OXFORD AQA
INTERNATIONAL QUALIFICATIONS

International GCSE
Chemistry

(9202) Specification

For teaching from September 2016 onwards

For exams May/June 2018 onwards

For teaching and examination outside the United Kingdom

Contents

Key for SYMBOL

Most of the subject content is common with and co-teachable with OxfordAQA International GCSE Combined Science (9204). Content that is only applicable to chemistry is indicated by C either next to the topic heading where it applies to the whole topic or immediately preceding each paragraph or bullet point as applicable.

Are you using the latest version of this specification?

- You will always find the most up-to-date version of this specification on our website at **oxfordaqa.com/9202**
- We will write to you if there are significant changes to the specification.

1 Introduction

1.1 Why choose OxfordAQA International GCSEs?

Our International qualifications enable schools that follow a British curriculum to benefit from the best education expertise in the United Kingdom (UK).

Our International GCSEs offer the same rigour and high quality as GCSEs in the UK and are relevant and appealing to students worldwide. They reflect a deep understanding of the needs of teachers and schools around the globe and are brought to you by Oxford University Press and AQA, the UK's leading awarding body.

Providing valid and reliable assessments, these qualifications are based on over 100 years of experience, academic research and international best practice. They have been independently validated as being to the same standard as the qualifications accredited by the UK examinations regulator, Ofqual. They reflect the latest changes to the British system, enabling students to progress to higher education with up-to-date qualifications.

You can find out about OxfordAQA at **oxfordaqa.com**

1.2 Why choose our International GCSE Chemistry?

In developing this specification we have consulted widely with teachers and science advisers to produce content and assessments that will both stimulate students' interest in and enthusiasm for chemistry and provide an excellent grounding for further study. This specification contains a broad range of topics that are designed to engage students whilst providing the knowledge and understanding required for progression to Level 3 qualifications.

Chemistry is an enquiry-based discipline involving practical and investigational skills as well as knowledge. The specification emphasises scientific knowledge, the application of science and the scientific process. Section 3 gives the fundamental ideas behind scientific enquiry that should be delivered through teaching of the content. The experimental and investigative skills that will be assessed in this specification are listed in Section 6.1. There are a number of required practicals identified in the specification, which students will need to cover as part of the content of the specification. These practicals will be assessed during the lifetime of the specification. These are summarised in Section 6.2.

The terminal assessment model is designed to ensure the maximum amount of time for teaching.

You can find out about all our International GCSE Chemistry qualifications at **oxfordaqa.com/science**

1.3 Recognition

OxfordAQA meet the needs of international students. They are an international alternative and comparable in standard to the Ofqual regulated qualifications offered in the UK. Our qualifications have been independently benchmarked by UK ENIC, the UK national agency for providing expert opinion on qualifications worldwide. They have confirmed they can be considered 'comparable to the overall GCE A-level and GCSE standard offered in the UK'.

To read their report and see the latest list of universities who have stated they accept these international qualifications, visit **oxfordaqa.com/recognition**

1.4 The Oxford International Programme learner attributes

In order to equip students with the skills they need for success both now and in the future, we have worked with Oxford University Press to create the Oxford International Programme. This combines the Oxford International Curriculum with OxfordAQA qualifications, creating an integrated offer for international schools, from Early Years to A-level.

At its core we have introduced the Oxford International Programme learner attributes – the skills and competencies that enable our students to thrive academically, socially and personally.

The learner attributes, alongside our focus on demonstrating higher order critical thinking skills, ensure that students are equipped to get the grades that will take them places, and build the skills they need to be successful when they get there.

Empowered & independent

Our students are independent, critical thinkers who are adaptable and look to develop strategies to be lifelong learners. They are confident leading on projects but also work well in a collaborative environment.

Inventive & curious

Our students are inventive, resourceful, and creative. They question the world around them with a sense of wonder, and aspire to shape a better future for themselves and their community.

Future-ready

Our students are more prepared to succeed in the world that lies ahead and have the knowledge, skills, and drive to achieve any objective they may set themselves. They are comfortable being challenged, acquiring new skills quickly, and seeking new adventures.

Ambitious & self-motivated

Our students are ambitious and want to strive for success in every aspect of their lives. They take the initiative, approaching every task with an eagerness to learn and take ownership of their own learning with the utmost integrity.

1.5 Support and resources to help you teach

We know that support and resources are vital for your teaching and that you have limited time to find or develop good quality materials. That's why we've worked with experienced teachers to provide resources that will help you confidently plan, teach and prepare for exams.

Teaching resources

You will have access to:

- sample schemes of work to help you plan your course with confidence
- training courses to help you deliver our qualifications
- student textbooks that have been checked and approved by us
- engaging worksheets and activities developed by teachers, for teachers
- command words with exemplars
- science vocabulary with definitions
- a handbook to support practical work.

Preparing for exams

You will have access to the support you need to prepare for our exams, including:

- specimen papers and mark schemes
- exemplar student answers with examiner commentaries
- a searchable bank of past AQA exam questions mapped to these new International qualifications.

Analyse your students' results with Enhanced Results Analysis (ERA)

After the first examination series, you can use this tool to see which questions were the most challenging, how the results compare to previous years and where your students need to improve. ERA, our free online results analysis tool, will help you see where to focus your teaching.

Information about results, including maintaining standards over time, grade boundaries and our post-results services, will be available on our website in preparation for the first examination series.

Help and support

Visit our website for information, guidance, support and resources at **oxfordaqa.com/9202**

You can contact the subject team directly at **info@oxfordaqa.com** or call us on +44 (0)161 696 5995 (option 1 and then 1 again).

Please note: We aim to respond to all email enquiries within two working days.

Our UK office hours are Monday to Friday, 8am – 5pm.

2 Specification at a glance

The title of the qualification is:

- OxfordAQA International GCSE Chemistry.

This qualification is linear. Linear means that students will sit all their exams at the end of the course.

Exams will be available May/June and in November.

The guided learning hours (GLH) for this qualification are 120. This figure is for guidance only and may vary according to local practice and the learner's prior experience of the subject.

2.1 Subject content

Atomic structure and the Periodic Table

- Solid, liquids and gases
- A simple model of the atom
- The periodic table

Structure, bonding and the properties of matter

- Chemical bonds: ionic, covalent and metallic
- How bonding and structure are related to the properties of substances
- Structure and bonding of carbon
- Nanoparticles

Chemical changes

- Metals
- The reactivity series
- Metal carbonates
- Electrolysis

Chemical analysis

- Purity and chromatography
- Identification of common gases
- Identification of ions

Acids, bases and salts

- The properties of acids and bases
- Preparation of salts

Quantitative chemistry

- Conservation of mass including the quantitative interpretation of chemical equations
- Use of amount of substance in relation to masses of pure substances
- The mole concept
- Using molar concentrations of solutions and amount of substance in relation to volumes of gases

TRENDS WITHIN THE PERIODIC TABLE

- Group properties
- Transition metals

The rate and extent of chemical change

- Rate of reaction
- Reversible reactions and dynamic equilibrium
- Redox reactions

Energy changes

- Exothermic and endothermic reactions
- Calculating and explaining energy change
- Chemical cells and fuel cells

Organic chemistry

- Carbon compounds as fuels
- Crude oil
- Hydrocarbons
- Obtaining useful substances from crude oil
- Synthetic and naturally occurring polymers
- Organic compounds – their structure and reactions
- Alcohols
- Carboxylic acids
- Esters

2.2 Assessments

OxfordAQA International GCSE Chemistry is linear, with two question papers to be taken in the same examination series.

Paper 1		Paper 2
What's assessed Content from any part of the specification may be assessed.	+	**What's assessed** Content from any part of the specification may be assessed.
How it's assessed Written exam: 1 hour 30 minutes 90 marks		**How it's assessed** Written exam: 1 hour 30 minutes 90 marks
Questions Structured and open questions.		**Questions** Structured and open questions.

Please refer to section 4.2.1 for assessment objective weightings for Paper 1 and Paper 2.

3 Subject content

Through the teaching of this chemistry syllabus, students will develop knowledge and understanding of the subject content of chemistry, the practices of science and how science as a discipline develops. Students will develop their ability to work as a scientist.

Working as a scientist involves being able to observe, question, hypothesise and carry out various types of scientific enquiry to further scientific knowledge, and to be able to use models and arguments to support explanations and decision making. It also involves following established procedures to ensure that new scientific knowledge can be validated.

Working this way requires knowledge and understanding of the practices of science and how science as a discipline develops.

Knowledge of the subject content in isolation does **not** provide the knowledge, understanding and skills required for progression to higher qualifications or develop the knowledge, understanding and skills required for students to be future scientists or scientifically literate citizens.

There are three dimensions to working as a scientist:

- Subject content
- The practices of science
- How science as a discipline develops.

Subject content

The established facts, concepts, ideas and theories.

The assessed subject content is presented as a series of topic areas listing the statements students need to know, understand and apply. Expansion of the content and clarification of what may be examined is given in *italics*.

The practices of science

How observation and experimentation is carried out to obtain evidence. The assessment requirements are detailed in the specification appendices 6.1 and 6.2.

Students should develop an understanding of how the following elements relate to the subject content and practices of science.

Students should be able to:

- suggest, describe and explain experimental and investigative procedures
- justify the choice of experimental or investigative procedure and the use of apparatus
- identify possible hazards, the risks associated with these hazards, and methods of minimising the risks
- recognise and explain the need to manipulate and control variables, including the use of control groups where necessary
- assess whether sufficient measurements have been taken with appropriate precision, and appreciate when it is appropriate to calculate a mean
- recognise and identify the causes of anomalous results and suggest what should be done about them
- present, analyse and interpret data in tabular and graphical forms, identifying patterns and correlations (which may be causal or non-causal)
- recognise and identify the causes of random and systematic errors

- evaluate data, considering its validity, repeatability and reproducibility in supporting conclusions
- evaluate working methods, suggesting advantages and disadvantages of approaches used.

How science as a discipline develops

The defining features that characterise the nature of the subject and how new scientific knowledge is established.

The defining features of how science knowledge and understanding develops over time:

- Predictions are tested to support or refute a new scientific idea or explanation.
- Scientific claims are supported by evidence and scientific reasoning, and should be able to be confirmed by other scientists.
- Evidence and creative thinking is used to develop new scientific ideas and explanations.
- Different conclusions may be drawn from available evidence and can be influenced by personal background, experience or interests.
- New technologies and practical techniques can lead to new investigations and discoveries, and advance scientific knowledge and understanding.
- New evidence can lead to new lines of enquiry and changes in scientific ideas and explanations.
- Models are used to support scientific explanations with limits to what they can and cannot explain.
- Accepted scientific ideas and explanations can take a long time to be abandoned even if new evidence disagrees with predictions based upon them.
- Science often involves collaboration in interdisciplinary teams, often from several countries.

The scientific terms used in this specification 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 students are familiar with these terms. Definitions of the terms will **not** be required in assessments, but students will be expected to use them correctly.

3.1 Atomic structure and the periodic table

Atoms are the building blocks of all materials and knowledge of atomic structure and the periodic table are fundamental to the learning associated with all the following sections.

3.1.1 Solids, liquids and gases

a. Matter can be classified in terms of the three states of matter.

Students should be familiar with states of matter and be able to name each inter-conversion process. They should be able to describe and explain their inter-conversion in terms of how the particles are arranged and their movement. They should understand the energy changes that accompany changes of state.

b. Evidence for the existence of particles can be obtained from simple experiments.

Students should be familiar with simple diffusion experiments such as Br_2*/air,* NH_3*/HCl,* $KMnO_4$*/water.*

3.1.2 A simple model of the atom

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.

b. Atoms of each element are represented by a chemical symbol, eg O represents an atom of oxygen.

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

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

Students should be aware that the atomic model has changed over time.

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. 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.

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

g. Atoms of the same element can have different numbers of neutrons; these atoms are called isotopes of that element.

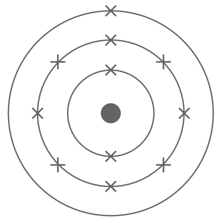
h. Atoms can be represented as shown in this example:

(Mass number) (Atomic number) $^{23}_{11}\mathrm{Na}$

i. 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).

Students may answer questions in terms of either energy levels or shells.

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



sodium 2,8,1

j. The relative masses of protons, neutrons and electrons are:

Name of particle	Mass
Proton	1
Neutron	1
Electron	Very small

k. 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.

Students will not be expected to calculate relative atomic masses from isotopic abundances.

3.1.3 The Periodic Table

a. The periodic table is arranged in order of atomic (proton) number. Elements with similar properties are in columns, known as groups. The table is called a periodic table because similar properties occur at regular intervals.

Students should know that the current periodic table is based on the work of Mendeleev.

b. 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.

Students should know that basing the periodic table on groups of elements with similar properties has allowed for the prediction of elements which were still to be discovered.

c. 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.

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

3.2 Structure, bonding and the properties of matter

This section examines how atoms interact to form chemical bonds and how these bonds determine the properties and uses of materials.

3.2.1 Chemical bonds: ionic, covalent and metallic

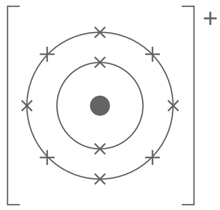
a. Compounds are substances in which atoms of two or more elements are chemically combined.

b. Chemical bonding involves either transferring or sharing electrons in the highest occupied energy levels (outer shells) of atoms in order to achieve the electron arrangement 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 electron arrangement of a noble gas (Group 0). Compounds formed from metals and non-metals consist of ions.

Students should know that metals form positive ions, whereas non-metals form negative ions.

Students should be able to represent the electron arrangement of ions in the following form:



for a sodium ion (Na^+).

Students 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 and water.

e. The elements in Group 7 of the periodic table, the halogens, all react with 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 metals and displacement of less reactive halogens.

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.

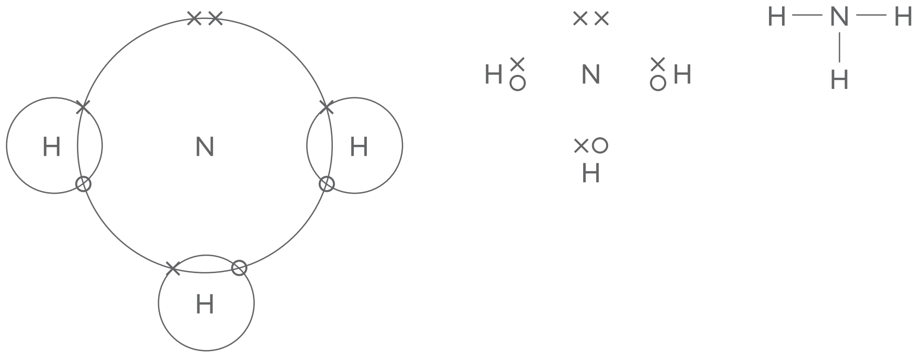
*Students should be familiar with the structure of sodium chloride but do **not** need to know the structures of other ionic compounds.*

Students given appropriate information, should be able to draw or complete diagrams to show how elements form ions and ionic compounds.

g. When atoms share pairs of electrons, they form covalent bonds. These bonds between atoms are strong. Some covalently bonded substances, such as H_2, Cl_2, O_2, N_2, HCl, H_2O, NH_3 and CH_4, consist of simple molecules. Others, such as diamond and silicon dioxide, have giant covalent structures (macromolecules).

Students should be able to represent the covalent bonds in molecules such as water, ammonia, hydrogen, hydrogen chloride, methane and oxygen in the following forms:

For ammonia (NH_3) and/or and/or



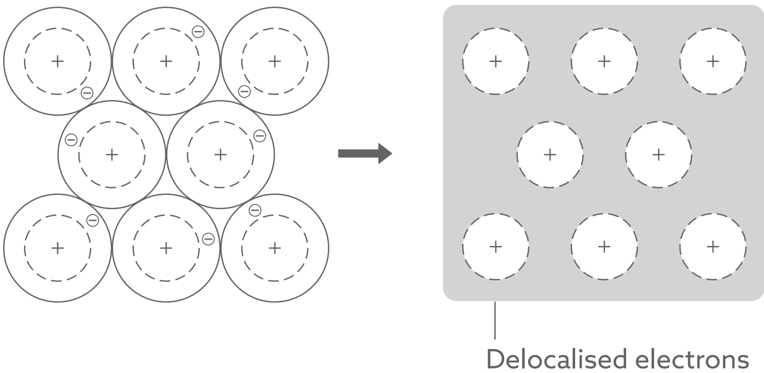
Students, given appropriate information, should be able to draw or complete diagrams to show how elements form covalent compounds by sharing electrons.

Students should be able to recognise other simple molecules and giant structures from diagrams that show their bonding.

h. Compounds formed from non-metals consist of molecules. In molecules, the atoms are held together by covalent bonds.

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

j. 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. The bonding in metals is represented in the following form:



3.2.2 How bonding and structure are related to the properties of substances

a. Ionic compounds have regular structures (giant ionic lattices) in which there are strong electrostatic forces of attraction 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.

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

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

d. 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.

Students should understand that intermolecular forces are weak compared with covalent bonds.

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

f. 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.

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

g. Metals conduct heat and electricity because of the delocalised electrons in their structures.

Students should know that conduction depends on the ability of electrons to move through the metal.

3.2.3 Structure and bonding of carbon

a. The element carbon can form four covalent bonds.

b. In diamond, each carbon atom forms four covalent bonds with other carbon atoms in a giant covalent structure, so diamond is very hard.

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.

Students should be able to explain the properties of graphite in terms of weak 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.

Students 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.

Students are only required to know that the structure of fullerenes is based on hexagonal rings of carbon atoms.

3.2.4 Nanoparticles C

Nanoscience refers to structures that are 1–100 nm in size, of the order of a few hundred atoms. Nanoparticles show properties different from those for 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 suntan creams and deodorants.

*Students 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 relating their use to their structure.

3.3 Chemical changes

The group of materials known as metals are explored in more detail, including how atoms are rearranged to form new substances in chemical reactions.

3.3.1 Metals

a. Metals are useful materials as they are good conductors of heat and electricity. They can also be bent or hammered into shape because the layers of atoms in metals are able to slide over each other.

b. An alloy is a mixture of at least two elements, at least one of which is a metal. Alloys often have properties that are different from the metals they contain. This makes them more useful than the pure metals alone. Steels are a mixture of iron with carbon and sometimes other metals.

   Students may be given information on the composition of specific alloys so that they can evaluate their uses.

c. Copper is useful for electrical wiring and plumbing because it has the following properties:

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

3.3.1.1 The reactivity series

a. Metals can be arranged in an order of their reactivity from their reactions with water and dilute acids.

   Students should be able to recall and describe the reactions, if any, of potassium, sodium, lithium, calcium, magnesium, zinc, iron and copper with water or dilute acids. Students should be able, where appropriate, to place these metals in order of reactivity.

b. Displacement reactions involving metals and their compounds in aqueous solution establish positions within the reactivity series.

   Students should be able to describe displacement reactions in terms of oxidation and reduction, and to write the ionic equations.

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.

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.

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

Knowledge of reduction is limited to the removal of oxygen.

*Details of the blast furnace are **not** required, but students should know the raw materials used and explain the simple chemistry involved, including the use of equations.*

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

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.

*Knowledge of the details of industrial methods of electrolysis is **not** required, other than the detail required for aluminium (see Section 3.3.2).*

f. 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.

Students 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.*

g. Copper can be obtained from solutions of copper salts by electrolysis.

Students should know the electrode material and be able to write the ionic half equations for the reactions occurring at both electrodes.

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

Students should be able to describe this in terms of oxidation and reduction, and to write the ionic equation.

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

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

3.3.1.2 Metal carbonates

a. The carbonates of magnesium, copper, zinc, calcium and lithium decompose on heating (thermal decomposition) in a similar way.

Students 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.

b. Metal carbonates react with acids to produce carbon dioxide, a salt and water.

3.3.2 Electrolysis

a. When an ionic substance is melted or dissolved in water, the ions are free to move about within the liquid or solution.

b. Passing an electric current through ionic substances that are molten, eg lead bromide, or in solution breaks them down into elements. This process is called electrolysis and the substance broken down is called the electrolyte.

c. During electrolysis, positively charged ions move to the negative electrode (the cathode), and negatively charged ions move to the positive electrode (the anode).

Required practical:
Investigate the products at the anode and cathode in the electrolysis of copper sulfate solution. C

d. Oxidation and reduction can be defined as the loss and gain of electrons respectively.

e. At the cathode, positively charged ions gain electrons; at the anode, negatively charged ions lose electrons.

f. Reactions at electrodes can be represented by half equations, for example:

$2Cl^- \rightarrow Cl_2 + 2e^-$
or
$2Cl^- - 2e^- \rightarrow Cl_2$

Students should be able to write half equations for the reactions occurring at the electrodes during electrolysis, and may be required to complete and balance supplied half equations.

g. If there is a mixture of ions:

- at the cathode, the products formed depend on the reactivity of the elements involved
- at the anode, the products formed also depend on the relative concentrations of the ions present.

h. Electrolysis is used to electroplate objects. This may be for reasons such as appearance, durability and prevention of corrosion. It includes copper plating and silver plating.

i. 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.

Students should understand why cryolite is used in this process.

Students should be aware that large amounts of energy are needed in the extraction process.

j. 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.

Students should be able to explain, using ideas relating to reactivity why each of these products is produced.

3.4 Chemical analysis

This section focuses on developing practical skills in chemistry which identify substances, and reinforces the idea of a pure substance as consisting of one substance only.

3.4.1 Purity and chromatography

a. A pure element or compound contains only one substance, with no other substances mixed in.

Students should be able to identify substances and assess their purity from melting point and boiling point information.

b. Measures of purity are important in everyday substances such as foodstuffs and drugs.

c. 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, filtration and crystallisation.

d. Paper chromatography can be used to analyse substances present in a solution, eg food colourings and inks/dyes.

Students should be able to describe how to carry out paper chromatography separations and how the components of a mixture can be identified using R_f values. They have to be aware that solvents other than water can be used.

e. Chromatography involves a stationary and a mobile phase and separation depends on the relative solubility of the components.

Students should be able to suggest chromatographic methods for distinguishing pure from impure substances.

3.4.2 Identification of common gases C

a. A pop is heard when a lighted splint is placed near hydrogen gas.

b. A glowing splint relights in a test tube of oxygen gas.

c. Carbon dioxide turns limewater (calcium hydroxide solution) cloudy white.

d. Ammonia has a characteristic sharp, choking smell. It also makes damp red litmus paper turn blue. Ammonia forms a white smoke of ammonium chloride when hydrogen chloride gas, from concentrated hydrochloric acid, is held near it.

e. Chlorine has a characteristic sharp, choking smell. It also makes damp blue litmus paper turn red, and then bleaches it white.

3.4.3 Identification of ions

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.

Required practical:
Identify the metal ion in an unknown compound using flame testing techniques.

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(II) 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, which turns limewater cloudy white.

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.

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

3.5 Acids, bases and salts

This section looks in greater detail at the properties and applications of acids and bases.

3.5.1 The properties of acids and bases

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

b. Acids react with bases to form salts. These reactions are called neutralisation reactions.

c. 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.

d. Ammonia dissolves in water to produce an alkaline solution. It is used to produce ammonium salts.

e. A solution of calcium hydroxide in water (limewater) reacts with carbon dioxide to produce calcium carbonate.

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

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

Students should be able to describe the use of universal indicator to measure the approximate pH of a solution.

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

$H^+ (aq) + OH^- (aq) \rightarrow H_2O (l)$

3.5.2 Preparation of salts

a. 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.

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

b. Salt solutions can be crystallised to produce solid salts.

c. 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.

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

3.6 Quantitative chemistry

Conservation of mass is a key concept in chemistry and this is developed during this section. This is then used to develop a quantitative approach to chemical reactions, leading to many opportunities to develop experimental skills through practical work and mathematical skills.

3.6.1 Conservation of mass including the quantitative interpretation of chemical equations

a. Chemical reactions can be represented by word equations or by symbol equations.

Students should be able to write word and balanced symbol equations for reactions in the specification.

b. Information about the states of reactants and products can be included in chemical equations.

Students should be able to use the state symbols (g), (l), (s) and (aq) in equations where appropriate.

c. No atoms are lost or made during a chemical reaction so the mass of the products equals the mass of the reactants.

d. The masses of reactants and products can be calculated from balanced symbol equations.

Students 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 and the balanced symbol equation.

e. 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.

3.6.2 Use of amount of substance in relation to masses of pure substances

a. 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.

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

b. The percentage by mass of an element in a compound can be calculated from the relative atomic mass of the element in the formula and the relative formula mass of the compound.

c. The empirical formula of a compound can be calculated from the masses or percentages of the elements in a compound.

Students should be able to calculate empirical formulae and molecular formulae.

3.6.3 The mole concept

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

Students should be able to use the relative formula mass of a substance to calculate the number of moles in a given mass of that substance and vice versa.

b. One mole contains 6.02×10^{23} atoms or molecules. This number is known as Avogadro's constant.

3.6.4 molar concentrations

a. The concentration of a solution is related to the mass of the solute (in terms of number of moles) and the volume of the solution. The concentration of a solution is calculated as follows:

Concentration (mol/dm^3) = number of moles/volume of solution (in dm^3).

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

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

Required practical:
Establish the concentration of an unknown strong acid through titration with a strong base.

c. 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.

Students should know how to carry out a titration and be able to calculate the chemical quantities in titrations involving concentrations in mol/dm^3 and in g/dm^3.

d. The molar gas volume at room temperature and pressure is assumed to be 24 dm^3 C

Students are expected to be able to calculate the number of moles or the volume of gas in a reaction.

3.7 Trends within the periodic table

This section looks to both describe and explain trends within the periodic table along with more detailed knowledge and understanding of identified groups.

3.7.1 Group properties

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.

c. 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.

d. In Group 7, the further down the group an element is:

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

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

f. 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.

Students should be able to explain the relative reactivities of the elements in Group 1 and 7.

3.7.2 Transition metals C

a. Transition metals are those in the centre of the periodic table between Groups 2 and 3. Many transition metals have ions with different charges, form coloured compounds and are useful as catalysts.

b. Compared with the elements in Group 1, transition metals:

- 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.

3.8 The rate and extent of chemical change

3.8.1 Rate 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:

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

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

Students need to be able to interpret graphs showing the amount of product formed (or reactant used up) with time, in terms of the rate of the reaction.

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

b. Chemical reactions can occur only when reacting particles collide with each other and with sufficient energy. The minimum amount of energy that 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.

Required practical:
Investigate factors affecting the rate of a reaction.

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

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

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

3.8.2 Factors affecting equilibrium C

a. When a reversible reaction occurs in a closed system, equilibrium is reached when the reactions occur at exactly the same rate in each direction.

b. The relative amounts of all the reacting substances at equilibrium depend on the conditions of the reaction.

c. If the temperature is raised:

- the yield from the endothermic reaction increases
- the yield from the exothermic reaction decreases.

If the temperature is lowered:

- the yield from the endothermic reaction decreases
- the yield from the exothermic reaction increases.

d. 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
- a decrease in pressure will favour the reaction that produces the greatest number of molecules as shown by the symbol equation for that reaction.

e. These factors, together with reaction rates, are important when determining the optimum conditions in industrial processes, including the Haber process.

3.8.3 PRODUCTION OF AMMONIA AND SULFURIC ACID C

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. Ammonia is a raw material in the production of fertilizers.

Students should be able to explain the global need for fertilizers to maximise food yields.

c. 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 react to form ammonia. The reaction is reversible so ammonia breaks down again into nitrogen and hydrogen:

nitrogen + hydrogen ⟶ ammonia

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

d. Sulfuric acid is produced industrially using the contact process. It is a three–stage process, which incorporates a reversible process and the use of a catalyst.

Stage 1: Sulfur is burned in air to produce sulfur dioxide

$S(s) + O_2(g) \rightarrow SO_2(g)$

Stage 2: Sulfur dioxide reacts with more oxygen to make sulfur trioxide

$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$

This exothermic reaction is reversible and it requires a catalyst of Vanadium(V) oxide, V_2O_5, a temperature of around 450 °C and atmospheric pressure.

Stage 3: Sulfur trioxide reacts with water to make sulfuric acid

$H_2O(l) + SO_3(g) \rightarrow H_2SO_4(aq)$

Students should be able to describe the stages in the contact process and also to explain why a catalyst, a high temperature and atmospheric pressure are used in Stage 2.

3.8.4 Redox reactions C

a. Oxidation can be described as the gain of oxygen by a substance and reduction as the loss of oxygen from a substance.

b. Oxidation can also be described as the loss of electrons and reduction as gain of electrons.

Students should be able to describe chemical reactions within this specification in terms of oxidation and reduction using the definitions above.

c. When oxidation and reduction are happening at the same time this is known as a redox reaction, for example:

Reduction

$Fe_2O_3 + 3\,CO \rightarrow 2\,Fe + 3\,CO_2$

Oxidation

3.9 Energy changes

This section highlights that chemical reactions involve changes which require energy to make them happen. This is a fundamental concept that links to key ideas in biology and physics. The section also involves developing mathematical skills and application of knowledge.

3.9.1 Exothermic and endothermic reactions

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

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 required.

b. An exothermic reaction is one that transfers energy to the surroundings. Examples of exothermic reactions include combustion, many oxidation reactions and neutralisation.

Students should be able to give examples of exothermic reactions including combustion, oxidation 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. 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 as follows:

$A + B \rightarrow C + D$

For example:

hydrated copper sulfate (blue)	endothermic $\rightarrow$ exothermic	anhydrous copper sulfate (white)	+ water

3.9.2 Calculating and explaining energy change

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 produced by fuels.

Students 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) or kilojoules (kJ) for a given mass or amount of substance eg kilojoules per gram or kilojoules per mole.

c. The amount of energy produced 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.

Students 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. Students 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.

Students should be able to calculate the energy transferred in reactions and 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).

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

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

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

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

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

3.9.3 Chemical cells and fuel cells

a. A chemical cell produces a potential difference until the reactants are used up.

b. Fuel cells produce electricity through the reaction of a fuel with oxygen. Hydrogen-oxygen fuel cells use hydrogen as their fuel, and are useful in cars and spacecraft. Water is the only waste product from a hydrogen–oxygen fuel cell, so they cause less pollution when in use.

Students 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.

Students should know and understand the benefits and disadvantages of hydrogen fuel in terms of:

- *storage and use*
- *products of combustion.*

*Knowledge of the details of the reactions in fuel cells is **not** required.*

3.10 Organic chemistry

3.10.1 Carbon compounds as fuels

3.10.1.1 Crude oil

a. Crude oil is a mixture of a very large number of compounds.

b. Most of the compounds in crude oil are hydrocarbons, which are molecules made up of hydrogen and carbon atoms only.

c. 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 called fractional distillation.

Students 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.*

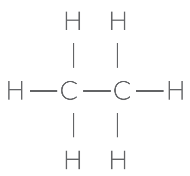
3.10.1.2 Hydrocarbons

a. Most of the hydrocarbons in crude oil are saturated hydrocarbons called alkanes. The general formula for the homologous series of alkanes is C_nH_{2n+2}

Students should know that in saturated hydrocarbons all the carbon–carbon bonds are single covalent bonds.

b. Alkane molecules can be represented in the following forms:

C_2H_6 *or*



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

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

c. Some properties of hydrocarbons depend on the size of their molecules. These properties influence how hydrocarbons are used as fuels.

Knowledge and understanding of trends in properties of hydrocarbons is limited to:

- *boiling points*

- *viscosity*
- *flammability.*

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

Sulfur dioxide and oxides of nitrogen cause acid rain, an increase in carbon dioxide may result in climate change, and solid particles cause global dimming.

Students 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 incomplete).

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

e. The combustion of hydrocarbon fuels releases energy. During combustion, the carbon and hydrogen in the fuels are oxidised.

f. Ethanol can be made by reacting ethene with steam: C

$C_2H_4 + H_2O \rightarrow C_2H_5OH$

Phosphoric acid is used as a catalyst to increase the rate of the reaction.

This is efficient because it is a continuous process. However, ethene is derived from crude oil, a non-renewable resource which may run out one day.

Ethanol can also be made by fermenting sugar:

$C_6H_{12}O_6 \rightarrow 2\,C_2H_5OH + 2CO_2$

Enzymes in yeast are natural catalysts for this reaction, and this is a batch process. Unlike ethene, sugar is a renewable resource.

Students should be able to compare the two ways of making ethanol in terms of type of raw material, type of process, labour, rate of reaction, conditions needed, purity of product and energy requirements.

g. Biofuels, including biodiesel and ethanol, are produced from plant material, and are possible alternatives to hydrocarbon fuels.

Students should know and understand the benefits and disadvantages of biofuels in terms of:

- *use of renewable resources*
- *their impacts on land use*
- *their carbon footprint.*

*Students should know that ethanol for use as a biofuel is produced from a dilute solution of ethanol obtained by the fermentation of plant materials at a temperature between 20 °C and 35 °C. Detailed knowledge of the methods used to produce other biofuels is **not** required.*

3.10.1.3 Obtaining useful substances from crude oil

a. Hydrocarbons can be broken down (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.

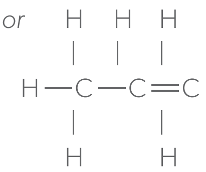
b. The products of cracking include alkanes and unsaturated hydrocarbons called alkenes. The general formula for the homologous series of alkenes is C_nH_{2n}

Required practical:
Test for the presence of a double bond in an unknown hydrocarbon.

Students should know that in unsaturated hydrocarbons some of the carbon–carbon bonds are double covalent bonds.

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

C_3H_6 or



Students should know that in displayed structures ═ represents a double bond.

*Students 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.*

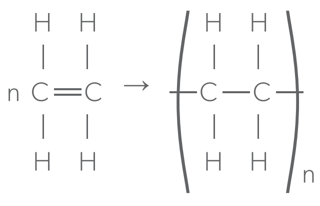
d. Alkenes react with bromine water, turning it from orange to colourless.

e. Some of the products of cracking are useful as fuels.

3.10.2 Synthetic and naturally occurring polymers

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

For example:



ethene *poly(ethene)*

Students 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.*

b. 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.

c. 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.

Students should be able to explain thermosoftening polymers in terms of intermolecular forces.

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

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

e. Many polymers are not biodegradable, ie they are not broken down by microbes. This can lead to problems with waste disposal.

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

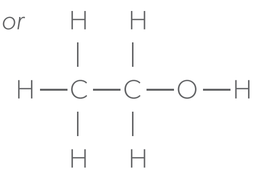
f. Plastic bags are being made from polymers and cornstarch so that they break down more easily. Biodegradable plastics made from cornstarch have been developed.

3.10.3 Organic compounds – their structure and reactions

3.10.3.1 Alcohols

a. Alcohols contain the functional group –OH. Methanol, ethanol and propanol are the first three members of a homologous series of alcohols. Alcohols can be represented in the following forms:

CH_3CH_2OH or



*Students 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:

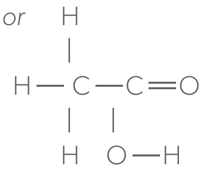
- dissolve in water to form a neutral solution
- react with sodium to produce hydrogen
- burn in air
- are used as fuels and solvents, and ethanol is the main alcohol in alcoholic drinks.

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

3.10.3.2 Carboxylic acids

a. Ethanoic acid is a member of the homologous series of carboxylic acids, which have the functional group –COOH. The structures of carboxylic acids can be represented in the following forms:

CH_3COOH or



*Students 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:

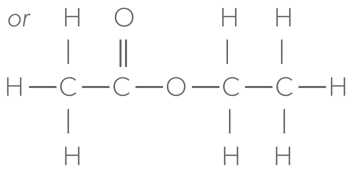
- dissolve in water to produce acidic solutions
- react with carbonates to produce carbon dioxide
- react with alcohols in the presence of an acid catalyst to produce esters
- do not ionise completely when dissolved in water and so are weak acids
- aqueous solutions of weak acids have a higher pH value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

Students are expected to write balanced chemical equations for the reactions of carboxylic acids.

3.10.3.3 Esters C

a. Esters have the functional group –COO–. The structures of esters can be represented in the following forms:

$CH_3COOCH_2CH_3$ or



*Students 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.*

Ethyl ethanoate is the ester produced from ethanol and ethanoic acid.

C_2H_5OH	+	CH_3COOH	$\rightarrow$	$CH_3COOC_2H_5$	+	H_2O
Ethanol		*Ethanoic acid*		*Ethyl ethanoate*		*Water*

b. Esters are volatile compounds with distinctive smells and are used as flavourings and perfumes.

4 Scheme of assessment

Find mark schemes, and specimen papers for new courses, on our website at **oxfordaqa.com/9202**

This is a linear qualification. In order to achieve the award, students must complete all assessments at the end of the course and in the same series.

Our International GCSE exams and certification for this specification are available for the first time in May/June 2018 and then every May/June and November for the life of the specification.

All materials are available in English only.

Our International GCSE exams in Chemistry include questions that allow students to demonstrate their ability to:

- recall the knowledge and understanding developed through the substantive content of the course
- apply their knowledge and understanding gained in discussing, evaluating and suggesting implications of data and evidence in both familiar and unfamiliar situations
- understand the scientific process while working scientifically and the skills developed while carrying out practical investigations.

4.1 Aims and learning outcomes

Our International GCSE in Chemistry should encourage students to be inspired, motivated and challenged by following a broad, coherent, practical, satisfying and worthwhile course of study. It should encourage students to develop their curiosity about the living world, enable students to engage with chemistry in their everyday lives in order to make informed choices about further study in chemistry and related disciplines.

Our International GCSE in Chemistry should enable students to:

- develop their knowledge and understanding of chemistry
- develop and apply their knowledge and understanding of the scientific process
- develop their understanding of the relationships between hypotheses, evidence, theories and explanations
- develop and apply their observational, practical, modelling, enquiry and problem-solving skills, and their understanding in laboratory, field 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 reporting and presenting information clearly and logically in different formats
- develop their skills in communication, mathematics and the use of technology in scientific contexts.

4.2 Assessment Objectives

The exams will measure how students have achieved the following Assessment Objectives.

- AO1: Knowledge and understanding of scientific principles.
- AO2: Application of knowledge and understanding of scientific principles and concepts in both familiar and novel contexts.
- AO3: Ability to describe, analyse, interpret and evaluate scientific information presented in different forms.
- AO4: Ability to select, describe and evaluate scientific procedures.

4.2.1 Assessment Objective weightings

Assessment Objectives (AOs)	Component weightings (approx %)		Overall weighting (approx %)
	Paper 1	Paper 2	
AO1	20	10	30
AO2	20	20	40
AO3	7	13	20
AO4	3	7	10
Overall weighting of components (%)	50	50	100

4.3 Assessment weightings

The assessments are equally weighted.

Component	Maximum mark
Paper 1	90
Paper 2	90
Total mark:	180

5 General administration

We are committed to delivering assessments of the highest quality and have developed practices and procedures that support this aim. To ensure that all students have a fair experience, we have worked with other awarding bodies in England to develop best practice for maintaining the integrity of exams. This is published through the Joint Council for Qualifications (JCQ). We will maintain the same high standard through their use for OxfordAQA.

More information on all aspects of administration is available at **oxfordaqa.com/exams-administration**

For any immediate enquiries please contact **info@oxfordaqa.com**

Please note: We aim to respond to all email enquiries within two working days.

Our UK office hours are Monday to Friday, 8am – 5pm local time.

5.1 Entries and codes

You only need to make one entry for each qualification – this will cover all the question papers and certification.

Qualification title	OxfordAQA entry code
OxfordAQA International GCSE Chemistry	9202

Please check the current version of the Entry Codes book and the latest information about making entries on **oxfordaqa.com/exams-administration**

Exams will be available May/June and in November.

5.2 Overlaps with other qualifications

This specification overlaps with the AQA UK GCSE Chemistry (8462). This specification overlaps with the OxfordAQA International GCSE Combined Science (9204). Entry for this specification and OxfordAQA International GCSE Combined Science (9204) is **not** permitted in the same series.

5.3 Awarding grades and reporting results

In line with UK GCSEs, this qualification will be graded on a nine-point scale: 1 to 9 – where 9 is the best grade. Students who fail to reach the minimum standard for grade 1 will be recorded as U (unclassified) and will not receive a qualification certificate.

To find out more about the new grading system, visit our website at **oxfordaqa.com**

5.4 Resits

Candidates can re-take the whole qualification as many times as they wish. This is a traditional linear specification, individual components cannot be re-sat.

You only need to make one entry for each qualification – this will cover all the question papers and certification.

5.5 Previous learning and prerequisites

There are no previous learning requirements. Any requirements for entry to a course based on this specification are at the discretion of schools.

5.6 Access to assessment: equality and inclusion

Our general qualifications are designed to prepare students for a wide range of occupations and further study whilst assessing a wide range of competences.

The subject criteria have been assessed to ensure they test specific competences. The skills or knowledge required do not disadvantage particular groups of students.

Exam access arrangements are available for students with disabilities and special educational needs.

We comply with the *UK Equality Act 2010* to make reasonable adjustments to remove or lessen any disadvantage that affects a disabled student. Information about access arrangements will be issued to schools when they become OxfordAQA centres.

5.7 Working with OxfordAQA for the first time

You will need to apply to become an OxfordAQA centre to offer our specifications to your students. Find out how at **oxfordaqa.com/centreapprovals**

5.8 Private candidates

Centres may accept private candidates for examined units/components only with the prior agreement of OxfordAQA. If you are an approved OxfordAQA centre and wish to accept private candidates, please contact OxfordAQA at: **info@oxfordaqa.com**

As some of the marks in the GCSE papers will relate to practical work, students undertaking this specification must carry out the required practical activities in section 6.2 of the specification.

Centres accepting private candidates must ensure they have carried out this minimum requirement. Private candidates may also enter for examined only units via the British Council; please contact your local British Council office for details.

6 Appendices

6.1 Experimental and investigative skills

During this course, students should be encouraged to develop their understanding of the scientific process and the skills associated with scientific enquiry. Students will be assessed on aspects of the skills listed below, and may be required to read and interpret information from scales given in diagrams and charts, present data in appropriate formats, design investigations and evaluate information that is presented to them.

Scientific process and skill	
Designing a practical procedure	Design a practical procedure to answer a question, solve a problem or test a hypothesis.
	Comment on/evaluate plans for practical procedures.
	Select suitable apparatus for carrying out experiments accurately and safely.
Control	Appreciate that, unless certain variables are controlled, experimental results may not be valid.
	Recognise the need to choose appropriate sample sizes, and study control groups where necessary.
Risk assessment	Identify possible hazards in practical situations, the risks associated with these hazards, and methods of minimising the risks.
Collecting data	Make and record observations and measurements with appropriate precision and record data collected in an appropriate format (such as a table, chart or graph).
Analysing data	Recognise and identify the cause of anomalous results and suggest what should be done about them.
	Appreciate when it is appropriate to calculate a mean, calculate a mean from a set of at least three results and recognise when it is appropriate to ignore anomalous results in calculating a mean.
	Recognise and identify the causes of random errors and systematic errors.
	Recognise patterns in data, form hypotheses and deduce relationships.
	Use and interpret tabular and graphical representations of data.
Making conclusions	Draw conclusions that are consistent with the evidence obtained and support them with scientific explanations.
Evaluation	Evaluate data, considering its repeatability, reproducibility and validity in presenting and justifying conclusions.
	Evaluate methods of data collection and appreciate that the evidence obtained may not allow a conclusion to be made with confidence.
	Suggest ways of improving an investigation or practical procedure to obtain extra evidence to allow a conclusion to be made.

6.2 Required practicals

The table below summarises the required practicals.

Specification	Required practicals
1. Chemical changes C 3.3.2 Electrolysis	Investigate the products at the anode and cathode in the electrolysis of copper sulfate solution.
2. Chemical analysis 3.4.3 Identification of ions	Identify the metal ion in an unknown compound using flame testing techniques.
3. Quantitative chemistry 3.6.4 Molar concentrations	Establish the concentration of an unknown strong acid through titration with a strong base.
4. The rate and extent of chemical change 3.8.1 Rate of reaction	Investigate factors affecting the rate of a reaction.
5. Organic chemistry C 3.10.1.3 Obtaining useful substances from crude oil	Test for the presence of a double bond in an unknown hydrocarbon.

Opportunities to develop experimental and investigative skills during the teaching and learning of the required practicals are identified in the table below.

Scientific process and skill	Electrolysis	Flame tests	Titration	Rates of reaction	Test for alkene
Designing a practical procedure	✓	✓	✓	✓	x
Control	x	x	✓	✓	x
Risk assessment	✓	✓	✓	✓	✓
Collecting data	✓	✓	✓	✓	✓
Analysing data	✓	✓	✓	✓	✓
Making conclusions	✓	✓	✓	✓	✓
Evaluation	✓	✓	✓	✓	x

6.3 Mathematical requirements

This specification provides 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 students to demonstrate scientific knowledge using appropriate mathematical skills.

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

Students are permitted to use calculators in all assessments.

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

All students 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 +, –, x, ÷, 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 =, <, >, ~
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.
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.

6.4 Periodic table

Key

relative atomic mass **atomic symbol** name atomic (proton) number

1	2											3	4	5	6	7	0
							1 **H** hydrogen 1										4 **He** helium 2
7 **Li** lithium 3	9 **Be** beryllium 4											11 **B** boron 5	12 **C** carbon 6	14 **N** nitrogen 7	16 **O** oxygen 8	19 **F** fluorine 9	20 **Ne** neon 10
23 **Na** sodium 11	24 **Mg** magnesium 12											27 **Al** aluminium 13	28 **Si** silicon 14	31 **P** phosphorus 15	32 **S** sulfur 16	35.5 **Cl** chlorine 17	40 **Ar** argon 18
39 **K** potassium 19	40 **Ca** calcium 20	45 **Sc** scandium 21	48 **Ti** titanium 22	51 **V** vanadium 23	52 **Cr** chromium 24	55 **Mn** manganese 25	56 **Fe** iron 26	59 **Co** cobalt 27	59 **Ni** nickel 28	63.5 **Cu** copper 29	65 **Zn** zinc 30	70 **Ga** gallium 31	73 **Ge** germanium 32	75 **As** arsenic 33	79 **Se** selenium 34	80 **Br** bromine 35	84 **Kr** krypton 36
85 **Rb** rubidium 37	88 **Sr** strontium 38	89 **Y** yttrium 39	91 **Zr** zirconium 40	93 **Nb** niobium 41	96 **Mo** molybdenum 42	[98] **Tc** technetium 43	101 **Ru** ruthenium 44	103 **Rh** rhodium 45	106 **Pd** palladium 46	108 **Ag** silver 47	112 **Cd** cadmium 48	115 **In** indium 49	119 **Sn** tin 50	122 **Sb** antimony 51	128 **Te** tellurium 52	127 **I** iodine 53	131 **Xe** xenon 54
133 **Cs** caesium 55	137 **Ba** barium 56	139 **La*** lanthanum 57	178 **Hf** hafnium 72	181 **Ta** tantalum 73	184 **W** tungsten 74	186 **Re** rhenium 75	190 **Os** osmium 76	192 **Ir** iridium 77	195 **Pt** platinum 78	197 **Au** gold 79	201 **Hg** mercury 80	204 **Tl** thallium 81	207 **Pb** lead 82	209 **Bi** bismuth 83	[209] **Po** polonium 84	[210] **At** astatine 85	[222] **Rn** radon 86
[223] **Fr** francium 87	[226] **Ra** radium 88	[227] **Ac*** actinium 89	[261] **Rf** rutherfordium 104	[262] **Db** dubnium 105	[266] **Sg** seaborgium 106	[264] **Bh** bohrium 107	[277] **Hs** hassium 108	[268] **Mt** meitnerium 109	[271] **Ds** darmstadtium 110	[272] **Rg** roentgenium 111	[285] **Cn** copernicium 112	[286] **Uut** ununtrium 113	[289] **Fl** flerovium 114	[289] **Uup** ununpentium 115	[293] **Lv** livermorium 116	[294] **Uus** ununseptium 117	[294] **Uuo** ununoctium 118

* The Lanthanides (atomic numbers 58 – 71) and the Actinides (atomic numbers 90 – 103) have been omitted.

Relative atomic masses for **Cu** and **Cl** have not been rounded to the nearest whole number.

6.5 Glossary of subject specific terminology

The following subject specific vocabulary provides definitions of key terms used in our International GCSE science specifications.

Wherever possible we have used the definitions derived from a booklet created in a joint project of the Association for Science Education and the Nuffield Foundation:

The Language of Measurement: Terminology used in school science investigations. Association for Science Education (ASE), 2010. ISBN 978 0 86357 424 5.

This list is **draft** and subject to change.

Accuracy

A measurement result is considered accurate if it is judged to be close to the true value.

Calibration

Marking a scale on a measuring instrument.

This involves establishing the relationship between indications of a measuring instrument and standard or reference quantity values, which must be applied.

For example, placing a thermometer in melting ice to see whether it reads zero, in order to check if it has been calibrated correctly.

Data

Information, either qualitative or quantitative, that has been collected.

Errors

See also uncertainty.

Measurement error: the difference between a measured value and the true value.

Anomalies: these are values in a set of results which are judged not to be part of the variation caused by random uncertainty.

Random error: these cause readings to be spread about the true value, due to results varying in an unpredictable way from one measurement to the next. Random errors are present when any measurement is made, and cannot be corrected. The effect of random errors can be reduced by making more measurements and calculating a new mean.

Systematic error: these cause readings to differ from the true value by a consistent amount each time a measurement is made. Sources of systematic error can include the environment, methods of observation or instruments used. Systematic errors cannot be dealt with by simple repeats. If a systematic error is suspected, the data collection should be repeated using a different technique or a different set of equipment, and the results compared.

Zero error: any indication that a measuring system gives a false reading when the true value of a measured quantity is zero, eg the needle on an ammeter failing to return to zero when no current flows. A zero error may result in a systematic uncertainty.

Evidence

Data which has been shown to be valid.

Fair test

A fair test is one in which only the independent variable has been allowed to affect the dependent variable.

Hypothesis

A proposal intended to explain certain facts or observations.

Interval

The quantity between readings, eg a set of 11 readings equally spaced over a distance of 1 metre would give an interval of 10 centimetres.

Precision

Precise measurements are ones in which there is very little spread about the mean value.

Precision depends only on the extent of random errors – it gives no indication of how close results are to the true value.

Prediction

A prediction is a statement suggesting what will happen in the future, based on observation, experience or a hypothesis.

Range

The maximum and minimum values of the independent or dependent variables; important in ensuring that any pattern is detected.

For example a range of distances may be quoted as either: 'From 10 cm to 50 cm' or 'From 50 cm to 10 cm'.

Repeatable

A measurement is repeatable if the original experimenter repeats the investigation using same method and equipment and obtains the same results.

Reproducible

A measurement is reproducible if the investigation is repeated by another person, or by using different equipment or techniques, and the same results are obtained.

Resolution

This is the smallest change in the quantity being measured (input) of a measuring instrument that gives a perceptible change in the reading.

Sketch graph

A line graph, not necessarily on a grid, that shows the general shape of the relationship between two variables. It will not have any points plotted and although the axes should be labelled they may not be scaled.

True value

This is the value that would be obtained in an ideal measurement.

Uncertainty

The interval within which the true value can be expected to lie, with a given level of confidence or probability, eg 'the temperature is 20 °C ± 2 °C, at a level of confidence of 95 %'.

Validity

Suitability of the investigative procedure to answer the question being asked. For example, an investigation to find out if the rate of a chemical reaction depended upon the concentration of one of the reactants would not be a valid procedure if the temperature of the reactants was not controlled.

Valid conclusion

A conclusion supported by valid data, obtained from an appropriate experimental design and based on sound reasoning.

Variables

These are physical, chemical or biological quantities or characteristics.

Categoric: categoric variables have values that are labels eg names of plants or types of material.

Continuous: continuous variables can have values (called a quantity) that can be given a magnitude either by counting (as in the case of the number of shrimp) or by measurement (eg light intensity, flow rate etc).

Control: a control variable is one which may, in addition to the independent variable, affect the outcome of the investigation and therefore has to be kept constant or at least monitored.

Dependent: the dependent variable is the variable of which the value is measured for each and every change in the independent variable.

Independent: the independent variable is the variable for which values are changed or selected by the investigator.

Terms no longer used

The term 'discrete variable' will no longer be used as this has been subsumed by the definition of 'continuous variable'.

The terms 'reliable' and 'reliability' will no longer be used. Instead, the terms 'repeatable' or 'repeatability' and 'reproducible' or 'reproducibility' will be used.

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