AQA Level 1/2 Certificate in Chemistry

Specification

For exams June 2013 onwards
For certification June 2013 onwards

Level 1/2

Specification

Certificate in Chemistry 8402

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Contents

1 Introduction

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1a Why choose AQA?

We are the United Kingdom's favourite exam board and more students get their academic qualifications from us than from any other board. But why are we so popular?

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

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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.

1b Why choose AQA Level 1/2 Certificate in Chemistry?

In developing this specification we have consulted widely with teachers, science advisers and learned societies to produce content and assessments that will both stimulate students' interest in and enthusiasm for chemistry and provide an excellent grounding for further study.

The substantive content covers much of, but is not restricted by, the GCSE Programme of Study. This specification thus contains a broad range of chemical topics that are designed to engage and stimulate students' interest in chemistry whilst providing the knowledge and understanding required for progression to Level 3 qualifications. The specification emphasises scientific knowledge, the application of science and the scientific process.

Chemistry is an enquiry-based discipline involving practical and investigational skills as well as knowledge. Section 3b gives the fundamental ideas behind scientific enquiry that should be delivered through teaching of the content.

This specification has less focus on some of the aspects of How Science Works that are covered in GCSE Chemistry (for example, there is less sociological, economic and environmental content). This gives time for more detailed study of scientific knowledge and for development of the skills of scientific enquiry essential to this subject. The experimental and investigative skills that will be assessed in this specification are listed in Section 3d.

The terminal assessment model is designed to ensure the maximum amount of time for teaching chemistry without frequent interruptions for examinations.

The content has a significant overlap with that in the AQA GCSE Chemistry, thereby enabling co-teaching if required.

1c How do I start using this specification?

You need to register at **www.aqa.org.uk/askaqa.php** to ensure that you receive regular updates and have access to mark schemes, past question papers, a whole range of teacher support materials and receive details of teacher support meetings.

Once you have decided to enter candidates you need to tell us so we can make sure that you get all the material you need for the examinations. You can let us know by filling in the appropriate *Intention to Enter* and *Estimated Entry* forms.

- If your centre is registered on e-AQA you will receive an e-mail prompting you to submit entry information on-line.
- If you are not e-AQA registered we will send copies to your Examinations Officer. Both forms can be downloaded from our website (**www.aqa.org.uk/admin/p_entries.php**).

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

1d How can I find out more?

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Ask AQA

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

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Speak to your subject team

You can talk directly to the GCSE Sciences subject team about this specification either by e-mailing **science-gcse@aqa.org.uk** or by calling 08442 090 415.

Teacher Support Meetings

Details of the full range of our Teacher Support meetings are available on our website at **www.aqa.org.uk/support/teachers.php**

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If you need to contact the Teacher Support team, you can call us on 01483 477 860 or e-mail us at **teachersupport@aqa.org.uk**

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2 Specification at a Glance

AQA Level 1/2 Certificate in Chemistry

The Scheme of Assessment is linear, with two question papers to be taken in the same examination series, as detailed below.

Paper 1

Written paper – 1 hour 30 minutes

90 marks – **50%**

Structured and open questions

PLUS

Paper 2

Written paper – 1 hour 30 minutes

90 marks – **50%**

Structured and open questions

3 Subject Content

3a Introduction

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

How the specification is assessed

The content is assessed through two 1 hour 30 minute written papers, each worth 50% of the overall marks for the specification. Assessments will be available twice a year, in January and June.

In both written papers, questions will be set that examine application of the knowledge and understanding gained in discussing, evaluating and suggesting implications of data and evidence in both familiar and unfamiliar situations. All applications will use the knowledge and understanding developed through the substantive content. Questions may be taken from any part of the substantive content.

Paper 1 is more weighted to assessment of knowledge, understanding and application than Paper 2. Paper 2 will include a higher proportion of questions aimed towards the skills listed in Section 3d than Paper 1.

The importance of scientific literacy

Scientists need to be able to communicate their knowledge and understanding to others in a clear, comprehensive and literate manner. One question in each paper will specifically test students' ability to use good English, organise information clearly and use scientific terms correctly. Each paper will also include some questions that require students to write full descriptions, explanations and/or evaluations in which statements and ideas are clearly and coherently linked.

3b The scientific process

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, for example, using hypotheses and models, and to solve problems using evidence.

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

The repeatability and 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 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
- carrying out 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 and relationships and making suitable conclusions.

These ideas inform decisions and are central to science education. They constitute the scientific process that is a necessary complement to the subject content of chemistry.

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 the scientific process.

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.

Investigations

An investigation is an attempt to determine whether or not there is a relationship between variables. It is therefore 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.

Measurements in investigations

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.

Presentation of 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. The choice of graphical representation depends upon the type of variable represented.

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.

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 be biased, or may not be based on evidence alone, as other societal factors may be relevant.

Limitations of scientific evidence

Science can help us in many ways but it cannot supply all the answers. There are some questions that science cannot answer directly. These tend to be questions where beliefs, opinions and ethics are important.

Investigative skills and practical work

During their study of this course, students should be encouraged 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 methodology, evidence and data.

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.

Further information on how experimental and investigative skills will be assessed in this specification is given in Section 3d.

3c Subject content

Ref	Content
1	**The fundamental ideas in chemistry**
1.1	**Solids, liquids and gases**
a)	Matter can be classified in terms of the three states of matter, which are inter-convertible. *Candidates should be familiar with the 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.* *Candidates should understand the energy changes that accompany changes of state.*
b)	Evidence for the existence of particles can be obtained from simple experiments. *Candidates should be familiar with simple diffusion experiments such as Br_2 / air, NH_3 / HCl, $KMnO_4$ / water.*
1.2	**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. *Candidates should know 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, Na represents an atom of sodium. *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

Ref	Content
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. *Candidates will be expected to calculate the numbers of each sub-atomic particle in an atom from its atomic number and mass number.*
g)	All atoms of a particular element have the same number of protons. Atoms of different elements have different numbers of protons.
h)	Atoms of the same element can have different numbers of neutrons; these atoms are called isotopes of that element.
i)	Atoms can be represented as shown in this example: (Mass number) 23 Na (Atomic number) 11

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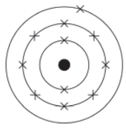
Ref	Content
j)	Electrons occupy particular energy levels. Each electron in an atom is at a particular energy level (in a particular shell). The electrons in an atom occupy the lowest available energy levels (innermost available shells).

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

Candidates 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

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

Name of particle	Charge
Proton	1
Neutron	1
Electron	Very small

l) 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.

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

1.3 Chemical reactions and related calculations

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 to attain the electron arrangement of the nearest noble gas.

b) 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.

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.

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

Candidates are expected 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.

d) 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.

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

Candidates should be able to calculate empirical formulae.

f) Chemical reactions can be represented by word equations or by symbol equations.

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

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

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

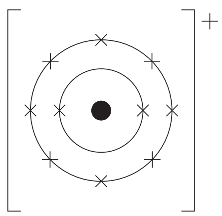
h) No atoms are lost or made during a chemical reaction so the mass of the products equals the mass of the reactants.

Ref	Content
i)	The masses of reactants and products can be calculated from balanced symbol equations. *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 and the balanced symbol equation.*
j)	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.
k)	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. *Candidates will be expected to calculate percentage yields of reaction products.*
l)	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: $A + B \rightleftharpoons C + D$ For example: ammonium chloride $\rightleftharpoons$ ammonia + hydrogen chloride

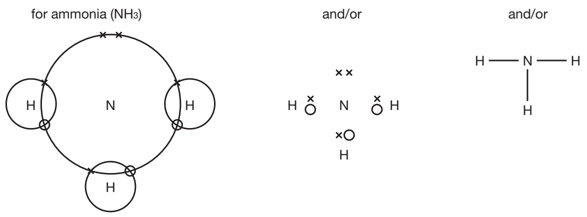
3

2 Bonding and structure

2.1 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 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. *Candidates should know that metals form positive ions, whereas non-metals form negative ions.* *Candidates should be able to represent the electron arrangement of ions in the following form:*  *for sodium ion (Na^+)* *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 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.*

Ref	Content
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, such as H_2, Cl_2, O_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).
h)	Compounds formed from non-metals consist of molecules. In molecules, the atoms are held together by covalent bonds. *Candidates should be able to represent the covalent bonds in molecules such as water, ammonia, hydrogen, hydrogen chloride, methane and oxygen in the following forms:*



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

Ref	Content
2.2	**Structure and how it influences the properties and uses 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. *Candidates need to 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. *Candidates should be able to recognise other giant structures or macromolecules from diagrams showing their bonding.*
g)	In diamond, each carbon atom forms four covalent bonds with other carbon atoms in a giant covalent structure, so diamond is very hard.
h)	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. *Candidates should be able to explain the properties of graphite in terms of weak forces between the layers.*

Ref	Content
i)	In graphite, one electron from each carbon atom is delocalised. These delocalised electrons allow graphite to conduct heat and electricity. *Candidates should realise that graphite is similar to metals in that it has delocalised electrons.*
j)	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. *Candidates are only required to know that the structure of fullerenes is based on hexagonal rings of carbon atoms.*
k)	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. *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.*

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3 Air and water

3.1 Air and oxygen

a)	Air is a mixture of gases with different boiling points. *Candidates should recall the approximate composition of air in terms of percentages of oxygen and nitrogen.* *Candidates should know that there are relatively small amounts of water vapour, carbon dioxide, neon and argon but the percentages of these components is **not** required.*
b)	Dry air, free from carbon dioxide, can be liquefied and then fractionally distilled to obtain oxygen and nitrogen. *Knowledge of the boiling points of the different gases is **not** required.*
c)	Elements can burn in air to form oxides, which can be classified as acidic, basic and amphoteric. *Candidates should be able to describe the burning of Na, Mg, Fe, C and S. They should know that water-soluble oxides of metals give alkaline solutions and those of non-metals give acidic solutions.*
d)	When substances burn in air they are reacting with the oxygen. *Candidates should be able to describe a test for oxygen.*
e)	Oxidation and reduction reactions involve the addition and removal of oxygen respectively.
f)	Air is often polluted by carbon monoxide, sulfur dioxide and oxides of nitrogen. *Candidates should know how each pollutant arises and be able to describe one effect of each pollutant.*

3.2 Water

a)	Natural waters contain dissolved salts, which can be removed to obtain pure water. *Candidates should be aware that pure water can be made by distillation and that desalination is an important method of obtaining water for domestic use in some countries.* *Candidates should know the boiling point of pure water and a simple chemical test to show the presence of water.*
b)	Drinking water should have sufficiently low levels of dissolved salts and microbes. *Candidates should be aware that water of the correct quality is produced by passing water from a suitable source through filter beds to remove solids, and then sterilising with chlorine.*

Ref	Content
c)	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.*
d)	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.*

3.3 Rusting

a)	Both air and water are necessary for iron to rust. *Candidates should know that rusting refers to the corrosion of iron. They should be able to describe and interpret experiments to show that both air and water are necessary for rusting.*
b)	There are a number of ways in which rusting can be prevented, most of which are based on the exclusion of air and water. *Candidates should be able to recall and explain some methods of rust prevention, eg greasing, painting and sacrificial protection.*

4 The periodic table

4.1 The periodic table

a)	The periodic table is arranged in order of atomic (proton) number and 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)	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.
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. *Candidates should know that the noble gases have eight electrons in their outer energy level, except for helium, which has only two electrons.*

4.2 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.
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.

Ref	Content
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.

5 Acids, bases and salts

5.1 Acids, bases and salts

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. Ammonium salts are important as fertilisers.
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. *Candidates should be familiar with using limewater to test for carbon dioxide gas.*
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. *Candidates should be familiar with the pH scale from 0 to 14, and know that pH 7 is a neutral solution.* *Candidates 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: $H^+ (aq) + OH^- (aq) \longrightarrow H_2O (l)$
h)	The volumes of acid and alkali solutions that react with each other can be measured by titration using a suitable indicator. *Candidates should be able to carry out titrations using strong acids and strong alkalis only (sulfuric, hydrochloric and nitric acids only).*
i)	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. *Candidates should be able to calculate the chemical quantities in titrations involving concentrations (in moles per dm^3) and masses (in grams per dm^3).*

3

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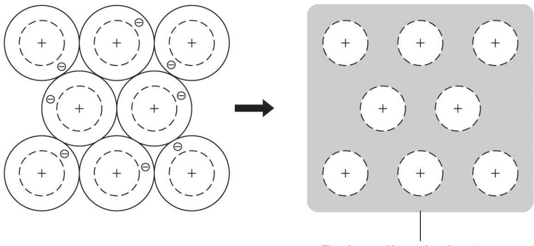
Ref	Content
5.2	**Making salts**
a)	Soluble salts can be made from acids by reacting them with: - metals – not all metals are suitable; some are too reactive and others are not reactive enough - insoluble bases – the base is added to the acid until no more will react and the excess solid is filtered off - alkalis – an indicator can be used to show when the acid and alkali have completely reacted to produce a salt solution. *Candidates 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. *Candidates should be able to name the substances needed to make a named insoluble salt.*
5.3	**Metal carbonates**
a)	The carbonates of magnesium, copper, zinc, calcium and lithium decompose on heating (thermal decomposition) in a similar way. *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.*
b)	Metal carbonates react with acids to produce carbon dioxide, a salt and water.
c)	Limestone, containing the compound calcium carbonate ($CaCO_3$), is quarried and can be used as a building material, or powdered and used to control acidity in the soil. It can be used in the manufacture of cement, glass and iron and to produce calcium oxide (lime).
6	**Metals**
6.1	**The reactivity series**
a)	Metals can be arranged in an order of their reactivity from their reactions with water and dilute acids. *Candidates 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, where appropriate, to place them in order of reactivity.*
b)	Displacement reactions involving metals and their compounds in aqueous solution establish positions within the reactivity series. *Candidates should be able to describe displacement reactions in terms of oxidation and reduction, and to write the ionic equations.* *Candidates should be aware that copper can be obtained from solutions of copper salts by displacement using scrap iron.*
c)	The non-metals hydrogen and carbon are often included in the reactivity series based on the reactions of metals with dilute acid, and of metal oxides with carbon. *Candidates should know that a lighted spill can be used to test for hydrogen.*

Ref	Content
6.2	**Extracting metals**
a)	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.
b)	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 candidates 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 information about specific processes for candidates to interpret or evaluate.*
c)	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 13(i)).*
d)	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 and is being depleted. Traditional mining and extraction have major environmental impacts. *Details of the industrial smelting processes are* ***not*** *required but candidates should be aware that chemical processes are involved and that examination questions may provide further information for them to interpret or evaluate.*
e)	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. *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.*
f)	Copper can be obtained from solutions of copper salts by electrolysis. *Candidates should know the electrode material and be able to write the ionic half equations for the reactions occurring at both electrodes.*
g)	Copper can be obtained from solutions of copper salts by displacement using scrap iron. *Candidates should be able to describe this in terms of oxidation and reduction, and to write the ionic equation.*
h)	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. *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.*

Ref	Content
6.3	**Structure and bonding in metals and alloys**
a)	Metals consist of giant structures of atoms arranged in a regular pattern.
b)	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: 
c)	Metals conduct heat and electricity because of the delocalised electrons in their structures. *Candidates should know that conduction depends on the ability of electrons to move throughout the metal.*
d)	The layers of atoms in metals are able to slide over each other. This means metals can be bent and shaped.
e)	Alloys are usually made from two or more metals. The different sizes of atoms in the metals distort the layers in the structure, making it more difficult for them to slide over each other. This makes alloys harder than pure metals.
f)	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 other 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.*
g)	Shape memory alloys can return to their original shape after being deformed. An example is Nitinol, which is used in dental braces.

6.4	**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. *Knowledge of the properties of specific transition metals other than those named in this specification is **not** required.*
b)	Iron from the blast furnace contains about 96% iron. The impurities make it brittle and so it has limited uses. *Knowledge of uses of iron from the blast furnace is limited to its use as cast iron because of its strength in compression.*
c)	Most iron is converted into steels. Steels are alloys since they are mixtures of iron with carbon. Some steels contain other metals. Steels 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 are 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.*

Ref	Content
d)	Copper has properties that make it useful for electrical wiring and plumbing. *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.*

7 Rates of reaction

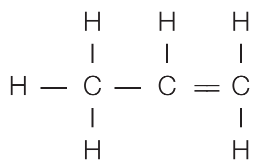
Ref	Content
a)	The rate of a chemical reaction can be found by measuring the amount of a reactant used or the amount of product formed over time: $\text{Rate of reaction} = \dfrac{\text{amount of reactant used}}{\text{time}}$ $\text{Rate of reaction} = \dfrac{\text{amount of product formed}}{\text{time}}$ *Candidates 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 candidates 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.
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 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.

Ref	Content
8	**Crude oil and fuels**
8.1	**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. *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.*
8.2	**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} *Candidates 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 $\begin{array}{ccccccc} & & H & & H & & \\ & & \vert & & \vert & & \\ H & — & C & — & C & — & H \\ & & \vert & & \vert & & \\ & & H & & H & & \end{array}$ *Candidates should know that in displayed structures a — represents a covalent bond.* *Candidates 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 of trends in properties of hydrocarbons is limited to:* ▪ *boiling points* ▪ *viscosity* ▪ *flammability.*
8.3	**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. *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.*
b)	The combustion of hydrocarbon fuels releases energy. During combustion, the carbon and hydrogen in the fuels are oxidised.

Ref	Content
c)	Sulfur dioxide and oxides of nitrogen cause acid rain, an increase in carbon dioxide results in climate change, and solid particles cause global dimming. *Candidates should know at least one effect of, but are* ***not*** *required to know details of any other causes of, acid rain or climate change.*
d)	Sulfur can be removed from fuels before they are burned, eg in vehicles. Sulfur dioxide can be removed from the waste gases after combustion, eg in power stations. *Knowledge of the methods of removing sulfur is* ***not*** *required.*
e)	Biofuels, including biodiesel and ethanol, are produced from plant material, and are possible alternatives to hydrocarbon fuels. *Candidates 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.* *Candidates 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.*
f)	Hydrogen can be burned as a fuel in combustion engines or can be used in fuel cells that produce electricity to power vehicles. *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.* *Candidates 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.*

9 Other useful substances from crude oil

9.1 Obtaining useful substances from crude oil

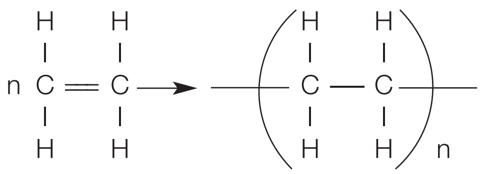
Ref	Content
a)	Hydrocarbons can be broken down (cracked) to produce smaller, more useful molecules. This process involves heating the hydrocarbons to vaporise them. The vapours are either passed over a hot catalyst or mixed with steam and heated to a very high temperature so that thermal decomposition 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} *Candidates 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  *Candidates should know that in displayed structures an = represents a double bond.* *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.*
d)	Alkenes react with bromine water, turning it from orange to colourless.
e)	Some of the products of cracking are useful as fuels.
f)	Ethanol can be produced by reacting ethene with steam in the presence of a catalyst.

3

9.2 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)

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.*

*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.*

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.

Candidates 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).

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.

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 candidates 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

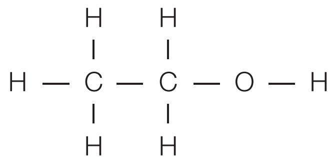
Ref	Content

10 Alcohols, carboxylic acids and esters

10.1 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



*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.

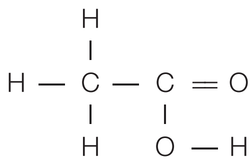
c) Ethanol can be oxidised to ethanoic acid, either by chemical oxidising agents or by microbial action. Ethanoic acid is the main acid in vinegar.

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

10.2 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

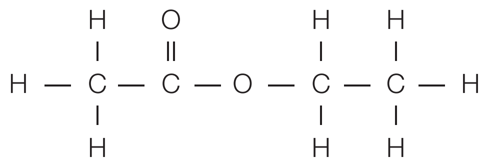


*Candidates should be able to recognise carboxylic acids from their names or formulae, but do **not** need to know the names of individual carboxylic acids other than methanoic acid, ethanoic acid and propanoic acid.*

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

Ref	Content
10.3	**Esters**
a)	Ethyl ethanoate is the ester produced from ethanol and ethanoic acid. Esters have the functional group –COO–. The structures of esters can be represented in the following forms: $CH_3COOCH_2CH_3$ or  *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.*
b)	Esters are volatile compounds with distinctive smells and are used as flavourings and perfumes.

11 Energy changes in chemical reactions

Ref	Content
11.1	**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. 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: hydrated copper sulfate (blue) $\underset{\text{exothermic}}{\overset{\text{endothermic}}{\rightleftharpoons}}$ anhydrous copper sulfate (white) + water
11.2	**Calculating and explaining energy changes**
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. *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 the question.*
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.

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

12 The production of 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: nitrogen + hydrogen $\rightleftharpoons$ ammonia 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 ■ the yield from the exothermic reaction decreases.
f)	If the temperature is lowered: ■ the yield from the endothermic reaction decreases ■ 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 ■ a decrease in pressure will favour the reaction that produces the greatest 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.

Ref	Content
13	**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).
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 $2Cl^- - 2e^- \rightarrow Cl_2$ *Candidates 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. *Candidates should understand why cryolite is used in this process.* *Candidates 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.

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

Ref	Content
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.
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.

14.2 Analysis of mixtures

a)	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.
b)	Paper chromatography can be used to analyse substances present in a solution, eg food colourings and inks/dyes. *Candidates 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 and that the separation depends on the relative solubilities of the components.*
c)	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.
d)	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. *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* ■ *the molecular mass is given by the molecular ion peak.* *Knowledge of fragmentation patterns is* ***not*** *required.*

3d 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. In Paper 2, 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.

a) Design a practical procedure to answer a question, solve a problem or test a hypothesis.

b) Comment on/evaluate plans for practical procedures.

c) Select suitable apparatus for carrying out experiments accurately and safely.

d) Appreciate that, unless certain variables are controlled, experimental results may not be valid.

e) Recognise the need to choose appropriate sample sizes, and study control groups where necessary.

f) Identify possible hazards in practical situations, the risks associated with these hazards, and methods of minimising the risks.

g) Make and record observations and measurements with appropriate precision and record data collected in an appropriate format (such as a table, chart or graph).

h) Recognise and identify the cause of anomalous results and suggest what should be done about them.

i) 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.

j) Recognise and identify the causes of random errors and systematic errors.

k) Recognise patterns in data, form hypotheses and deduce relationships.

l) Use and interpret tabular and graphical representations of data.

m) Draw conclusions that are consistent with the evidence obtained and support them with scientific explanations.

n) Evaluate data, considering its repeatability, reproducibility and validity in presenting and justifying conclusions.

o) Evaluate methods of data collection and appreciate that the evidence obtained may not allow a conclusion to be made with confidence.

p) Suggest ways of improving an investigation or practical procedure to obtain extra evidence to allow a conclusion to be made.

3e Mathematical and other requirements

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 candidates 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.

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 +, –, ×, ÷, 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.

4 Scheme of Assessment

This specification is designed to be taken over a one or two-year course of study with all assessment at the end of the course.

Examinations and certification for this specification are available for the first time in June 2013 and then every January and June thereafter throughout the life of the specification.

4a Aims and learning outcomes

The AQA Level 1/2 Certificate 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 and to make informed choices about further study in chemistry and related disciplines.

The AQA Level 1/2 Certificate 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.

4b Assessment Objectives (AOs)

The examination papers will assess the following assessment objectives 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

The table below shows approximate weighting of each of the Assessment Objectives in the AQA Level 1/2 Certificate in Chemistry assessments.

Assessment Objectives	Paper weightings (%)		Overall weighting of AOs (%)
	Paper 1	Paper 2	
AO1	27.5	15.0	**42.5**
AO2	19.5	15.5	**35.0**
AO3	3.0	19.5	**22.5**
Overall weighting of papers (%)	**50**	**50**	**100**

4c National criteria

This specification is in line with the following.

- The Code of Practice.
- 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.

4d Previous learning requirements

There are no prior learning requirements.

However, any requirements set for entry to a course based on this specification are at your centre's discretion.

4e Access to assessment: diversity and inclusion

This 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.

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. More details are given in Section 5d.

5 Administration

5a Availability of assessment components and certification

Examinations and certification for this specification are available for the first time in June 2013, and then each January and June thereafter.

5b 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 components and for certification.

AQA Level 1/2 Certificate in Chemistry – 8402

A single entry is all that is needed for both examination papers and certification.

5c Private candidates

This specification is available to private candidates. Private candidates should write to us for a copy of Supplementary Guidance for Private Candidates (for specifications without controlled assessment).

5d 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 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 **jcq.org.uk** or you can follow the link from our website **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. Further detailed information is available in the JCQ regulations *Access arrangements, reasonable adjustments and special consideration*. The needs of individual candidates covered by the Equality Act will vary considerably. For queries relating to individual candidate's needs and what reasonable adjustments may be approved you can contact our Access Arrangements team for specialist advice.

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 **aqa.org.uk**

5e Examination language

We only provide components for this specification in English.

5f Qualification titles

The qualification based on this specification is:

- AQA Level 1/2 Certificate in Chemistry

5g Awarding grades and reporting results

This qualification will be graded on an eight-grade scale: A*, A, B, C, D, E, F, 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, for each paper and for the overall qualification, when we issue candidates' results. We will report a candidate's results to your centre in terms of uniform marks and qualification results in terms of uniform marks and grades. A candidate's grade is determined solely by their overall mark. There is no requirement to achieve the grade boundary in each paper in order to achieve a particular grade overall. Hence, a strong performance in one paper can compensate for a weaker performance in the other.

For each paper, the uniform mark corresponds to a grade as follows:

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 papers. We convert this total uniform mark into a grade as follows.

AQA Level 1/2 Certificate in Chemistry
(maximum uniform mark = 200)

Grade	Uniform Mark Range
A*	180 – 200
A	160 – 179
B	140 – 159
C	120 – 139
D	100 – 119
E	80 – 99
F	60 – 79
G	40 – 59
U	0 – 39

5

5h Re-sits

This is a traditional linear specification and, as such, individual components may not be retaken, neither can results for individual examination papers be carried forward or re-used.

Candidates can re-sit the whole qualification as many times as they wish. Candidates' grades are based on the work they submit for assessment.

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 should be considered in relation to the content outlined in the specification – they are not designed to define that content. The grade awarded will depend on how well the candidate has met the assessment objectives (see Section 4b). If a candidate has performed less well in some areas this may be balanced by better performance in others.

Grade	Description
A	■ Candidates recall, select and communicate precise knowledge and detailed understanding of chemistry. ■ They demonstrate a comprehensive understanding of chemical laws, principles and applications. ■ They use scientific and technical knowledge, terminology and conventions appropriately and consistently. ■ They apply appropriate skills, including communication, mathematical, technical and observational skills, knowledge and understanding effectively in a wide range of contexts. ■ They are confident with a wide range of appropriate methods, sources of information and data, consistently applying relevant skills to address scientific questions, solve problems and recognise appropriate hypotheses. ■ They 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 judgements consistently and draw detailed, evidence-based conclusions.
C	■ Candidates recall, select and communicate secure knowledge and understanding of chemistry. ■ They demonstrate understanding of chemical laws, principles and applications. ■ They use scientific and technical knowledge, terminology and conventions appropriately. ■ They apply appropriate skills, including communication, mathematical, technical and observational skills, knowledge and understanding in a range of contexts. ■ They are familiar with a range of appropriate methods, sources of information and data, applying their skills to address scientific questions, solve problems and usually recognise hypotheses. ■ They 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 make judgements and draw conclusions based on the available evidence.

F	- Candidates recall, select and communicate limited knowledge and understanding of chemistry. - They demonstrate some understanding of chemical laws, principles and applications. - They use limited scientific and technical knowledge, terminology and conventions. - They apply skills, including limited communication, mathematical, technical and observational skills, knowledge and understanding in some contexts. - They are familiar with a limited range of methods, sources of information and data to address straightforward scientific questions and problems. - They interpret limited quantitative and qualitative data and information from a narrow range of sources. - They have some understanding of the limitations of evidence. - 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 and have been identified in Section 3: Subject Content.

European Dimension

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

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 components.

Avoiding bias

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

C Overlaps with other qualifications

Much of the content in the AQA Level 1/2 Certificate in Chemistry is contained in the AQA Level 1/2 Certificate in Science: Double Award.

D The replacement of Key Skills with Functional Skills

The Key Skills qualifications have been replaced by Functional Skills. However, centres may claim proxies for Key Skills components and / or certification in the following series: January, March and June 2012. The **Administration Handbook for the Key Skills Standards 2012** has further details. All Examination Officers in centres offering AQA Key Skills and Wider Key Skills have been sent a letter outlining the details of the end dates of these subjects. Copies of the letters have also been sent to the Head of Centre and Key Skills coordinator. This is a brief outline of that information. It is correct as at August 2011 and replaces the information on the same subject found in other documents on the AQA website:

Key Skills Levels 1, 2 and 3 Test and Portfolio

The final opportunity for candidates to enter for a level 1, 2 or 3 Key Skills test or portfolio was June 2011 with last certification in 2012.

Key Skills Level 4

The last series available to candidates entering for the Key Skills Level 4 test and portfolio was June 2010 with the last certification in the June series 2012.

Wider Key Skills

The AQA Wider Key Skills qualifications are no longer available. The last portfolio moderation took place in June 2010.

Further updates to this information will be posted on the website as it becomes available:

http://web.aqa.org.uk/qual/keyskills/wider_noticeboard.php

1	2											3	4	5	6	7	0
				Key			1 **H** hydrogen 1										4 **He** helium 2
7 **Li** lithium 3	9 **Be** beryllium 4		relative atomic mass **atomic symbol** name atomic (proton) number									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	Elements with atomic numbers 112 – 116 have been reported but not fully authenticated						

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

Cu and **Cl** have not been rounded to the nearest whole number.

AQA Level 1/2 Certificate in Chemistry from 2012 onwards

Qualification Accreditation Number: 600/4410/X

For updates and further information on any of our specifications, to find answers or ask us a question, register with Ask AQA at:
aqa.org.uk/askaqa

Download a copy of this specification from our website at:
aqa.org.uk/igcse-science

Free launch meetings are available in 2012 followed by further support meetings through the life of the specification.

Further information is available at:
http://events.aqa.org.uk/ebooking

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