and understanding to:

- evaluate the impact on the environment of burning hydrocarbon fuels
- consider and evaluate the social, economic and environmental impacts of the uses of fuels
- evaluate developments in the production and uses of better fuels, for example ethanol and hydrogen
- evaluate the benefits, drawbacks and risks of using plant materials to produce fuels.

Additional guidance:

Knowledge and understanding of the products of burning hydrocarbon fuels and the effects of these products is limited to those named in the subject content for this section.

Candidates may be given information and data about other fuels and their products of combustion for comparison and evaluation in the examinations.

Candidates should know and understand the benefits and disadvantages of ethanol and hydrogen as fuels in terms of:

- use of renewable resources
- storage and use of the fuels
- their products of combustion.

C1.4.1 Crude oil

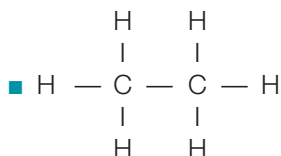
- a) Crude oil is a mixture of a very large number of compounds.
- b) A mixture consists of two or more elements or compounds not chemically combined together. The chemical properties of each substance in the mixture are unchanged. It is possible to separate the substances in a mixture by physical methods including distillation.
- c) Most of the compounds in crude oil consist of molecules made up of hydrogen and carbon atoms only (hydrocarbons). Most of these are saturated hydrocarbons called alkanes, which have the general formula C_nH_{2n+2} .

Additional guidance:

Candidates are **not** expected to know the names of specific alkanes other than methane, ethane and propane.

C1.4.2 Hydrocarbons

- a) Alkane molecules can be represented in the following forms:



- b) The many hydrocarbons in crude oil may be separated into fractions, each of which contains molecules with a similar number of carbon atoms, by evaporating the oil and allowing it to condense at a number of different temperatures. This process is fractional distillation.
- c) Some properties of hydrocarbons depend on the size of their molecules. These properties influence how hydrocarbons are used as fuels.

Additional guidance:

Candidates should be able to recognise alkanes from their formulae in any of the forms but do not need to know the names of individual alkanes other than methane, ethane, propane and butane.

Candidates should know that in displayed structures — represents a covalent bond.

Candidates should know and understand the main processes in continuous fractional distillation in a fractionating column.

Knowledge of the names of specific fractions or fuels is **not** required.

Knowledge of trends in properties of hydrocarbons is limited to:

- boiling points
- viscosity
- flammability.

C1.4.3 Hydrocarbon fuels

- a) Most fuels, including coal, contain carbon and/or hydrogen and may also contain some sulfur. The gases released into the atmosphere when a fuel burns may include carbon dioxide, water (vapour), carbon monoxide, sulfur dioxide and oxides of nitrogen. Solid particles (particulates) may also be released.
- b) The combustion of hydrocarbon fuels releases energy. During combustion the carbon and hydrogen in the fuels are oxidised.

Additional guidance:

Candidates should be able to relate products of combustion to the elements present in compounds in the fuel and to the extent of combustion (whether complete or partial).

No details of how the oxides of nitrogen are formed are required, other than the fact that they are formed at high temperatures.

Solid particles may contain soot (carbon) and unburnt fuels.

- c) Sulfur dioxide and oxides of nitrogen cause acid rain, carbon dioxide causes global warming, and solid particles cause global dimming.
- d) Sulfur can be removed from fuels before they are burned, for example in vehicles. Sulfur dioxide can be removed from the waste gases after combustion, for example in power stations.
- e) Biofuels, including biodiesel and ethanol, are produced from plant material. There are economic, ethical and environmental issues surrounding their use.

Additional guidance:

Candidates are not required to know details of any other causes of acid rain or global warming.

Knowledge of the methods of removing sulfur is **not** required.

Knowledge of the methods of biofuel production is **not** required but candidates may be given information from which a range of questions may be asked.

Suggested ideas for practical work to develop skills and understanding include the following:

- demonstration of fractional distillation of crude oil using CLEAPSS mixture (take care to avoid confusion with the continuous process in a fractionating column)
- design an investigation on viscosity, ease of ignition or sootiness of flame of oils or fuels
- comparison of the energy content of different fuels, for example by heating a fixed volume of water
- demonstration of the production of solid particles by incomplete combustion using a Bunsen burner yellow flame or a candle flame to heat a boiling tube of cold water
- collecting and testing the products of combustion of candle wax and methane
- demonstration of burning sulfur or coal in oxygen and then testing the pH of the gas produced
- design an investigation on growing cress from seeds in various concentrations of sodium metabisulfite solution to show how acid rain affects plants.



C1.5 Other useful substances from crude oil

Fractions from the distillation of crude oil can be broken down (cracked) to make smaller molecules including unsaturated hydrocarbons such as ethene. Unsaturated hydrocarbons can be used to make polymers and ethene can be used to make ethanol. Ethanol can also be made by fermentation.

Candidates should use their skills, knowledge and understanding to:

- evaluate the social and economic advantages and disadvantages of using products from crude oil as fuels or as raw materials for plastics and other chemicals

Additional guidance:

Candidates should be aware that crude oil is used to produce fuels and chemicals, and that it is a limited resource.

Candidates should be able to evaluate information about the ways in which crude oil and its products are used. Although candidates will probably know the names of some common polymers, these are **not** required knowledge, unless they are included in the subject content for this section.

- evaluate the social, economic and environmental impacts of the uses, disposal and recycling of polymers

Additional guidance:

Candidates should be able to compare the environmental impact of producing ethanol from renewable and non-renewable sources.

- evaluate the advantages and disadvantages of making ethanol from renewable and non-renewable sources.

C1.5.1 Obtaining useful substances from crude oil

- a) Hydrocarbons can be cracked to produce smaller, more useful molecules. This process involves heating the hydrocarbons to vaporise them. The vapours are either passed over a hot catalyst or mixed with steam and heated to a very high temperature so that thermal decomposition reactions then occur.

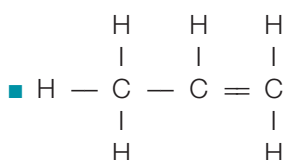
Additional guidance:

Candidates should be able to recognise alkenes from their names or formulae, but do **not** need to know the names of individual alkenes, other than ethene and propene.

- b) The products of cracking include alkanes and unsaturated hydrocarbons called alkenes. Alkenes have the general formula C_nH_{2n} .

- c) Unsaturated hydrocarbon molecules can be represented in the following forms:

- C_3H_6

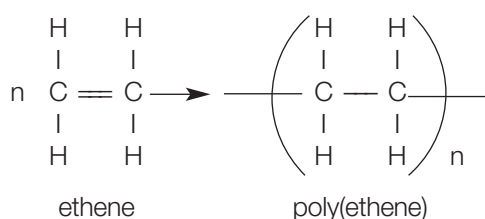


Candidates should know that in displayed structures $=$ represents a double bond.

- d) Alkenes react with bromine water, turning it from orange to colourless.
- e) Some of the products of cracking are useful as fuels.

C1.5.2 Polymers

- a) Alkenes can be used to make polymers such as poly(ethene) and poly(propene). In these reactions, many small molecules (monomers) join together to form very large molecules (polymers).
For example:



- b) Polymers have many useful applications and new uses are being developed, for example: new packaging materials, waterproof coatings for fabrics, dental polymers, wound dressings, hydrogels, smart materials (including shape memory polymers).

- c) Many polymers are not biodegradable, so they are not broken down by microbes and this can lead to problems with waste disposal.

- d) Plastic bags are being made from polymers and cornstarch so that they break down more easily. Biodegradable plastics made from cornstarch have been developed.

C1.5.3 Ethanol

- a) Ethanol can be produced by hydration of ethene with steam in the presence of a catalyst.
- b) Ethanol can also be produced by fermentation with yeast, using renewable resources. This can be represented by:



Additional guidance:

Candidates should be able to recognise the molecules involved in these reactions in the forms shown in the subject content. They should be able to represent the formation of a polymer from a given alkene monomer.

Further details of polymerisation are **not** required.

Candidates should consider the ways in which new materials are being developed and used, but will **not** need to recall the names of specific examples.

Knowledge of specific named examples is **not** required, but candidates should be aware of the problems that are caused by landfill sites and by litter.

Additional guidance:

No further details of these processes are required.

Suggested ideas for practical work to develop skills and understanding include the following:

- demonstration of the cracking of liquid paraffin using broken pottery as the catalyst
- testing for unsaturation in the alkenes using bromine water
- making a polymer from cornstarch
- demonstration of making Perspex
- molecular modelling of polymers
- design an investigation of a property of different plastics, eg strength, flexibility, biodegradability
- investigate the amount of water that can be absorbed by a hydrogel (eg those used as additives to garden composts)
- testing coated fabrics for water penetration.

C1.6 Plant oils and their uses

Many plants produce useful oils that can be converted into consumer products including processed foods. Emulsions can be made and have a number of uses. Vegetable oils can be hardened to make margarine. Biodiesel fuel can be produced from vegetable oils.

Candidates should use their skills, knowledge and understanding to:

- evaluate the effects of using vegetable oils in foods and the impacts on diet and health
- evaluate the use, benefits, drawbacks and risks of emulsifiers in foods.

Additional guidance:

Knowledge is limited to the high-energy content of vegetable oils, the possible health benefits of unsaturated fats compared with saturated fats, and the effects of cooking foods in oil. Information may be provided in examinations for candidates to evaluate.

Candidates do **not** need to recall the names of specific additives.

Further information will be provided in questions for evaluation and comparison.

C1.6.1 Vegetable oils

- a) Some fruits, seeds and nuts are rich in oils that can be extracted. The plant material is crushed and the oil removed by pressing or in some cases by distillation. Water and other impurities are removed.

Additional guidance:

Candidates should study the general principles of the extraction of vegetable oils, such as olive oil, rapeseed oil or lavender oil.

Knowledge of specific examples or processes is **not** required.

- b) Vegetable oils are important foods and fuels as they provide a lot of energy. They also provide us with nutrients.

Knowledge of the details of the production of biodiesel is **not** required.

Knowledge of specific nutrients is **not** required.

- c) Vegetable oils have higher boiling points than water and so can be used to cook foods at higher temperatures than by boiling. This produces quicker cooking and different flavours but increases the energy that the food releases when it is eaten.

C1.6.2 Emulsions

- a) Oils do not dissolve in water. They can be used to produce emulsions. Emulsions are thicker than oil or water and have many uses that depend on their special properties. They provide better texture, coating ability and appearance, for example in salad dressings, ice creams, cosmetics and paints.
- b) **Emulsifiers have hydrophilic and hydrophobic properties.**

Additional guidance:

Candidates should study how emulsions are made and should understand the role of emulsifiers in producing emulsions that are more stable. Knowledge of specific names of ingredients in proprietary products is **not** required.

HT only

Knowledge is limited to a simple model of the structure of emulsifier molecules.

C1.6.3 Saturated and unsaturated oils

- a) Vegetable oils that are unsaturated contain double carbon-carbon bonds. These can be detected by reacting with bromine water.
- b) **Vegetable oils that are unsaturated can be hardened by reacting them with hydrogen in the presence of a nickel catalyst at about 60 °C. Hydrogen adds to the carbon-carbon double bonds. The hydrogenated oils have higher melting points so they are solids at room temperature, making them useful as spreads and in cakes and pastries.**

Additional guidance:

Candidates should be familiar with a test for unsaturation using bromine water.

HT only

Candidates should know how and why vegetable oils are hardened for use in foods. Knowledge of trans fats is not required.

Examination questions may provide further information from which candidates may be asked to make comparisons.

Suggested ideas for practical work to develop skills and understanding include the following:

- pressing nuts (eg walnuts) between paper towels and studying the grease marks
- steam distillation of lavender oil, orange oil, lemon oil, olive oil, rapeseed oil or vegetable oil
- simple calorimetry investigations using small spirit burners or bottle tops to measure the energy released from various oils (weigh before and after, and measure the temperature change for a known mass of water)
- making emulsions, eg oil/water, oil/vinegar
- design and carry out an investigation into the effect of emulsifiers on the stability of emulsions
- using bromine water to test fats and oils for unsaturation, eg testing sunflower oil against butter (using colorimeter to measure level of unsaturation).

C1.7 Changes in the Earth and its atmosphere

The Earth and its atmosphere provide everything we need. The Earth has a layered structure. The surface of the Earth and its atmosphere have changed since the Earth was formed and are still changing. The atmosphere has been much the same for the last 200 million years and provides the conditions needed for life on Earth. Recently human activities have resulted in further changes in the atmosphere. There is more than one theory about how life was formed.

Candidates should use their skills, knowledge and understanding to:

- recognise that the Earth's crust, the atmosphere and the oceans are the only source of minerals and other resources that humans need

- explain why Wegener's theory of crustal movement (continental drift) was not generally accepted for many years

Additional guidance:

Candidates should have studied accounts of Wegener's work. Knowledge is limited to the theories relating to mountain building and continental drift.

Candidates should know that scientists once thought that the features of the Earth's surface were the result of the shrinking of the crust as the Earth cooled down following its formation.

- explain why scientists cannot accurately predict when earthquakes and volcanic eruptions will occur

Candidates may be given information which they will be expected to interpret.

- explain and evaluate theories of the changes that have occurred and are occurring in the Earth's atmosphere

Candidates should be able to compare and evaluate different theories when given suitable information.

- explain and evaluate the effects of human activities on the atmosphere

Knowledge of the effects of human activities is limited to those in the subject content.

- **describe why we do not know how life was first formed.**

HT only

C1.7.1 The Earth's crust

- a) The Earth consists of a core, mantle and crust, and is surrounded by the atmosphere.

Additional guidance:

Knowledge is limited to the names of the three major parts, and an awareness of the relative sizes of these features.

- b) The Earth's crust and the upper part of the mantle are cracked into a number of large pieces (tectonic plates).

Knowledge of the names, shapes or locations of specific plates is **not** required.

- c) Convection currents within the Earth's mantle driven by heat released by natural radioactive processes cause the plates to move at relative speeds of a few centimetres per year.

Candidates should know that the mantle is mostly solid, but that it is able to move slowly.

- d) The movements can be sudden and disastrous. Earthquakes and / or volcanic eruptions occur at the boundaries between tectonic plates.

Additional guidance:

Knowledge of the changes that occur at plate boundaries is limited to earthquakes and volcanic eruptions.

Knowledge of the mechanism of these changes is **not** required.

C1.7.2 The Earth's atmosphere

- a) For 200 million years, the proportions of different gases in the atmosphere have been much the same as they are today:
- about four-fifths (80 %) nitrogen
 - about one-fifth (20 %) oxygen
 - small proportions of various other gases, including carbon dioxide, water vapour and noble gases.
- b) During the first billion years of the Earth's existence there was intense volcanic activity. This activity released the gases that formed the early atmosphere and water vapour that condensed to form the oceans.

- c) There are several theories about how the atmosphere was formed.

One theory suggests that during this period the Earth's atmosphere was mainly carbon dioxide and there would have been little or no oxygen gas (like the atmospheres of Mars and Venus today). There may also have been water vapour and small proportions of methane and ammonia.

Additional guidance:

No knowledge of other theories is required. Information may be given in questions which candidates will be expected to interpret.

- d) There are many theories as to how life was formed billions of years ago.

- e) **One theory as to how life was formed involves the interaction between hydrocarbons, ammonia and lightning.**

Additional guidance:**HT only**

Candidates should be aware of the Miller-Urey experiment and the 'primordial soup' theory, but they should know that this is not the only theory.

- f) Plants and algae produced the oxygen that is now in the atmosphere.

Candidates should be aware that plants and algae produce oxygen by a process called photosynthesis and that this process uses carbon dioxide from the atmosphere.

Knowledge of the process of photosynthesis is **not** required.

- g) Most of the carbon from the carbon dioxide in the air gradually became locked up in sedimentary rocks as carbonates and fossil fuels.

Additional guidance:

Candidates should know that carbon dioxide dissolves in the oceans and that limestone was formed from the shells and skeletons of marine organisms. Fossil fuels contain carbon and hydrocarbons that are the remains of plants and animals.

- h) The oceans also act as a reservoir for carbon dioxide but increased amounts of carbon dioxide absorbed by the oceans has an impact on the marine environment.

Additional guidance:

Candidates should be aware that this increase in carbon dioxide is thought to be causing global warming but, for this unit, candidates do **not** need to know how CO₂ causes this effect.

- i) Nowadays the release of carbon dioxide by burning fossil fuels increases the level of carbon dioxide in the atmosphere.

- j) **Air is a mixture of gases with different boiling points and can be fractionally distilled to provide a source of raw materials used in a variety of industrial processes.**

HT only

Knowledge of the boiling points of the different gases is not required.

Suggested ideas for practical work to develop skills and understanding include the following:

- investigating the composition of air by passing air over heated copper using gas syringes and measuring the percentage of oxygen. Then burning magnesium in the nitrogen to form Mg₃N₂. Add water to produce ammonia (nitrogen must have come from the air)
- collecting gas produced by aquatic plants and testing for oxygen (using dissolved oxygen sensor)
- measuring the amount of carbon dioxide in inhaled and exhaled air (using carbon dioxide sensor)
- testing the products of combustion of fuels to show that carbon dioxide is produced
- design an investigation to compare the amount of carbon dioxide released by reacting crushed shells (eg cockle, oyster) with dilute hydrochloric acid.



3.4 Unit 2: Chemistry 2

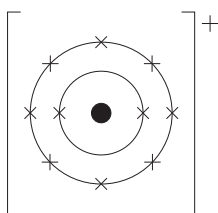
Throughout this unit candidates will be expected to write word equations for reactions specified. **Higher tier candidates will also be expected to write and balance symbol equations for reactions specified throughout the unit.**

C2.1 Structure and bonding

Simple particle theory is developed in this unit to include atomic structure and bonding. The arrangement of electrons in atoms can be used to explain what happens when elements react and how atoms join together to form different types of substances.

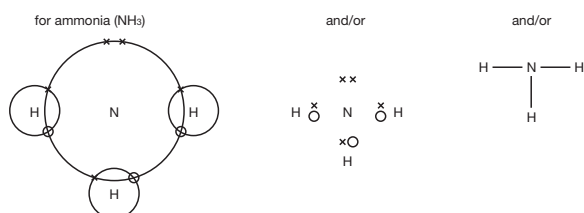
Candidates should use their skills, knowledge and understanding to:

- write formulae for ionic compounds from given symbols and ionic charges
- represent the electronic structure of the ions in sodium chloride, magnesium oxide and calcium chloride in the following form:

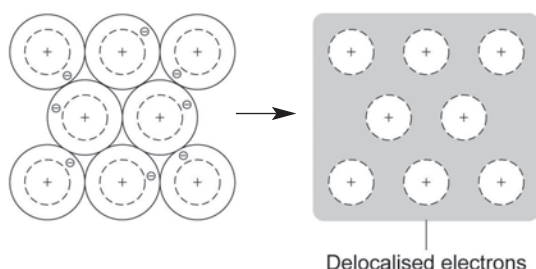


for sodium ion (Na^+)

- represent the covalent bonds in molecules such as water, ammonia, hydrogen, hydrogen chloride, methane and oxygen, and in giant structures such as diamond and silicon dioxide, in the following forms:



- represent the bonding in metals in the following form:



Additional guidance:

HT only

C2.1.1 Structure and bonding

a) Compounds are substances in which atoms of two or more elements are chemically combined.

b) Chemical bonding involves either transferring or sharing electrons in the highest occupied energy levels (shells) of atoms in order to achieve the electronic structure of a noble gas.

c) When atoms form chemical bonds by transferring electrons, they form ions. Atoms that lose electrons become positively charged ions. Atoms that gain electrons become negatively charged ions. Ions have the electronic structure of a noble gas (Group 0).

Additional guidance:

Candidates should be able to relate the charge on simple ions to the group number of the element in the periodic table.

d) The elements in Group 1 of the periodic table, the alkali metals, all react with non-metal elements to form ionic compounds in which the metal ion has a single positive charge.

Knowledge of the chemical properties of alkali metals is limited to their reactions with non-metal elements.

e) The elements in Group 7 of the periodic table, the halogens, all react with the alkali metals to form ionic compounds in which the halide ions have a single negative charge.

Knowledge of the chemical properties of the halogens is limited to reactions with alkali metals.

f) An ionic compound is a giant structure of ions. Ionic compounds are held together by strong electrostatic forces of attraction between oppositely charged ions. These forces act in all directions in the lattice and this is called ionic bonding.

Candidates should be familiar with the structure of sodium chloride but do **not** need to know the structures of other ionic compounds.

g) When atoms share pairs of electrons, they form covalent bonds. These bonds between atoms are strong. Some covalently bonded substances consist of simple molecules such as H_2 , Cl_2 , O_2 , HCl , H_2O , NH_3 and CH_4 . Others have giant covalent structures (macromolecules), such as diamond and silicon dioxide.

Candidates should know the bonding in the examples in the specification for this unit, and should be able to recognise simple molecules and giant structures from diagrams that show their bonding.

h) Metals consist of giant structures of atoms arranged in a regular pattern.

Additional guidance:

i) **The electrons in the highest occupied energy levels (outer shell) of metal atoms are delocalised and so free to move through the whole structure. This corresponds to a structure of positive ions with electrons between the ions holding them together by strong electrostatic attractions.**

HT only

Suggested ideas for practical work to develop skills and understanding include the following:

- molecular modelling
- modelling electron transfer and electron sharing using computer simulations
- Group 1 and Group 7 reactions, eg sodium with chlorine
- the reactions of bromine, chlorine and iodine with iron wool
- growing metal crystals by displacement reactions using metals and salts
- modelling metal structures using polyspheres and bubble rafts.

C2.2 How structure influences the properties and uses of substances

Substances that have simple molecular, giant ionic and giant covalent structures have very different properties. Ionic, covalent and metallic bonds are strong. However, the forces between molecules are weaker, eg in carbon dioxide and iodine. Metals have many uses. When different metals are combined, alloys are formed. Shape memory alloys have a range of uses. There are different types of polymers with different uses. Nanomaterials have new properties because of their very small size.

Candidates should use their skills, knowledge and understanding to:

- relate the properties of substances to their uses

Additional guidance:

Candidates may be provided with information about the properties of substances that are not specified in this unit to enable them to relate these to their uses.

- suggest the type of structure of a substance given its properties

Additional guidance:

Candidates should be familiar with some examples of new materials but do **not** need to know the properties or names of specific new materials.

- evaluate developments and applications of new materials, eg nanomaterials, fullerenes and shape memory materials.

C2.2.1 Molecules

- a) Substances that consist of simple molecules are gases, liquids or solids that have relatively low melting points and boiling points.

Additional guidance:

- b) **Substances that consist of simple molecules have only weak forces between the molecules (intermolecular forces). It is these intermolecular forces that are overcome, not the covalent bonds, when the substance melts or boils.**

HT only

Candidates need to be able to explain that intermolecular forces are weak in comparison with covalent bonds.

- c) Substances that consist of simple molecules do not conduct electricity because the molecules do not have an overall electric charge.

C2.2.2 Ionic compounds

- a) Ionic compounds have regular structures (giant ionic lattices) in which there are strong electrostatic forces in all directions between oppositely charged ions. These compounds have high melting points and high boiling points because of the large amounts of energy needed to break the many strong bonds.
- b) When melted or dissolved in water, ionic compounds conduct electricity because the ions are free to move and carry the current.

Additional guidance:

Knowledge of the structures of specific ionic compounds other than sodium chloride is **not** required.

C2.2.3 Covalent structures

- a) Atoms that share electrons can also form giant structures or macromolecules. Diamond and graphite (forms of carbon) and silicon dioxide (silica) are examples of giant covalent structures (lattices) of atoms. All the atoms in these structures are linked to other atoms by strong covalent bonds and so they have very high melting points.
- b) In diamond, each carbon atom forms four covalent bonds with other carbon atoms in a giant covalent structure, so diamond is very hard.

Additional guidance:

Candidates should be able to recognise other giant structures or macromolecules from diagrams showing their bonding.

- c) In graphite, each carbon atom bonds to three others, forming layers. The layers are free to slide over each other because there are no covalent bonds between the layers and so graphite is soft and slippery.

Additional guidance:

Higher Tier candidates should be able to explain the properties of graphite in terms of weak intermolecular forces between the layers.

- d) **In graphite, one electron from each carbon atom is delocalised. These delocalised electrons allow graphite to conduct heat and electricity.**

HT only

Candidates should realise that graphite is similar to metals in that it has delocalised electrons.

- e) **Carbon can also form fullerenes with different numbers of carbon atoms. Fullerenes can be used for drug delivery into the body, in lubricants, as catalysts, and in nanotubes for reinforcing materials, eg in tennis rackets.**

HT only

Candidates' knowledge is limited to the fact that the structure of fullerenes is based on hexagonal rings of carbon atoms.

C2.2.4 Metals

- a) **Metals conduct heat and electricity because of the delocalised electrons in their structures.**

Additional guidance:

HT only

Candidates should know that conduction depends on the ability of electrons to move throughout the metal.

- b) The layers of atoms in metals are able to slide over each other and so metals can be bent and shaped.
- c) Alloys are usually made from two or more different metals. The different sized atoms of the metals distort the layers in the structure, making it more difficult for them to slide over each other and so make alloys harder than pure metals.
- d) Shape memory alloys can return to their original shape after being deformed, eg Nitinol used in dental braces.

C2.2.5 Polymers

- a) The properties of polymers depend on what they are made from and the conditions under which they are made. For example, low density (LD) and high density (HD) poly(ethene) are produced using different catalysts and reaction conditions.

Additional guidance:

- b) Thermosoftening polymers consist of individual, tangled polymer chains. Thermosetting polymers consist of polymer chains with cross-links between them so that they do not melt when they are heated.

Higher Tier candidates should be able to explain the properties of thermosoftening polymers in terms of intermolecular forces.

C2.2.6 Nanoscience

- a) Nanoscience refers to structures that are 1–100 nm in size, of the order of a few hundred atoms. Nanoparticles show different properties to the same materials in bulk and have a high surface area to volume ratio, which may lead to the development of new computers, new catalysts, new coatings, highly selective sensors, stronger and lighter construction materials, and new cosmetics such as sun tan creams and deodorants.

Additional guidance:

Candidates should know what is meant by nanoscience and nanoparticles and should consider some of the applications of these materials, but do **not** need to know specific examples or properties.

Questions may be set on information that is provided about these materials and their uses.

Suggested ideas for practical work to develop skills and understanding include the following:

- demonstration of heating sulfur and pouring it into cold water to produce plastic sulfur
- investigating the properties of ionic compounds, eg NaCl:
 - melting point, conductivity, solubility, use of hand lens to study crystal structure
- investigating the properties of covalent compounds:
 - simple molecules, eg wax, methane, hexane
 - macromolecules, eg SiO₂ (sand)
- investigating the properties of graphite
- demonstrations involving shape memory alloys
- investigating the properties of metals and alloys:
 - melting point and conductivity, hardness, tensile strength, flexibility
 - using models, for example using expanded polystyrene spheres or computer animations to show how layers of atoms slide
 - making metal crystals by displacement reactions, eg copper wire in silver nitrate solution
- distinguishing between LD and HD poly(ethene) using 50:50 ethanol:water
- making slime using different concentrations of poly(ethenol) and borax solutions
- investigating the effect of heat on polymers to find which are thermosoftening and which are thermosetting.

C2.3 Atomic structure, analysis and quantitative chemistry

The relative masses of atoms can be used to calculate how much to react and how much we can produce, because no atoms are gained or lost in chemical reactions. There are various methods used to analyse these substances.

Candidates should use their skills, knowledge and understanding to:

- evaluate sustainable development issues relating the starting materials of an industrial process to the product yield and the energy requirements of the reactions involved.

Additional guidance:

Candidates may be given appropriate information from which to draw conclusions.

C2.3.1 Atomic structure

- a) Atoms can be represented as shown in this example:

Mass number 23
 Na
 Atomic number 11

- b) The relative masses of protons, neutrons and electrons are:

Name of particle	Mass
Proton	1
Neutron	1
Electron	Very small

- c) The total number of protons and neutrons in an atom is called its mass number.
- d) Atoms of the same element can have different numbers of neutrons; these atoms are called isotopes of that element.

- e) **The relative atomic mass of an element (A_r) compares the mass of atoms of the element with the ^{12}C isotope. It is an average value for the isotopes of the element.**

- f) The relative formula mass (M_r) of a compound is the sum of the relative atomic masses of the atoms in the numbers shown in the formula.

- g) The relative formula mass of a substance, in grams, is known as one mole of that substance.

Additional guidance:

HT only

Candidates are expected to use relative atomic masses in the calculations specified in the subject content. Candidates should be able to calculate the relative formula mass (M_r) of a compound from its formula.

C2.3.2 Analysing substances

- a) Elements and compounds can be detected and identified using instrumental methods. Instrumental methods are accurate, sensitive and rapid and are particularly useful when the amount of a sample is very small.

- b) Chemical analysis can be used to identify additives in foods. Artificial colours can be detected and identified by paper chromatography.

Additional guidance:

Knowledge of methods other than paper chromatography is **not** required, but questions may include information based on the results of chemical analysis.

- c) Gas chromatography linked to mass spectroscopy (GC-MS) is an example of an instrumental method:
- gas chromatography allows the separation of a mixture of compounds
 - the time taken for a substance to travel through the column can be used to help identify the substance
 - the output from the gas chromatography column can be linked to a mass spectrometer, which can be used to identify the substances leaving the end of the column
 - **the mass spectrometer can also give the relative molecular mass of each of the substances separated in the column.**

Additional guidance:

Candidates need only a basic understanding of how GC-MS works, limited to:

- different substances, carried by a gas, travel through a column packed with a solid material at different speeds, so that they become separated
- the number of peaks on the output of a gas chromatograph shows the number of compounds present
- the position of the peaks on the output indicates the retention time
- a mass spectrometer can identify substances very quickly and accurately and can detect very small quantities.

HT only

The molecular mass is given by the molecular ion peak.

Knowledge of fragmentation patterns is not required.

C2.3.3 Quantitative chemistry

- a) The percentage of an element in a compound can be calculated from the relative mass of the element in the formula and the relative formula mass of the compound.
- b) **The empirical formula of a compound can be calculated from the masses or percentages of the elements in a compound.**
- c) **The masses of reactants and products can be calculated from balanced symbol equations.**

Additional guidance:

Candidates should be able to calculate the percentage of an element in a compound, given its formula

HT only

Candidates should be able to calculate empirical formulae.

HT only

Candidates should be able to calculate the masses of individual products from a given mass of a reactant and the balanced symbol equation.

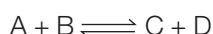
- d) Even though no atoms are gained or lost in a chemical reaction, it is not always possible to obtain the calculated amount of a product because:
- the reaction may not go to completion because it is reversible
 - some of the product may be lost when it is separated from the reaction mixture
 - some of the reactants may react in ways different from the expected reaction.

- e) The amount of a product obtained is known as the yield. When compared with the maximum theoretical amount as a percentage, it is called the percentage yield.

Additional guidance:

Higher Tier candidates will be expected to calculate percentage yields of reactions.

- f) In some chemical reactions, the products of the reaction can react to produce the original reactants. Such reactions are called reversible reactions and are represented:



For example:

**Suggested ideas for practical work to develop skills and understanding include the following:**

- investigating food colours using paper chromatography
- working out the empirical formulae of copper oxide and magnesium oxide
- calculating yields, for example magnesium burning to produce magnesium oxide or wire wool burning to produce iron oxide
- there are opportunities in this section to build in the idea of instrumentation precision, eg for the collection of gases, the use of boiling tubes, gas jars or gas syringes
- copper sulfate – hydration/dehydration
- heating ammonium chloride in a test tube
- adding alkali and acid alternately to bromine water or to potassium chromate solution
- ‘blue bottle’ reaction (RSC Classic Chemistry Experiments no. 83)
- oscillating reaction (RSC Classic Chemistry Experiments no.140).

C2.4 Rates of reaction

Being able to speed up or slow down chemical reactions is important in everyday life and in industry. Changes in temperature, concentration of solution, gas pressure, surface area of solids and the presence of catalysts all affect the rates of reactions. Catalysts can help to reduce the cost of some industrial processes.

Candidates should use their skills, knowledge and understanding to:

- interpret graphs showing the amount of product formed (or reactant used up) with time, in terms of the rate of the reaction
- explain and evaluate the development, advantages and disadvantages of using catalysts in industrial processes.

Additional guidance:

Knowledge of specific reactions other than those in the subject content for this unit is **not** expected, but candidates will be expected to have studied examples of chemical reactions and processes in developing their skills during their study of this section.

Information may be given in examination questions so that candidates can make evaluations.

C2.4.1 Rates of reaction

- a) The rate of a chemical reaction can be found by measuring the amount of a reactant used or the amount of product formed over time:

$$\text{Rate of reaction} = \frac{\text{amount of reactant used}}{\text{time}}$$

$$\text{Rate of reaction} = \frac{\text{amount of product formed}}{\text{time}}$$

- b) Chemical reactions can only occur when reacting particles collide with each other and with sufficient energy. The minimum amount of energy particles must have to react is called the activation energy.
- c) Increasing the temperature increases the speed of the reacting particles so that they collide more frequently and more energetically. This increases the rate of reaction.
- d) Increasing the pressure of reacting gases increases the frequency of collisions and so increases the rate of reaction.
- e) Increasing the concentration of reactants in solutions increases the frequency of collisions and so increases the rate of reaction.
- f) Increasing the surface area of solid reactants increases the frequency of collisions and so increases the rate of reaction.

- g) Catalysts change the rate of chemical reactions but are not used up during the reaction. Different reactions need different catalysts.

Additional guidance:

Knowledge of named catalysts other than those specified in the subject content for this unit is **not** required, but candidates should be aware of some examples of chemical reactions and processes that use catalysts.

- h) Catalysts are important in increasing the rates of chemical reactions used in industrial processes to reduce costs.

Suggested ideas for practical work to develop skills and understanding include the following:

- designing and carrying out investigations into factors such as:
 - temperature, eg magnesium with acids at different temperatures
 - surface area, eg different sizes of marble chips
 - catalysts, eg the decomposition of hydrogen peroxide using manganese(IV) oxide, potato and/or liver; the ignition of hydrogen using platinum; oxidation of ammonia using platinum; cracking liquid paraffin using broken pot
 - concentration, eg sodium thiosulfate solution and dilute hydrochloric acid.

There are opportunities here for measurements using sensors (eg carbon dioxide, oxygen, light, pH, gas pressure and temperature) to investigate reaction rates.

C2.5 Exothermic and endothermic reactions

Chemical reactions involve energy transfers. Many chemical reactions involve the release of energy. For other chemical reactions to occur, energy must be supplied.

Candidates should use their skills, knowledge and understanding to:

- evaluate everyday uses of exothermic and endothermic reactions.

Additional guidance:

Candidates may be given data from which to draw conclusions.

C2.5.1 Energy transfer in chemical reactions

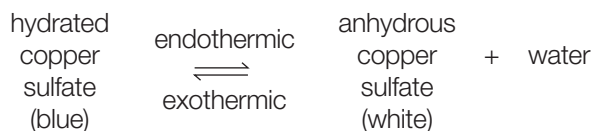
- a) When chemical reactions occur, energy is transferred to or from the surroundings.

Additional guidance:

Knowledge of delta H (ΔH) conventions and enthalpy changes, including the use of positive values for endothermic reactions and negative values for exothermic reactions, is **not** required.

- b) An exothermic reaction is one that transfers energy to the surroundings. Examples of exothermic reactions include combustion, many oxidation reactions and neutralisation. Everyday uses of exothermic reactions include self-heating cans (eg for coffee) and hand warmers.

- c) An endothermic reaction is one that takes in energy from the surroundings. Endothermic reactions include thermal decompositions. Some sports injury packs are based upon endothermic reactions.
- d) If a reversible reaction is exothermic in one direction, it is endothermic in the opposite direction. The same amount of energy is transferred in each case. For example:



Suggested ideas for practical work to develop skills and understanding include the following:

- investigating temperature changes of neutralisations and displacement reactions, eg zinc and copper sulfate
- investigating temperature changes when dissolving ammonium nitrate, or reacting citric acid and sodium hydrogencarbonate
- adding ammonium nitrate to barium hydroxide
- demonstration of the addition of concentrated sulfuric acid to sugar
- demonstration of the reaction between iodine and aluminium after activation by a drop of water
- demonstration of the screaming jelly baby
- demonstration of the thermite reaction, ie aluminium mixed with iron(III) oxide
- investigation of hand warmers, self-warming cans, sports injury packs.

There are opportunities here for measurements using temperature sensors to investigate energy transfer.



C2.6 Acids, bases and salts

Soluble salts can be made from acids and insoluble salts can be made from solutions of ions. When acids and alkalis react the result is a neutralisation reaction.

Candidates should use their skills, knowledge and understanding to:

- select an appropriate method for making a salt, given appropriate information.

C2.6.1 Making salts

- a) The state symbols in equations are (s), (l), (g) and (aq).

Additional guidance:

Candidates should be able to suggest methods to make a named soluble salt.

- b) Soluble salts can be made from acids by reacting them with:

- metals – not all metals are suitable; some are too reactive and others are not reactive enough
- insoluble bases – the base is added to the acid until no more will react and the excess solid is filtered off
- alkalis – an indicator can be used to show when the acid and alkali have completely reacted to produce a salt solution.

- c) Salt solutions can be crystallised to produce solid salts.

Additional guidance:

Candidates should be able to name the substances needed to make a named insoluble salt.

- d) Insoluble salts can be made by mixing appropriate solutions of ions so that a precipitate is formed. Precipitation can be used to remove unwanted ions from solutions, for example in treating water for drinking or in treating effluent.

C2.6.2 Acids and bases

- a) Metal oxides and hydroxides are bases. Soluble hydroxides are called alkalis.

- b) The particular salt produced in any reaction between an acid and a base or alkali depends on:

- the acid used (hydrochloric acid produces chlorides, nitric acid produces nitrates, sulfuric acid produces sulfates)
- the metal in the base or alkali.

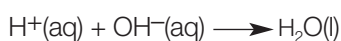
- c) Ammonia dissolves in water to produce an alkaline solution. It is used to produce ammonium salts. Ammonium salts are important as fertilisers.

- d) Hydrogen ions, $\text{H}^+(\text{aq})$, make solutions acidic and hydroxide ions, $\text{OH}^-(\text{aq})$, make solutions alkaline. The pH scale is a measure of the acidity or alkalinity of a solution.

Additional guidance:

Candidates should be familiar with the pH scale from 0 to 14, and that pH 7 is a neutral solution.

- e) In neutralisation reactions, hydrogen ions react with hydroxide ions to produce water. This reaction can be represented by the equation:



Suggested ideas for practical work to develop skills and understanding include the following:

- the preparation of soluble salts:
 - copper sulfate by adding copper oxide to sulfuric acid
 - magnesium sulfate by adding magnesium oxide to sulfuric acid
 - copper chloride by adding copper oxide to hydrochloric acid
 - zinc nitrate by adding zinc oxide to nitric acid
 - sodium chloride by adding sodium hydroxide to hydrochloric acid
 - copper sulfate by adding copper carbonate to sulfuric acid
 - investigation of the effect of conditions on the yield of the salt
- the preparation of insoluble salts:
 - lead iodide by mixing solutions of lead nitrate and potassium iodide
 - barium sulfate by mixing solutions of barium chloride and sodium sulfate
 - investigation of the effect of conditions on the formation of precipitates.

There are opportunities here for using pH sensors to investigate neutralisation.

C2.7 Electrolysis

Ionic compounds have many uses and can provide other substances. Electrolysis is used to produce alkalis and elements such as aluminium, chlorine and hydrogen. Oxidation–reduction reactions do not just involve oxygen.

Candidates should use their skills, knowledge and understanding to:

- predict the products of electrolysis solutions of ions

Additional guidance:

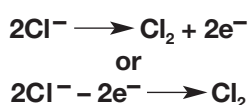
Knowledge and understanding is limited to the methods indicated in the subject content.

- explain and evaluate processes that use the principles described in this unit, including the use of electroplating.

C2.7.1 Electrolysis

- When an ionic substance is melted or dissolved in water, the ions are free to move about within the liquid or solution.
- Passing an electric current through ionic substances that are molten, for example lead bromide, or in solution breaks them down into elements. This process is called electrolysis and the substance that is broken down is called the electrolyte.
- During electrolysis, positively charged ions move to the negative electrode, and negatively charged ions move to the positive electrode.
- Electrolysis is used to electroplate objects. This may be for a variety of reasons and includes copper plating and silver plating.
- At the negative electrode, positively charged ions gain electrons (reduction) and at the positive electrode, negatively charged ions lose electrons (oxidation).
- If there is a mixture of ions, the products formed depend on the reactivity of the elements involved.

- Reactions at electrodes can be represented by half equations, for example:**



Additional guidance:

HT only

Candidates should be able to complete and balance half equations for the reactions occurring at the electrodes during electrolysis.

- h) Aluminium is manufactured by the electrolysis of a molten mixture of aluminium oxide and cryolite. Aluminium forms at the negative electrode and oxygen at the positive electrode. The positive electrode is made of carbon, which reacts with the oxygen to produce carbon dioxide.

Additional guidance:

Candidates should understand why cryolite is used in this process.

- i) The electrolysis of sodium chloride solution produces hydrogen and chlorine. Sodium hydroxide solution is also produced. These are important reagents for the chemical industry, eg sodium hydroxide for the production of soap and chlorine for the production of bleach and plastics.

Suggested ideas for practical work to develop skills and understanding include the following:

- the electrolysis of molten lead bromide or zinc chloride
- investigation of the electrolysis of any solutions of a soluble ionic compound, eg copper chloride, sodium chloride, zinc bromide, zinc iodide
- a demonstration of the Hoffman voltameter
- the electroplating of copper foil with nickel in a nickel sulfate solution
- the movement of ions, eg by the electrolysis of a crystal of KMnO_4 on filter paper dampened with sodium chloride solution, or the electrolysis of CuCrO_4 in a saturated urea solution using a U-tube
- using conductivity sensors to monitor conductivity and changes in conductivity.

3.5 Unit 3: Chemistry 3

Throughout this unit candidates will be expected to write word equations for reactions specified. **Higher tier candidates will also be expected to write and balance symbol equations for reactions specified throughout the unit.**

C3.1 The periodic table

The modern periodic table has been developed from work begun by Newlands and Mendeleev. There are trends in chemical properties within the periodic table linked to how easily the element gains or loses electrons.

Candidates should use their skills, knowledge and understanding to:

- evaluate the work of Newlands and Mendeleev in terms of their contributions to the development of the modern periodic table
- explain why scientists regarded a periodic table of the elements first as a curiosity, then as a useful tool and finally as an important summary of the structure of atoms.

Additional guidance:

Knowledge of the history of the periodic table is limited to that specified in the subject content.

Candidates may consider other models, but knowledge is limited to the work of Newlands and Mendeleev. Examination questions would give information about other models so that comparisons can be made.

C3.1.1 The early periodic table

- a) Newlands, and then Mendeleev, attempted to classify the elements by arranging them in order of their atomic weights. The list can be arranged in a table so that elements with similar properties are in columns, known as groups. The table is called a periodic table because similar properties occur at regular intervals.
- b) The early periodic tables were incomplete and some elements were placed in inappropriate groups if the strict order of atomic weights was followed. Mendeleev overcame some of the problems by leaving gaps for elements that he thought had not been discovered.

C3.1.2 The modern periodic table

- a) When electrons, protons and neutrons were discovered early in the 20th century, the periodic table was arranged in order of atomic (proton) numbers. When this was done, all elements were placed in appropriate groups.

- b) The modern periodic table can be seen as an arrangement of the elements in terms of their electronic structures. Elements in the same group have the same number of electrons in their highest occupied energy level (outer shell).

Additional guidance:

The periodic table that will be used in the examinations is on the Data Sheet, with main groups numbered from 1 to 7 and the noble gases as Group 0.

Candidates are **not** expected to know detailed electronic configurations for elements beyond calcium, but should understand that the number of electrons in the highest occupied energy level (outer shell) for elements in the main groups is equal to the group number.

C3.1.3 Trends within the periodic table

- a) The elements in Group 1 of the periodic table (known as the alkali metals):
- are metals with low density (the first three elements in the group are less dense than water)
 - react with non-metals to form ionic compounds in which the metal ion carries a charge of +1. The compounds are white solids that dissolve in water to form colourless solutions
 - react with water, releasing hydrogen
 - form hydroxides that dissolve in water to give alkaline solutions.
- b) In Group 1, the further down the group an element is:
- the more reactive the element
 - the lower its melting point and boiling point.
- c) Compared with the elements in Group 1, transition elements:
- have higher melting points (except for mercury) and higher densities
 - are stronger and harder
 - are much less reactive and so do not react as vigorously with water or oxygen.
- d) Many transition elements have ions with different charges, form coloured compounds and are useful as catalysts.
- e) The elements in Group 7 of the periodic table (known as the halogens) react with metals to form ionic compounds in which the halide ion carries a charge of -1.

f) In Group 7, the further down the group an element is:

- the less reactive the element
- the higher its melting point and boiling point.

g) A more reactive halogen can displace a less reactive halogen from an aqueous solution of its salt.

h) **The trends in reactivity within groups in the periodic table can be explained because the higher the energy level of the outer electrons:**

- the more easily electrons are lost
- the less easily electrons are gained.

Additional guidance:

HT only

Suggested ideas for practical work to develop skills and understanding include the following:

- demonstration of the combustion of reactions of sodium and potassium
- demonstration of the reactions of sodium and potassium with chlorine
- demonstration of the reactions of lithium, sodium and potassium with water
- demonstration of the reactions of the halogens with iron wool
- investigation of the displacement of halogens from solutions of their salts by more reactive halogens
- heating transition metals in air (any of Ti, Cr, Co, Ni, Fe, Cu) to compare reactivity and melting points with Group 1
- demonstration of the reaction of iron wool with steam
- observation of as many salts of transition metals as possible (bottles with formulae clearly displayed)
- demonstrations of transition metals and their salts as catalysts
- investigation of the catalysis of hydrogen peroxide decomposition by different transition metals and their compounds.

C3.2 Water

The water we drink is not pure water because it contains dissolved substances. It should be safe to drink water that has been treated. This means that the water does not contain anything that could cause us harm. Some of the dissolved substances are beneficial to our health but some cause hard water.

Candidates should use their skills, knowledge and understanding to:

- evaluate the use of commercial water softeners

- consider and evaluate the environmental, social and economic aspects of water quality and hardness
- consider the advantages and disadvantages of adding chlorine and fluoride to drinking water.

Additional guidance:

Candidates may be asked to evaluate different methods of softening water, or of providing drinking water of sufficient quality.

Candidates will be expected to interpret and evaluate information and data that is provided in questions set within these contexts.

C3.2.1 Hard and soft water

- a) Soft water readily forms lather with soap. Hard water reacts with soap to form scum and so more soap is needed to form lather. Soapless detergents do not form scum.
- b) Hard water contains dissolved compounds, usually of calcium or magnesium. The compounds are dissolved when water comes into contact with rocks.

Additional guidance:

Candidates should be able to measure the hardness of water by titration with soap solution.

- c) There are two types of hard water. Permanent hard water remains hard when it is boiled. Temporary hard water is softened by boiling.

Additional guidance:

Candidates should be able to distinguish between temporary hard water and permanent hard water.

- d) **Temporary hard water contains hydrogencarbonate ions (HCO_3^-) that decompose on heating to produce carbonate ions which react with calcium and magnesium ions to form precipitates.**

HT only

- e) Using hard water can increase costs because more soap is needed. When temporary hard water is heated it can produce scale that reduces the efficiency of heating systems and kettles.
- f) Hard water has some benefits because calcium compounds are good for the development and maintenance of bones and teeth and also help to reduce heart disease.
- g) Hard water can be made soft by removing the dissolved calcium and magnesium ions. This can be done by:
- adding sodium carbonate, which reacts with the calcium and magnesium ions to form a precipitate of calcium carbonate and magnesium carbonate
 - using commercial water softeners such as ion exchange columns containing hydrogen ions or sodium ions, which replace the calcium and magnesium ions when hard water passes through the column.

C3.2.2 Purifying water

- a) Water of the correct quality is essential for life. For humans, drinking water should have sufficiently low levels of dissolved salts and microbes.

Additional guidance:

Water of the correct quality is produced by:

- choosing an appropriate source
- passing the water through filter beds to remove any solids
- sterilising with chlorine.

- b) Water filters containing carbon, silver and ion exchange resins can remove some dissolved substances from tap water to improve the taste and quality.

Detailed knowledge of specific water filters is **not** required.

Examination questions may give information about water filters so that comparisons can be made.

Candidates should understand the principles of how ion exchange resins work but do **not** need detailed knowledge of the structure or chemical nature of specific resins.

- c) Chlorine may be added to drinking water to reduce microbes and fluoride may be added to improve dental health.

Candidates should be aware of the arguments for and against the addition of fluoride to drinking water.

- d) Pure water can be produced by distillation.

Candidates should be aware of the large amount of energy needed for distillation and, as a consequence, of the high costs involved.

Suggested ideas for practical work to develop skills and understanding include the following:

- investigation of which ions cause hard water, eg adding soap solution to solutions of NaCl, CaCl₂, KCl, and MgCl₂
- making temporary hard water by adding excess carbon dioxide to limewater
- determining hardness of samples of water – shake with soap solution – measuring cm³ of soap to get permanent lather
- the removal of hardness:
 - temporary hardness: test before and after boiling, with soap
 - permanent hardness: test before and after addition of sodium carbonate
- testing hard water before and after passing through an ion exchange column
- using conductivity sensors to analyse different samples of hard and soft water
- design and carry out an investigation to compare the effectiveness of commercial water softeners using soap titration
- investigating the various types of water ‘filters’ that are commercially available
- distillation of seawater – design a simple apparatus to do the distillation and check the quality of the distillate (boiling point and evaporation to dryness of a sample on a watch glass).

C3.3 Calculating and explaining energy change

Knowing the amount of energy involved in chemical reactions is useful so that resources are used efficiently and economically. It is possible to measure the amount of energy experimentally or to calculate it.

Candidates should use their skills, knowledge and understanding to:

- consider the social, economic and environmental consequences of using fuels
- interpret simple energy level diagrams in terms of bond breaking and bond formation (including the idea of activation energy and the effect on this of catalysts)
- evaluate the use of hydrogen to power cars compared to other fuels

Additional guidance:

Candidates may be provided with information for comparison and evaluation. For example, they may be given information about the ingredients of a particular food or the components of a fuel, but will **not** be expected to have knowledge of the constituents of commercial products beyond that specified in the subject content for this unit.

C3.3.1 Energy from reactions

- a) The relative amounts of energy released when substances burn can be measured by simple calorimetry, eg by heating water in a glass or metal container. This method can be used to compare the amount of energy released by fuels and foods.

Additional guidance:

Candidates should be able to calculate and compare the amount of energy released by different fuels given the equation:

$$Q = mc \Delta T$$

- b) Energy is normally measured in joules (J).

For comparison purposes, energy values could be given in kJ or calories for a given mass or amount of substance, eg calories per gram, kJ per mole or kJ per gram. If candidates are required to convert from calories to joules, the conversion factor will be given in questions.

- c) The amount of energy released or absorbed by a chemical reaction in solution can be calculated from the measured temperature change of the solution when the reagents are mixed in an insulated container. This method can be used for reactions of solids with water or for neutralisation reactions.

- d) Simple energy level diagrams can be used to show the relative energies of reactants and products, the activation energy and the overall energy change of a reaction.

Additional guidance:

Candidates will be expected to understand simple energy level diagrams showing the relative energies of reactants and products, the activation energy and the overall energy change, with a curved arrow to show the energy as the reaction proceeds. Candidates should be able to relate these to exothermic and endothermic reactions.

- e) During a chemical reaction:

- energy must be supplied to break bonds
- energy is released when bonds are formed.

- f) **In an exothermic reaction, the energy released from forming new bonds is greater than the energy needed to break existing bonds.**

Additional guidance:**HT only**

Candidates should be able to calculate the energy transferred in reactions using supplied bond energies.

- g) **In an endothermic reaction, the energy needed to break existing bonds is greater than the energy released from forming new bonds.**

HT only

- h) Catalysts provide a different pathway for a chemical reaction that has a lower activation energy.

Candidates should be able to represent the effect of a catalyst on an energy level diagram.

- i) Hydrogen can be burned as a fuel in combustion engines.

hydrogen + oxygen \longrightarrow water

It can also be used in fuel cells that produce electricity to power vehicles.

Knowledge of the details of the reactions in fuel cells is **not** required. Candidates should be able to compare the advantages and disadvantages of the combustion of hydrogen with the use of hydrogen fuel cells from information that is provided.

Suggested ideas for practical work to develop skills and understanding include the following:

- design an investigation to compare the energy produced by different liquid fuels and different foods using a simple calorimeter
- measuring and calculating the energy change for exothermic reactions (eg react acid with *Mg* ribbon) and endothermic reactions (eg dissolving potassium nitrate)
- carrying out some reactions and measuring the energy produced, assuming that it is only the water in the solution that is being heated and that 4.2 joules will raise the temperature of 1 cm³ of water by 1 °C.

C3.4 Further analysis and quantitative chemistry

A range of chemical tests can be used for the detection and identification of elements and compounds. Titrations can be used to find the amounts of acid or alkali in a solution.

Candidates should use their skills, knowledge and understanding to:

- interpret results of the chemical tests in this specification
- interpret and evaluate the results of analyses carried out to identify elements and compounds for forensic, health or environmental purposes.

Additional guidance:

Candidates are expected to know the chemical tests specified in the subject content and may be asked to interpret results of any of those tests applied to solutions or mixtures of substances in different contexts.

Candidates should be able to comment on results and data from such analyses that are presented to them. This will **not** include interpretation of detailed information that uses knowledge beyond that expected at GCSE.

C3.4.1 Analysing substances

- a) Flame tests can be used to identify metal ions. Lithium, sodium, potassium, calcium and barium compounds produce distinctive colours in flame tests:
 - lithium compounds result in a crimson flame
 - sodium compounds result in a yellow flame
 - potassium compounds result in a lilac flame
 - calcium compounds result in a red flame
 - barium compounds result in a green flame.
- b) Aluminium, calcium and magnesium ions form white precipitates with sodium hydroxide solution but only the aluminium hydroxide precipitate dissolves in excess sodium hydroxide solution.
- c) Copper(II), iron(II) and iron(III) ions form coloured precipitates with sodium hydroxide solution. Copper forms a blue precipitate, iron(II) a green precipitate and iron(III) a brown precipitate.
- d) Carbonates react with dilute acids to form carbon dioxide. Carbon dioxide produces a white precipitate with limewater. This turns limewater cloudy.
- e) Halide ions in solution produce precipitates with silver nitrate solution in the presence of dilute nitric acid. Silver chloride is white, silver bromide is cream and silver iodide is yellow.

Additional guidance:

Flame colours of other metal ions are **not** required knowledge.

- f) Sulfate ions in solution produce a white precipitate with barium chloride solution in the presence of dilute hydrochloric acid.

- g) The volumes of acid and alkali solutions that react with each other can be measured by titration using a suitable indicator.

- h) **If the concentration of one of the reactants is known, the results of a titration can be used to find the concentration of the other reactant.**

Additional guidance:

Candidates should be able to carry out titrations using strong acids and strong alkalis only (sulfuric, hydrochloric and nitric acids only).

HT only

Candidates should be able to calculate the chemical quantities in titrations involving concentrations (in moles per dm³) and masses (in grams per dm³).

Suggested ideas for practical work to develop skills and understanding include the following:

- flame tests – spray solution into flame or use wooden splints soaked in solutions overnight or use nichrome wire loops
- try tests using mixtures of two salts, eg flame tests on solutions containing pairs of the listed ions
- Fe²⁺ with sodium hydroxide solution – note that the initial colour is quickly oxidised
- react carbonates with acid and test the gas for CO₂ using a drop of limewater on a glass rod
- distinguishing between the halide ions using silver nitrate solution
- identifying unknown single salts using the tests in the content
- plan a suitable order of tests to use on a solution that contains an unknown single salt
- strong acid/strong alkali titrations (HCl/NaOH) to find unknown concentration (using indicators and pH sensors to determine titration endpoints).

C3.5 The production of ammonia

In industrial processes, energy requirements and emissions need to be considered both for economic reasons and for sustainable development.

Candidates should use their skills, knowledge and understanding to:

- evaluate the conditions necessary in an industrial process to maximise yield and minimise environmental impact

Additional guidance:

HT only

- **describe and evaluate the effects of changing the conditions of temperature and pressure on a given reaction or process**
- evaluate the conditions used in industrial processes in terms of energy requirements.

C3.5.1 Making ammonia

- a) The raw materials for the Haber process are nitrogen and hydrogen. Nitrogen is obtained from the air and hydrogen may be obtained from natural gas or other sources.
- b) The purified gases are passed over a catalyst of iron at a high temperature (about 450 °C) and a high pressure (about 200 atmospheres). Some of the hydrogen and nitrogen reacts to form ammonia. The reaction is reversible so ammonia breaks down again into nitrogen and hydrogen:



On cooling, the ammonia liquefies and is removed. The remaining hydrogen and nitrogen are recycled.

- c) **When a reversible reaction occurs in a closed system, equilibrium is reached when the reactions occur at exactly the same rate in each direction.**
- d) **The relative amounts of all the reacting substances at equilibrium depend on the conditions of the reaction.**
- e) **If the temperature is raised, the yield from the endothermic reaction increases and the yield from the exothermic reaction decreases.**
- f) **If the temperature is lowered, the yield from the endothermic reaction decreases and the yield from the exothermic reaction increases.**
- g) **In gaseous reactions, an increase in pressure will favour the reaction that produces the least number of molecules as shown by the symbol equation for that reaction.**
- h) **These factors, together with reaction rates, are important when determining the optimum conditions in industrial processes, including the Haber process.**

Additional guidance:

HT only

HT only

HT only

HT only

HT only

HT only

Suggested ideas for practical work to develop skills and understanding include the following:

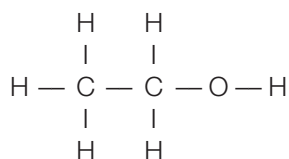
- demonstration of the effect of adding acid and then alkali to bromine water to show the effect of changing conditions on equilibrium
- investigation of the effect of adding acid and then alkali to a solution of potassium chromate
- modelling dynamic equilibrium with two 25 cm³ measuring cylinders, each with an open-ended glass tube but with different diameters. Put 25 cm³ of water into one cylinder. Transfer water from one cylinder to the other using a finger over the end of each tube in turn (keep the tubes in the same cylinder) until the level in each cylinder does not change any more
- demonstration of effect of temperature and pressure on equilibrium using 50 cm³ of NO₂/N₂O₄ in a gas syringe.

C3.6 Alcohols, carboxylic acids and esters

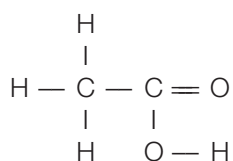
Alcohols and carboxylic acids are important organic chemicals that have many uses. Alcohols react with carboxylic acids to produce esters.

Candidates should use their skills, knowledge and understanding to:

- represent the structures of alcohols in the following forms:



- represent the structures of carboxylic acids in the following forms:



- evaluate the social and economic advantages and disadvantages of the uses of alcohols, carboxylic acids and esters.

Additional guidance:

Candidates may be given information and data about alcohols, carboxylic acids and esters for comparison and evaluation in the examination.

C3.6.1 Alcohols

- a) Alcohols contain the functional group -OH . Methanol, ethanol and propanol are the first three members of a homologous series of alcohols.

Additional guidance:

Candidates should be able to recognise alcohols from their names or formulae, but do **not** need to know the names of individual alcohols, other than methanol, ethanol and propanol.

- b) Methanol, ethanol and propanol:

- dissolve in water to form a neutral solution
- react with sodium to produce hydrogen
- burn in air
- are used as fuels and solvents, and ethanol is the main alcohol in alcoholic drinks.

Candidates are **not** expected to write balanced chemical equations for the reactions of alcohols other than combustion reactions.

- c) Ethanol can be oxidised to ethanoic acid, either by chemical oxidising agents or by microbial action. Ethanoic acid is the main acid in vinegar.

Candidates should be aware that vinegar is an aqueous solution that contains ethanoic acid.

C3.6.2 Carboxylic acids

- a) Ethanoic acid is a member of the carboxylic acids, which have the functional group -COOH .

Additional guidance:

Candidates should be able to recognise carboxylic acids from their names or formulae, but do **not** need to know the names of individual carboxylic acids, other than methanoic acid, ethanoic acid and propanoic acid.

- b) Carboxylic acids:

- dissolve in water to produce acidic solutions
- react with carbonates to produce carbon dioxide
- react with alcohols in the presence of an acid catalyst to produce esters
- **do not ionise completely when dissolved in water and so are weak acids**
- **aqueous solutions of weak acids have a higher pH value than aqueous solutions of strong acids with the same concentration.**

Candidates are **not** expected to write balanced chemical equations for the reactions of carboxylic acids.

HT only

HT only

C3.6.3 Esters

- a) Ethyl ethanoate is the ester produced from ethanol and ethanoic acid. Esters have the functional group -COO- . They are volatile compounds with distinctive smells and are used as flavourings and perfumes.

Additional guidance:

Candidates will **not** be expected to give the names of esters other than ethyl ethanoate, but should be able to recognise a compound as an ester from its name or its structural formula.

Suggested ideas for practical work to develop skills and understanding include the following:

- investigation of the reactions of ethanol
- comparison of properties of ethanol with water
- oxidation of ethanol using aqueous potassium dichromate
- design and carry out an investigation of the oxidation of dilute solutions of ethanol (eg wine or beer) by exposing to the air for several days
- comparison of the reactions of methanol, ethanol and propanol
- investigation of the reactions of ethanoic acid
- distinguishing between samples of ethanol, ethanoic acid and ethyl ethanoate using simple chemical tests
- preparation of ethyl ethanoate using ethanol and ethanoic acid with sulfuric acid as a catalyst. Recognise the ester by smell after neutralising the acid with sodium hydrogencarbonate
- add drops of esters to water to smell more effectively.



3.6 Unit 4: Controlled Assessment

3.6.1 Introduction

This unit is assessed by Controlled Assessment. It is worth 25 % of the total marks and consists of a minimum of **one** practical investigation based on topics in the specification.

Access arrangements (see sections 4.5 and 5.4) can enable candidates with special needs to undertake this assessment.

Teachers are encouraged to undertake a wide range of practical and investigative work, including fieldwork, with their candidates. We take the view that it is not good practice to do practical work only for the Controlled Assessment. As teachers know well, candidates enjoy and are motivated by practical work. Throughout this specification we have given many examples of practical work supporting the science content. Full details of this practical work are included in our resources package.

In this unit, candidates use a range of practical skills and knowledge in **one** investigation chosen from those supplied by AQA. The investigations are based on topics in the specification. Guidance for teachers will be given with each investigation. Every year, three Controlled Assessments will be available; one for Unit 2 and two for Unit 3. Each task assesses How Science Works skills, not candidates' knowledge and understanding of the science context.

The right-hand column of the tables below shows the Assessment Focus thread from APP (Assessing Pupils' Progress). This will enable teachers to ensure progression from KS3 to KS4.

C4.1 Plan practical ways to develop and test candidate's own scientific ideas

Candidates should be able to:

C4.1.1 develop hypotheses and plan practical ways to test them, by:

- a) being able to develop a hypothesis
- b) being able to test hypotheses
- c) using appropriate technology.

Additional guidance:

AF/thread

Candidates should be able to suggest the outcome of an investigation.

1/4

Candidates should be able to plan a fair test to investigate their hypothesis.

1/4

Candidates should appreciate that technology such as data logging may provide a better means of obtaining data. They should be able to suggest appropriate technology for collecting data and explain why a particular technological method is the most appropriate. Candidates should use ICT whenever appropriate.

4/1

C4.2 Assess and manage risks when carrying out practical work

Candidates should be able to:

C4.2.1 assess and manage risks when carrying out practical work, by:

- a) identifying some possible hazards in practical situations
- b) suggest ways of managing risks.

Additional guidance:

AF/thread

Candidates will be expected to independently recognise a range of familiar hazards and consult appropriate resources and expert advice.

4/4

Candidates should assess risks to themselves and others and take action to reduce these risks by adapting their approaches to practical work in order to control risk.

4/4

C4.3 Collect primary and secondary data

Candidates should be able to:

C4.3.1 make observations, by:

- a) carrying out practical work and research, and using the data collected to develop hypotheses.

AF/thread

4/3

C4.3.2 demonstrate an understanding of the need to acquire high-quality data, by:

- a) appreciating that, unless certain variables are controlled, the results may not be valid

Additional guidance:**AF/thread**

Candidates should be able to explain whether results can be considered valid and recognise when an instrument or technique might not be measuring the variable intended.

4/3

- b) identifying when repeats are needed in order to improve reproducibility

Candidates should recognise that a second set of readings with another instrument or by a different observer could be used to cross check results.

4/3

- c) recognising the value of further readings to establish repeatability and accuracy

Candidates should understand that accuracy is a measure of how close the measured value is to the true value.

4/3

- d) considering the resolution of the measuring device

Candidates should be able to explain that resolution is the smallest change in the quantity being measured (input) of a measuring instrument that gives a perceptible change in the indication (output).

4/3

- e) considering the precision of the measured data where precision is indicated by the degree of scatter from the mean.

Candidates should be able to distinguish between accuracy and precision when applied to an instrument's readings.

4/3

- f) identifying the range of the measured data.

Candidates should be able to identify the upper and lower limits of the range and be able to identify which extra results, within or outside the range would be appropriate.

4/3**C4.4 Select and process primary and secondary data****Candidates should be able to:****C4.4.1 show an understanding of the value of means, by:**

- a) appreciating when it is appropriate to calculate a mean

Additional guidance:**AF/thread****5/1**

- b) calculating the mean of a set of at least three results.

Candidates should be able to recognise the need to exclude anomalies before calculating means to an appropriate number of decimal places.

5/1**C4.4.2 demonstrate an understanding of how data may be displayed, by:**

- a) drawing tables

Additional guidance:**AF/thread**

Candidates should be able to draw up a table of two or more columns, with correct headings and units, adequately representing the data obtained.

3/2

- b) drawing charts and graphs

Candidates should be able to construct an appropriate graphical representation of the data such as a bar chart or line graph and draw a line of best fit when appropriate. Candidates may use ICT to produce their graphs or charts.

3/2

- c) choosing the most appropriate form of presentation.

Candidates should be able to identify the most appropriate method of display for any given set of data.

3/1

C4.5 Analyse and interpret primary and secondary data

Candidates should be able to:

C4.5.1 distinguish between a fact and an opinion, by:

- a) recognising that an opinion might be influenced by factors other than scientific fact
- b) identifying scientific evidence that supports an opinion.

Additional guidance:	AF/thread
Candidates should recognise that the opinion may be influenced by economic, ethical, moral, social or cultural considerations.	2/1
	1/2

C4.5.2 review methodology to assess fitness for purpose, by:

- a) identifying causes of variation in data
- b) recognising and identifying the cause of random errors. If a data set contains random errors, repeating the readings and calculating a new mean can reduce their effect
- c) recognising and identifying the cause of anomalous results
- d) recognising and identifying the cause of systematic errors.

Additional guidance:	AF/thread
Candidates should be able to identify from data whether there is any variation other than obvious anomalies, and identify a potential cause for variation or uncertainty.	5/2
Candidates should appreciate that human error might be the cause of inaccurate measurements and explain how human error might have influenced the accuracy of a measurement or might have introduced bias into a set of readings.	5/2
Candidates should be able to identify anomalous results and suggest what should be done about them.	5/2
Candidates should be able to identify when a data set contains a systematic error and appreciate that repeat readings cannot reduce the effect of systematic errors.	5/2
Candidates should realise that a zero error is a type of systematic error. Candidates should be able to identify if a scale has been incorrectly used and suggest how to compensate for a zero error.	5/2

C4.5.3 identify patterns in data, by:

- a) describing the relationship between two variables and deciding whether the relationship is causal or by association.

Additional guidance:	AF/thread
Candidates should be able to use terms such as linear or directly proportional, or describe a complex relationship.	5/3

C4.5.4 draw conclusions using scientific ideas and evidence, by:

a) writing a conclusion, based on evidence that relates correctly to known facts

b) using secondary sources

c) identifying extra evidence that is required for a conclusion to be made

d) evaluating methods of data collection.

Additional guidance:**AF/thread**

Candidates should be able to state simply what the evidence shows to justify a conclusion, and recognise the limitations of evidence.

5/3

Candidates should appreciate that secondary sources or alternative methods can confirm reproducibility.

5/3

Candidates should be able to suggest that extra evidence might be required for a conclusion to be made, and be able to describe the extra evidence required.

5/4

Candidates should appreciate that the evidence obtained may not allow the conclusion to be made with confidence. Candidates should be able to explain why the evidence obtained does not allow the conclusion to be made with confidence.

5/4**C4.6 Use of scientific models and evidence to develop hypotheses, arguments and explanations****Candidates should be able to:****C4.6.1 review hypotheses in the light of outcomes, by:**

a) considering whether or not any hypothesis made is supported by the evidence

b) developing scientific ideas as a result of observations and measurements.

Additional guidance:**AF/thread**

Candidates should be able to assess the extent to which the hypothesis is supported by the outcome.

1/2

Candidates should be able to suggest ways in which the hypothesis may need to be amended, or whether it needs to be discarded in the light of the achieved outcome of an investigation.

1/2

Guidance on Managing Controlled Assessment

What is Controlled Assessment?

For each subject, Controlled Assessment regulations from Ofqual stipulate the level of control required for task setting, task taking and task marking. The 'task' is what the candidate has to do; the 'level of control' indicates the degree of freedom given to teachers and candidates for different aspects of the 'task'.

For GCSE Chemistry, the regulations state:

Task setting – high control

Task taking

(research/data collection) – limited control

Task taking

(analysis and evaluation of findings) – high control

Task marking – medium control

For this specification, this means:

- We prepare equivalent Investigative Skills Assignments (ISAs) each year.
- We require the practical work and data collection to be carried out under teacher supervision, during normal class contact time.
- If more than one lesson is used, candidates' data and research work must be collected at the end of each lesson.
- Candidates can work together during the investigation, but each candidate must contribute to the collection of the data and process the data individually.
- ISA tests should be taken under formal supervision, in silence, without cooperation between candidates.
- Candidates should be given their processed data for reference during the ISA test, and will also be provided with a data sheet of secondary data.
- Teachers should not help candidates answer the questions.
- Each ISA test has a fixed time limit unless the candidate is entitled to access arrangements.
- Candidates' processed data and their ISA tests are collected by the teacher at the end of each test.
- We provide 'marking guidelines' for each ISA test.
- We moderate your marking.

What is the Controlled Assessment like?

The Controlled Assessment comprises an ISA test which is assessed in two sections.

Prior to taking Section 1 of the ISA test, candidates independently develop their own hypothesis and research possible methods for carrying out an experiment to test **their** hypothesis. During this research, candidates need to do a risk assessment and prepare a table for their results.

Section 1 of the ISA test (45 minutes, 20 marks) consists of questions relating to the candidate's own research.

Following Section 1 candidates carry out their investigation, and record and analyse their results. If the candidate's plan is unworkable, unsafe or unmanageable in the laboratory then they may be provided with a method – an example of which will be provided by AQA. For plans that are otherwise good, but unworkable for a good reason (ie logistical) candidates should not lose any marks. However, where the plan is dangerous or unworkable (from a scientific perspective) this will be reflected in the marking.

Section 2 of the ISA test (50 minutes, 30 marks) consists of questions related to the experiment candidates have carried out. They are also provided with a data sheet of secondary data by AQA, from which they select appropriate data to analyse and compare with their own results.

Candidates will be asked to suggest how ideas from their investigation and research could be used within a context.

Using ISAs

The documents provided by AQA for each ISA are:

- a set of Teachers' Notes
- the ISA – Section 1 and Section 2 which are to be copied for each candidate
- the marking guidelines for the teacher to use.

The Teachers' Notes provide suggestions on how to incorporate ISAs into the scheme of work. About five lessons should be allowed for the ISA: one lesson for discussion, research and planning; one lesson for the completion of Section 1; one or two lessons for completing the experiment and processing their results and one lesson for completing Section 2 of the ISA.

Candidates will be expected to plan their investigation independently and should each draw up an appropriate table for recording their results.

While carrying out the investigation, candidates should make and record observations. They should make measurements with precision and accuracy. They should record data as it is obtained in a table. They should use ICT where appropriate. Candidates are also required to process the data into a graph or chart.

Candidates' tables of data and graphs or charts must be collected by the teacher at the end of each lesson. Candidates must **not** be allowed to work on the presentation or processing of their data between lessons, because marks are available for these skills.

The paper containing Section 2 of the ISA should be taken as soon as possible after completion of the investigation.

During the test, candidates should work on their own and in silence. When candidates have completed the test the scripts must be collected. Teachers are required to mark the tests, using the marking guidelines provided by AQA. Tests should be marked in red ink with subtotals placed in the margin.

Teachers are expected to use their professional judgement in applying the marking guidelines: for example, applying it sensibly where candidates have given unexpected answers. When teachers have marked the scripts, they may tell candidates their marks but they must not return the scripts. Completed ISAs must be kept under secure conditions while the ISA is valid.

Other guidance

Teachers' Notes will be put on to the AQA website prior to the ISAs becoming valid. ISA tests and marking guidelines will be published in advance.

If ISAs are to be used with different classes, centres must ensure security between sessions.

ISAs have specific submission dates. They may not be submitted in more than one year. The submission dates are stated on the front cover of each ISA.

Candidates may attempt any number of the ISAs supplied by AQA for a particular subject. The best mark they achieve from a complete ISA is submitted.

A candidate is only allowed to have **one** attempt at each ISA, and this may only be submitted for moderation on **one** occasion. It would constitute **malpractice** if the candidate is found to have submitted the same ISA more than once and they could be excluded from at least this qualification.

Specimen ISAs or ISAs that are no longer valid may be given to candidates so that they can practise the skills required. In these cases, candidates can be given back their completed and marked scripts. However, ISAs that are currently valid must **not** be given back to candidates.

3.7 Mathematical and other requirements

Mathematical requirements

One learning outcome of this specification is to provide learners with the opportunity to develop their skills in communication, mathematics and the use of technology in scientific contexts. In order to deliver the mathematical element of this outcome, assessment materials for this specification contain opportunities for candidates to demonstrate scientific knowledge using appropriate mathematical skills.

The areas of mathematics that arise naturally from the science content in science GCSEs are listed below. This is not a checklist for each question paper or Controlled Assessment, but assessments reflect these mathematical requirements, covering the full range of mathematical skills over a reasonable period of time.

Candidates are permitted to use calculators in all assessments.

Candidates are expected to use units appropriately. However, not all questions reward the appropriate use of units.

All candidates should be able to:

- 1 Understand number size and scale and the quantitative relationship between units.
- 2 Understand when and how to use estimation.
- 3 Carry out calculations involving $+$, $-$, \times , \div , either singly or in combination, decimals, fractions, percentages and positive whole number powers.
- 4 Provide answers to calculations to an appropriate number of significant figures.
- 5 Understand and use the symbols $=$, $<$, $>$, \sim .
- 6 Understand and use direct proportion and simple ratios.
- 7 Calculate arithmetic means.
- 8 Understand and use common measures and simple compound measures such as speed.
- 9 Plot and draw graphs (line graphs, bar charts, pie charts, scatter graphs, histograms) selecting appropriate scales for the axes.
- 10 Substitute numerical values into simple formulae and equations using appropriate units.
- 11 Translate information between graphical and numeric form.
- 12 Extract and interpret information from charts, graphs and tables.

13 Understand the idea of probability.

14 Calculate area, perimeters and volumes of simple shapes.

In addition, Higher Tier candidates should be able to:

- 15 Interpret, order and calculate with numbers written in standard form.
- 16 Carry out calculations involving negative powers (only -1 for rate).
- 17 Change the subject of an equation.
- 18 Understand and use inverse proportion.
- 19 Understand and use percentiles and deciles.

Units, symbols and nomenclature

Units, symbols and nomenclature used in examination papers will normally conform to the recommendations contained in the following:

- *The Language of Measurement: Terminology used in school science investigations.* Association for Science Education (ASE), 2010. ISBN 978 0 86357 424 5.
- *Signs, Symbols and Systematics – the ASE companion to 16–19 Science.* Association for Science Education (ASE), 2000. ISBN 978 0 86357 312 5.
- *Signs, Symbols and Systematics – the ASE companion to 5–16 Science.* Association for Science Education (ASE), 1995. ISBN 0 86357 232 4.

Data sheet

A data sheet will be provided for each of the written units. This includes a periodic table and other information. Candidates will be expected to select the appropriate information to answer the question.

Scheme of Assessment

4.1 Aims and learning outcomes

GCSE specifications in chemistry should encourage learners to be inspired, motivated and challenged by following a broad, coherent, practical, satisfying and worthwhile course of study. They should encourage learners to develop their curiosity about the material and physical worlds and provide insight into and experience of how science works. They should enable learners to engage with chemistry in their everyday lives and to make informed choices about further study in chemistry and related disciplines and about career choices.

GCSE specifications in chemistry must enable learners to:

- develop their knowledge and understanding of chemistry
- develop their understanding of the effects of chemistry on society
- develop an understanding of the importance of scale in chemistry
- develop and apply their knowledge and understanding of the nature of science and of the scientific process
- develop their understanding of the relationships between hypotheses, evidence, theories and explanations
- develop their awareness of risk and the ability to assess potential risk in the context of potential benefits
- develop and apply their observational, practical, modelling, enquiry and problem-solving skills and understanding in the laboratory and other learning environments
- develop their ability to evaluate claims based on science through critical analysis of the methodology, evidence and conclusions both qualitatively and quantitatively
- develop their skills in communication, mathematics and the use of technology in scientific contexts.



4.2 Assessment Objectives

The assessment units assess the following Assessment Objectives (AOs) in the context of the content and skills set out in Section 3 (Subject Content).

AO1 Recall, select and communicate their knowledge and understanding of chemistry

AO2 Apply skills, knowledge and understanding of chemistry in practical and other contexts

AO3 Analyse and evaluate evidence, make reasoned judgements and draw conclusions based on evidence

Weighting of Assessment Objectives for GCSE Chemistry M (modular)

The table below shows the approximate weighting of each of the Assessment Objectives in the GCSE units.

Assessment Objectives	Unit Weightings (%)				Overall weighting of AOs (%)
	UNIT				
	1	2	3	4	
AO1	12.5	12.5	12.5	0	37.5
AO2	7.5	7.5	7.5	12.5	35.0
AO3	5.0	5.0	5.0	12.5	27.5
Overall weighting of units (%)	25	25	25	25	100.0

Quality of Written Communication

In GCSE specifications that require candidates to produce written material in English, candidates must do the following:

- ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

In this specification Quality of Written Communication (QWC) is assessed in units 1, 2, 3 and 4 by means of longer response questions. These questions are clearly indicated in each question paper. In these questions, candidates cannot obtain full marks unless they address the three bullet points listed in this section.

4.3 National criteria

This specification complies with:

- the Subject Criteria for GCSE Chemistry including the rules for Controlled Assessment
- the Code of Practice
- the GCSE Qualification Criteria as they apply to non-English centres
- the Arrangements for the Statutory Regulation of External Qualifications in England, Wales and Northern Ireland: Common Criteria
- the requirements for qualifications to provide access to Levels 1 and 2 of the National Qualification Framework.

4.4 Previous Learning requirements

There are no previous learning requirements. However, any requirements set for entry to a course based on this specification are at your centre's discretion.

4.5 Access to assessment: diversity and inclusion

GCSEs often need to assess a wide range of competences. This is because they are general qualifications designed to prepare candidates for a wide range of occupations and further study.

The revised GCSE Qualification and Subject Criteria were reviewed to see whether any of the skills or knowledge needed by the subject presented a possible difficulty to any candidates, whatever their ethnic background, religion, sex, age, disability or sexuality. If there were difficulties, the situation was reviewed again to make sure that such tests of specific competences were only included if they were important to the subject. The findings were discussed with groups who represented the interests of a diverse range of candidates.

The Assessment Objectives do not assess the ability of students to see, speak, hear, read independently, handwrite, manipulate manually, perform physically, or to work in a team. The assessments allow the use of readers, scribes, practical assistants, word processors, transcripts, BSL/ISL signers, live speakers, MQ papers and extra time. For Controlled Assessment tasks, practical assistants may assist under instruction from the student. Arrangements are made for candidates with special needs to help them access the assessments as long as the competences being tested are not changed. Because of this, most candidates will be able to access any part of the assessment. Section 5.4 provides further details.



Administration

5.1 Availability of assessment units and certification

Examinations and certification for this specification are available as follows.

	Availability of units				Availability of certification
	UNIT				GCSE
	1	2	3	4	
January 2013	✓				
June 2013	✓	✓			
January 2014	✓	✓			
June 2014	✓	✓	✓	✓	✓

5.2 Entries

Please check the current version of *Entry Procedures and Codes* for up-to-date entry procedures. You should use the following entry codes for the units and for certification.

Unit 1 – MCH1FP or MCH1HP

Unit 2 – MCH2FP or MCH2HP

Unit 3 – MCH3FP or MCH3HP

Unit 4 – MCH4P

GCSE certification – 4602

The 40 % terminal rule for GCSE means that 40 % of the assessment must be taken in the examination series in which the qualification is awarded.

The results from 40% terminal assessment must contribute to the candidate's final grade, even if a candidate has a better result from a previous series.

Please note that entries are not allowed in the same examination series for the following combination of GCSE certifications:

- GCSE Chemistry M (modular) and GCSE Chemistry
- GCSE Chemistry M (modular) and GCSE Science A or GCSE Science M (modular)
- GCSE Chemistry M (modular) and GCSE Additional Science or GCSE Additional Science M (modular)

5.3 Private candidates

This specification is available to private candidates under certain conditions. Because of the Controlled Assessment, candidates must attend an AQA centre, which will supervise and mark the Controlled

Assessment. Private candidates should write to us for a copy of *Supplementary Guidance for Private Candidates* (for Controlled Assessment specification with practical activities).

5.4 Access arrangements, reasonable adjustments and special consideration

We have taken note of the equality and discrimination legislation and the interests of minority groups in developing and administering this specification.

We follow the guidelines in the Joint Council for Qualifications (JCQ) document: *Access Arrangements, Reasonable Adjustments and Special Consideration: General and Vocational Qualifications*. This is published on the JCQ website (www.jcq.org.uk) or you can follow the link from our website www.aqa.org.uk

Access arrangements

We can arrange for candidates with special needs to access an assessment. These arrangements must be made **before** the examination. For example, we can produce a Braille paper for a candidate with sight problems.

Reasonable adjustments

An access arrangement which meets the needs of a particular disabled candidate would be a reasonable adjustment for that candidate. For example, a Braille paper would be a reasonable adjustment for a Braille reader but not for a candidate who did not read Braille. The Equality Act requires us to make reasonable adjustments to remove or lessen any disadvantage affecting a disabled candidate.

Special consideration

We can give special consideration to candidates who have had a temporary illness, injury or serious problem such as the death of a relative, at the time of the examination. We can only do this **after** the examination.

The Examinations Officer at the centre should apply online for access arrangements and special consideration by following the e-AQA link from our website www.aqa.org.uk

5.5 Examination language

We will only provide units for this specification in English.

5.6 Qualification titles

Qualifications based on this specification are:

- AQA GCSE in Chemistry M (modular).

5.7 Awarding grades and reporting results

This GCSE will be graded on an eight-grade scale: A*, A, B, C, D, E, F and G. Candidates who fail to reach the minimum standard for grade G will be recorded as 'U' (unclassified) and will not receive a qualification certificate.

We will publish the minimum raw mark for each grade and for each unit when we issue candidates' results. We will report a candidate's unit results to your centre in terms of uniform marks and qualification results in terms of uniform marks and grades.

For each unit, the uniform mark corresponds to a grade as follows.

Unit 1: Chemistry 1

(maximum uniform mark = 100)

Grade	Uniform Mark Range
A*	90–100
A	80–89
B	70–79
C	60–69
D	50–59
E	40–49
F	30–39
G	20–29
U	0–19

Unit 2: Chemistry 2

(maximum uniform mark = 100)

Grade	Uniform Mark Range
A*	90–100
A	80–89
B	70–79
C	60–69
D	50–59
E	40–49
F	30–39
G	20–29
U	0–19

Unit 3: Chemistry 3

(maximum uniform mark = 100)

Grade	Uniform Mark Range
A*	90–100
A	80–89
B	70–79
C	60–69
D	50–59
E	40–49
F	30–39
G	20–29
U	0–19

Unit 4: Controlled Assessment

(maximum uniform mark = 100)

Grade	Uniform Mark Range
A*	90–100
A	80–89
B	70–79
C	60–69
D	50–59
E	40–49
F	30–39
G	20–29
U	0–19

We calculate a candidate's total uniform mark by adding together the uniform marks for the units. We convert this total uniform mark to a grade as follows.

GCSE Chemistry M (modular)

(maximum uniform mark = 400)

Grade	Uniform Mark Range
A*	360–400
A	320–359
B	280–319
C	240–279
D	200–239
E	160–199
F	120–159
G	80–119
U	0–79

5.8 Grading and tiers

The Controlled Assessment is not tiered and the full range of grades A*–G is available to candidates for this unit.

For the other units, candidates take either the Foundation Tier or the Higher Tier. For candidates entered for the Foundation Tier, grades C–G are available; for candidates entered for the Higher Tier, A*–D are available. There is a safety net for candidates entered for the Higher Tier, where an allowed grade E will be awarded if candidates just fail to achieve grade D. Candidates who fail to achieve a grade E on the Higher Tier or grade G on the Foundation Tier will be reported as unclassified.

For the tiered units, candidates cannot obtain a Uniform Mark Scheme (UMS) score corresponding to a grade that is above the range for the tier entered.

The maximum UMS score for candidates on a Foundation Tier written paper is 69. In other words, they cannot achieve a UMS score corresponding to a grade B. Candidates who just fail to achieve grade E on the Higher Tier paper receive the UMS score corresponding to their raw mark (ie they do not receive a UMS score of zero).

During the awarding procedures the relationship between raw marks and UMS score is decided for each tier separately. Where a grade is available on two tiers, for example grade C, the two raw marks chosen as the boundary for the grade on the two tiers are given the same UMS score. Therefore, candidates receive the same UMS score for the same achievement whether this is demonstrated on the Foundation or the Higher Tier assessments.

5.9 Re-sits and shelf life of unit results

Unit results remain available to count towards certification within the shelf life of the specification, whether or not they have already been used.

Candidates may re-sit a unit once only.

The better result for each unit will count towards the final qualification **provided that the 40% rule is satisfied**.

Candidates may re-sit the qualification an unlimited number of times.

Candidates will be graded on the basis of the work submitted for assessment.

Candidates must take units comprising at least 40% of the total assessment in the series in which they enter for certification.



Controlled Assessment administration

The Head of Centre is responsible for making sure that Controlled Assessment work is conducted in line with our instructions and JCQ instructions.

6.1 Authentication of Controlled Assessment work

To meet the requirements of the Code of Practice, we need the following.

- **Candidates** must sign the Candidate Record Form to confirm that the work they have handed in is their own.
- **Teachers and assessors** must confirm on the Candidate Record Form that the work marked is only that done by that candidate and was conducted in line with the conditions in the specification document (authentication declaration).
- **Centres** must give a mark of zero if candidates cannot confirm the work handed in for assessment is their own.

You should attach the completed Candidate Record Form for each candidate to his or her work. All teachers who have marked the work of any candidate entered for each component must sign the declaration that the work is genuine.

If you have doubts about signing the authentication declaration, you should follow these guidance points.

- If you believe that a candidate had additional assistance and that this is acceptable within the guidelines for the relevant specification, you should award a mark which covers only the candidate's achievement without any help. (You should sign the authentication declaration and give information on the relevant form).
- If you cannot sign the authentication declaration, the candidate's work cannot be accepted for assessment.

If, during the external moderation process, there is no evidence that the work has been authenticated, we will award a mark of zero.

6.2 Malpractice

You should let candidates know about our malpractice regulations.

Candidates must **not**:

- submit work that is not their own
- lend work to other candidates
- give other candidates access to, or the use of, their own independently sourced research material (this does not mean that candidates cannot lend their books to another candidate, but that candidates should be stopped from copying other candidates' research)
- include work copied directly from books, the internet or other sources without acknowledgement of the source
- hand in work typed or word-processed by someone else without acknowledgement.

These actions are considered malpractice, for which a penalty (for example being disqualified from the exam) will be applied.

If you suspect malpractice, you should consult your Examinations Officer about the procedure to be followed.

Where you suspect malpractice in Controlled Assessments after the candidate has signed the declaration of authentication, your Head of Centre must submit full details of the case to us at the earliest opportunity. The form JCQ / M1 should be used. Copies of the form can be found on the JCQ website (www.jcq.org.uk).

Malpractice in Controlled Assessments discovered prior to the candidate signing the declaration of authentication need not be reported to us, but should be dealt with in accordance with your centre's internal procedures. We would expect you to treat such cases very seriously. Details of any work which is not the candidate's own must be recorded on the Candidate Record Form or other appropriate place.

6.3 Teacher standardisation

We will provide teacher standardisation opportunities for Controlled Assessment. Support will be provided in explaining tasks in context and using the marking criteria.

If your centre is new to this specification, you must complete teacher standardisation. If you have told us you are a new centre, either by sending us an *Intention to Enter* or an *Estimate of Entry*, or by contacting the subject team, we will contact you to provide details.

We will also contact centres in the following cases:

- if the moderation of Controlled Assessment work from the previous year has shown a serious misinterpretation of the Controlled Assessment requirements

- if a significant adjustment has been made to a centre's marks.

In these cases, you will also be expected to complete teacher standardisation. If you would like a copy of the written materials used at teacher standardisation, you should contact the subject administration team at **science-gcse@aqa.org.uk**

6.4 Internal standardisation of marking

Centres must have consistent marking standards for all candidates. One person must be responsible for ensuring that work has been marked to the same standard, and they need to sign the *Centre Declaration Sheet* to confirm that internal standardisation has taken place.

Internal standardisation may involve:

- all teachers marking some sample pieces of work and identifying differences in marking standards
- discussing any differences in marking at a training meeting for all teachers involved in the assessment
- referring to reference and archive material, such as previous work or examples from our teacher standardising meetings.

6.5 Annotation of Controlled Assessment work

The Code of Practice states that the awarding body must make sure that teachers marking Controlled Assessments clearly show how the marks have been awarded in line with the guidance provided. For this specification, the marking guidelines are provided by AQA and teachers must use these guidelines to annotate candidates' work.

Annotation helps our moderators to see as precisely as possible where the teacher has identified that candidates have met the requirements of the marking guidelines.

Annotation includes:

- ticks and numbers showing how many marks have been awarded
- comments on the work that refer to the marking guidelines.

6.6 Submitting marks and sample work for moderation

The total mark for each candidate must be sent to us and the moderator on the mark forms provided, or electronically by Electronic Data Interchange (EDI) by the date given (see www.aqa.org.uk/deadlines/coursework_deadlines).

Our moderator will contact you to let you know which pieces of work must be sent to them as part of the sample (please see Section 7.1 for more guidance on sending in samples).

6.7 Factors affecting individual candidates

You should be able to accept the occasional absence of candidates by making sure they have the chance to make up missed Controlled Assessments. (You may organise an alternative supervised time session for candidates who are absent at the time the centre originally arranged.)

If work is lost, you must tell us immediately the date it was lost, how it was lost, and who was responsible. Inform our Centre and Candidate Support Services using the JCQ form *Notification of Lost Coursework JCQ/LCW form 15*.

Where special help that goes beyond normal learning support is given, use the Candidate Record Form to inform us so that this help can be taken into account during moderation.

Candidates who move from one centre to another during the course sometimes need additional help to meet the requirements of a scheme of Controlled Assessment work. How this can be dealt with depends when the move takes place. If it happens early in the course the new centre should be responsible for Controlled Assessment work. If it happens late in the course it may be possible to arrange for the moderator to assess the work as a candidate who was 'Educated Elsewhere'. Centres should contact us by e-mailing science-gcse@aqa.org.uk as early as possible for advice about appropriate arrangements in individual cases.

6.8 Keeping candidates' work

From the time the work is marked, your centre must keep the work of all candidates, with Candidate Record Forms attached, under secure conditions, to allow the work to be available during the moderation

period or should there be an Enquiry about Results. You may return the work to candidates after the deadline for Enquiries about Results, or once any enquiry is resolved.

6.9 Grade boundaries on Controlled Assessment

The grade boundaries for the Controlled Assessment will be decided at the grade award meeting for each examination series and may, therefore, vary over time.

Moderation

7.1 Moderation procedures

Controlled Assessment work is moderated by inspecting a sample of candidates' work sent (by post or electronically) from the centre to a moderator appointed by us. The centre marks must be sent to us and the moderator by the deadline given (see www.aqa.org.uk/deadlines/coursework_deadlines). Centres entering fewer candidates than the minimum sample size (and centres submitting work electronically) should send the work of all of their candidates. Centres entering larger numbers of candidates will be told which candidates' work must be sent as part of the sample sent in for moderation.

Following the re-marking of the sample work, the moderator's marks are compared with the centre marks

to check whether any changes are needed to bring the centre's assessments in line with our agreed standards. In some cases the moderator may need to ask for the work of other candidates in the centre. To meet this request, centres must keep the Controlled Assessment work and Candidate Record Forms of every candidate entered for the examination under secure conditions, and they must be prepared to send it to us or the moderator when it is requested. Any changes to marks will normally keep the centre's rank order, but where major differences are found, we reserve the right to change the rank order.

7.2 Consortium arrangements

If you are a consortium of centres with joint teaching arrangements (where candidates from different centres have been taught together but where they are entered through the centre at which they are on roll), you must tell us by filling in the JCQ / CCA form *Application for Centre Consortium Arrangements for Centre-assessed Work*.

You must choose a consortium co-ordinator who can speak to us on behalf of all centres in the consortium. If there are different co-ordinators for different specifications, a copy of the JCQ / CCA form must be sent in for each specification.

We will allocate the same moderator to each centre in the consortium and the candidates will be treated as a single group for moderation.

7.3 Procedures after moderation

When the results are published, we will give centres details of the final marks for the Controlled Assessment work.

We will return candidates' work to you after the exam. You will receive a report, at the time results are issued,

giving feedback on any adjustments that were made to your marks.

We may keep some candidates' work for awarding, archive or standardising purposes and will inform you if this is the case.

Appendices

A Grade descriptions

Grade descriptions are provided to give a general indication of the standards of achievement likely to have been shown by candidates who were awarded particular grades. The descriptions must be interpreted in relation to the content in the specification; they are not designed to define that content.

The grade awarded will depend in practice upon the extent to which the candidate has met the assessment objectives overall. Shortcomings in some aspects of candidates' performance in the assessment may be balanced by better performances in others.

Grade A

Candidates recall, select and communicate precise knowledge and detailed understanding of chemistry. They demonstrate a comprehensive understanding of the nature of chemistry, its laws, principles and applications and the relationship between chemistry and society. They understand the relationships between scientific advances, their ethical implications and the benefits and risks associated with them. They use scientific and technical knowledge, terminology and conventions appropriately and consistently showing a detailed understanding of scale in terms of time, size and space.

They apply appropriate skills, including communication, mathematical, technical and observational skills, knowledge and understanding effectively in a wide range of practical and other contexts. They show a comprehensive understanding of the relationships between hypotheses, evidence, theories and explanations and make effective use of models, including mathematical models, to explain abstract ideas, phenomena, events and processes. They use a wide range of appropriate methods, sources of information and data consistently, applying relevant skills to address scientific questions, solve problems and test hypotheses.

Candidates analyse, interpret and critically evaluate a broad range of quantitative and qualitative data and information. They evaluate information systematically to develop arguments and explanations taking account of the limitations of the available evidence. They make reasoned judgments consistently and draw detailed, evidence-based conclusions.

Grade C

Candidates recall, select and communicate secure knowledge and understanding of chemistry. They demonstrate understanding of the nature of chemistry,

its laws, principles and applications and the relationship between chemistry and society. They understand that scientific advances may have ethical implications, benefits and risks. They use scientific and technical knowledge, terminology and conventions appropriately, showing understanding of scale in terms of time, size and space.

They apply appropriate skills, including communication, mathematical, technical and observational skills, knowledge and understanding in a range of practical and other contexts. They show understanding of the relationships between hypotheses, evidence, theories and explanations and use models, including mathematical models, to describe abstract ideas, phenomena, events and processes. They use a range of appropriate methods, sources of information and data, applying their skills to address scientific questions, solve problems and test hypotheses.

Candidates analyse, interpret and evaluate a range of quantitative and qualitative data and information. They understand the limitations of evidence and use evidence and information to develop arguments with supporting explanations. They draw conclusions based on the available evidence.

Grade F

Candidates recall, select and communicate limited knowledge and understanding of chemistry. They show a limited understanding that scientific advances may have ethical implications, benefits and risks. They recognise simple inter-relationships between chemistry and society. They use limited scientific and technical knowledge, terminology and conventions, showing some understanding of scale in terms of time, size and space.

They apply skills, including limited communication, mathematical, technical and observational skills, knowledge and understanding in practical and some other contexts. They recognise and use hypotheses, evidence and explanations and can explain straightforward models of phenomena, events and processes. They use a limited range of methods, sources of information and data to address straightforward scientific questions, problems and hypotheses.

Candidates interpret and evaluate limited quantitative and qualitative data and information from a narrow range of sources. They can draw elementary conclusions having collected limited evidence.

B Spiritual, moral, ethical, social, legislative, sustainable development, economic and cultural issues, and health and safety considerations

We have taken great care to make sure that any wider issues (for example, spiritual, moral, ethical, social, legal, sustainable development, economic and cultural issues), including those relevant to the education of students at Key Stage 4, have been taken into account when preparing this specification. They will only form part of the assessment requirements where they are relevant to the specific content of the specification. In Section 3 (Subject Content), aspects of the wider issues that may be assessed are introduced with the phrase: 'Candidates should use their skills, knowledge and understanding to:'. Additionally, health and safety considerations are addressed in the Controlled Assessment.

European Dimension

We have taken the 1988 Resolution of the Council of the European Community into account when preparing this specification and associated specimen units.

Environmental Education

We have taken the 1988 Resolution of the Council of the European Community and the Report '*Environmental Responsibility: An Agenda for Further and Higher Education*' 1993 into account when preparing this specification and associated specimen units.

Avoiding Bias

We have taken great care to avoid bias of any kind when preparing this specification and specimen units.

C Overlaps with other qualifications

The Unit 1 content of GCSE Chemistry M (modular) is contained within GCSE Science A and GCSE Science M (modular).

The Unit 2 content of GCSE Chemistry M (modular) is contained within GCSE Additional Science and GCSE Additional Science M (modular).

GCSE Chemistry M (modular) covers identical content to GCSE Chemistry.

D Wider Key Skills

The replacement of Key Skills with Functional Skills

The Key Skills qualifications have been replaced by Functional Skills (web.aqa.org.uk/qual/functional-skills).

Students following a course of study based on this specification for GCSE Chemistry M (modular) can be offered opportunities to develop and generate evidence of attainment in aspects of the Functional Skills.

Basic Skills Adult Literacy Levels 1 and 2, Adult Numeracy Levels 1 and 2

AQA Basic Skills qualifications will now be available until, at least, the June 2012 series. If you would like to check the funding provision, please contact the Skills Funding Agency:

info@skillsfundingagency.bis.gov.uk

0845 377 5000.

Wider Key Skills

Students following a course of study based on this specification for GCSE Chemistry M (modular) can be offered opportunities to develop and generate evidence of attainment in aspects of the Wider Key Skills of:

- Working with others
- Improving own learning and performance
- Problem solving.

The AQA Wider Key Skills qualifications are no longer available.

GCSE Chemistry M (modular) Specification

For exams January 2013 onwards

For certification June 2014

Qualification Accreditation Number: 600/7116/3

Centres should be aware that candidates who enter for more than one GCSE qualification with the same classification code will have only one grade counted for the purpose of the School and College Performance Tables. In the case of a candidate taking two qualifications with the same classification code that are of the same size and level, eg two full course GCSEs, the higher grade will count.

Centres may wish to advise candidates that, if they take two specifications with the same classification code, schools and colleges are very likely to take the view that they have achieved only one of the two GCSEs.

The same view may be taken if candidates take two GCSE specifications that have different classification codes but have significant overlap of content. Candidates who have any doubts about their subject combinations should check with the institution to which they wish to progress before embarking on their programmes.

To obtain specification updates, access our searchable bank of frequently asked questions, or to ask us a question, register with Ask AQA: [**aqa.org.uk/ask-aqa/register**](http://aqa.org.uk/ask-aqa/register)

You can also download a copy of the specification and support materials from our website: [**sciencelab.org.uk/subjects**](http://sciencelab.org.uk/subjects) for all your subject resources.