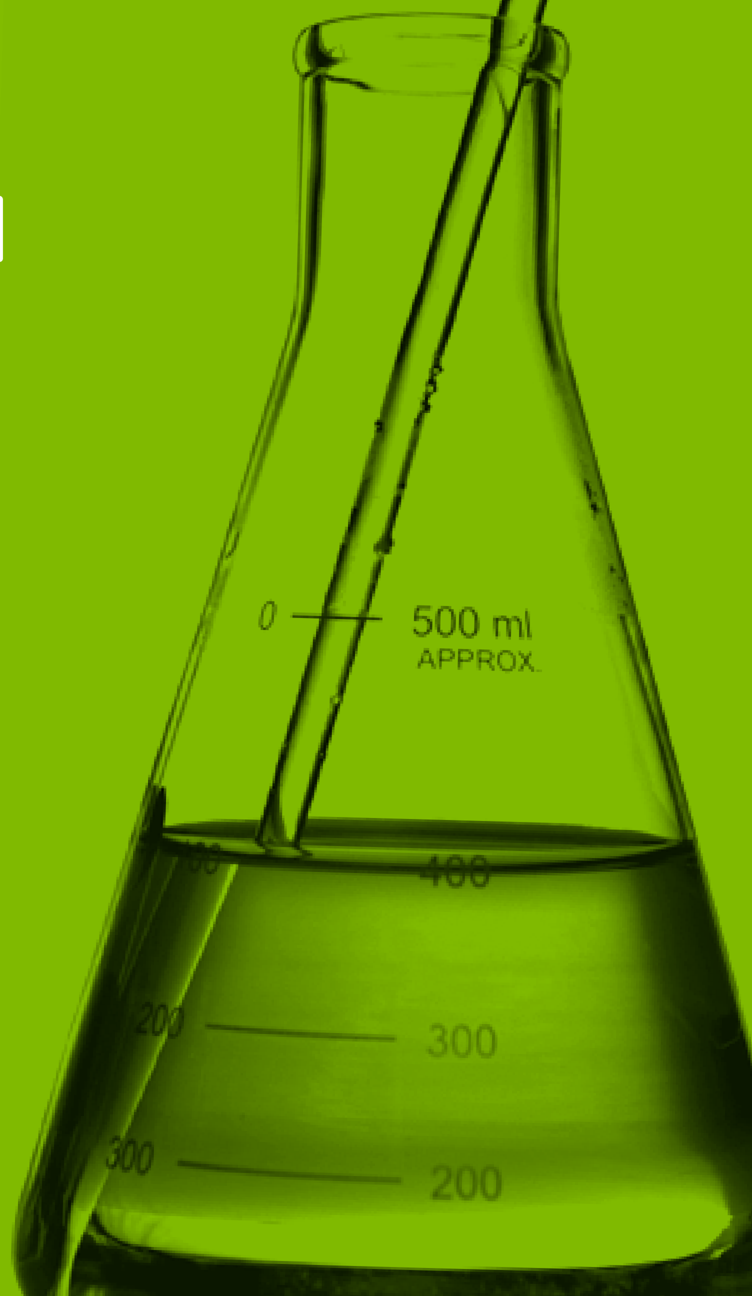
GCSE

WJEC Eduqas GCSE in CHEMISTRY

ACCREDITED BY OFQUAL

SPECIFICATION

Teaching from 2016
For award from 2018



This Ofqual regulated qualification is not available for candidates in maintained schools and colleges in Wales.

WJEC Eduqas GCSE (9-1) in CHEMISTRY

For teaching from 2016
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GCSE CHEMISTRY

SUMMARY OF ASSESSMENT

Component 1: Concepts in Chemistry
Written examination: 2 hours 15 minutes
75% of qualification

A mix of short answer questions, structured questions, extended writing and data response questions, with some set in a practical context

Component 2: Applications in Chemistry
Written examination: 1 hour 15 minutes
25% of qualification

Section A (FT) / Section B (HT):
A mix of short answer questions, structured questions, extended writing and data response questions, all set in a practical context

Section B (FT) / Section A (HT):
A resource booklet containing an unseen article will provide the basis for a mix of short answer questions, structured questions and data response questions

This linear qualification will be available in May/June each year. It will be awarded for the first time in summer 2018.

Learners entered for this qualification must sit both components at either foundation or higher tier, in the same examination series.

Qualification Accreditation Number: 601/8640/9

GCSE CHEMISTRY

1 INTRODUCTION

1.1 Aims and objectives

The WJEC Eduqas GCSE in Chemistry provides a broad, coherent, satisfying and worthwhile course of study. It encourages learners to develop confidence in, and a positive attitude towards, science and to recognise its importance in their own lives and to society.

Studying this GCSE in Chemistry provides the foundations for understanding the material world. Scientific understanding is changing our lives and is vital to the world's future prosperity, and all learners should be taught essential aspects of the knowledge, methods, processes and uses of science. They should be helped to appreciate how the complex and diverse phenomena of the natural world can be described in terms of a small number of key ideas relating to the sciences which are both inter-linked, and are of universal application. These key ideas include:

- the use of conceptual models and theories to make sense of the observed diversity of natural phenomena
- the assumption that every effect has one or more cause
- that change is driven by differences between different objects and systems when they interact
- that many such interactions occur over a distance without direct contact
- that science progresses through a cycle of hypothesis, practical experimentation, observation, theory development and review
- that quantitative analysis is a central element both of many theories and of scientific methods of inquiry.

This specification is intended to promote a variety of styles of teaching and learning so that the course is enjoyable for all participants. Learners will be introduced to a wide range of scientific principles which will allow them to enjoy a positive learning experience. Practical work is an intrinsic part of science. It is imperative that practical skills are developed throughout this course and that an investigatory approach is promoted.

1.2 Prior learning and progression

There are no previous learning requirements for this specification. Any requirements set for entry to a course based on this specification are at the school/college's discretion.

This specification builds on subject content which is typically taught at key stage 3 and provides a suitable foundation for the study of Chemistry at either AS or A level and Level 3 Science qualifications. In addition, the specification provides a coherent, satisfying and worthwhile course of study for learners who do not progress to further study in this subject.

1.3 Equality and fair access

This specification may be followed by any learner, irrespective of gender, ethnic, religious or cultural background. It has been designed to avoid, where possible, features that could, without justification, make it more difficult for a learner to achieve because they have a particular protected characteristic.

The protected characteristics under the Equality Act 2010 are age, disability, gender reassignment, pregnancy and maternity, race, religion or belief, sex and sexual orientation.

The specification has been discussed with groups who represent the interests of a diverse range of learners, and the specification will be kept under review.

Reasonable adjustments are made for certain learners in order to enable them to access the assessments (e.g. candidates are allowed access to a Sign Language Interpreter, using British Sign Language). Information on reasonable adjustments is found in the following document from the Joint Council for Qualifications (JCQ): *Access Arrangements and Reasonable Adjustments: General and Vocational Qualifications.*

This document is available on the JCQ website (www.jcq.org.uk). As a consequence of provision for reasonable adjustments, very few learners will have a complete barrier to any part of the assessment.

2 SUBJECT CONTENT

This section outlines the knowledge, understanding and skills to be developed by learners studying GCSE Chemistry.

Learners should be prepared to apply the knowledge, understanding and skills specified in a range of theoretical, practical, industrial and environmental contexts.

Learners' understanding of the connections between the different elements of the subject and their holistic understanding of the subject is a requirement of all GCSE specifications. In practice, this means that learners will be required to draw together different areas of knowledge, skills and understanding from across the full course of study.

Practical work is an intrinsic part of this specification. It is vitally important in developing a conceptual understanding of many topics and it enhances the experience and enjoyment of science. The practical skills developed are also fundamentally important to learners going on to further study in science and related subjects, and are transferable to many careers.

This section includes **specified practical work** that **must** be undertaken by learners in order that they are suitably prepared for the written examinations. The completion of this practical work will develop the skills listed in Appendix A. Appendix B lists the practical technique requirements with exemplification in the context of GCSE Chemistry.

Appendix C lists the mathematical skills that will be assessed. For the foundation tier, the mathematics will be assessed at levels not lower than expected at KS3. For the higher tier, the mathematics will be assessed at levels not lower than that for foundation tier GCSE Mathematics.

All content in the specification should be introduced in such a way that it enables learners to:

- develop scientific knowledge and conceptual understanding through the specific discipline of chemistry
- develop understanding of the nature, processes and methods of science, through different types of scientific enquiries that help them to answer scientific questions about the world around them
- develop and learn to apply observational, practical, modelling, enquiry and problem-solving skills, both in the laboratory, in the field and in 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.

The specification content is organised in topics. Each topic contains the following:

- An **overview** which sums up the content of each topic.
- **Working scientifically** - this section summarises how 'working scientifically' may be developed in the topic. The 'working scientifically' section forms part of the assessable content. All of the 'working scientifically' skills listed in Appendix A are referred to at least once in one of these sections.
- **Maths skills** - a summary of mathematical skills that should be developed in each topic. The mathematical statements in this section are part of the assessable content. All of the 'mathematical skills' in Appendix B are referred to at least once in one of these sections.
- **Content statements** - 'Learner's should be able to …' These statements clarify the breadth and depth of the content for each topic. In some cases these statements may be grouped into subtopics.
- **Specified practical work** - this section includes **specified practical work** that **must** be undertaken by learners in order that they are suitably prepared for the written examinations. The completion of this practical work will develop the skills listed in Appendix A. Appendix B lists the practical technique requirements with exemplification in the context of GCSE Chemistry. Practical work forms part of the assessable content.

Some areas of the content have been selected for assessment at higher tier only. This content is shown in **bold type**. All content may therefore be examined at higher tier but that in bold will not be examined on foundation tier papers.

2.1 Component 1

CONCEPTS IN CHEMISTRY

Written examination: 2 hours 15 minutes
75% of qualification
120 marks

Learners should be helped to appreciate the achievements of chemistry in showing how the complex and diverse phenomena of both the natural and man-made worlds can be described in terms of a small number of key ideas which are of universal application, and which can be illustrated in the separate topics covered in this component. These key ideas (which are assessable) include:

- matter is composed of tiny particles called atoms and there are about 100 different naturally occurring types of atoms called elements
- elements show periodic relationships in their chemical and physical properties
- these periodic properties can be explained in terms of the atomic structure of the elements
- atoms bond by either transferring electrons from one atom to another or by sharing electrons
- the shapes of molecules (groups of atoms bonded together) and the way giant structures are arranged is of great importance in terms of the way they behave
- there are barriers to reaction so reactions occur at different rates
- chemical reactions take place in only three different ways:
    - proton transfer
    - electron transfer
    - electron sharing
- energy is conserved in chemical reactions so can therefore be neither created or destroyed.

TOPICS

1. **Pure substances and mixtures**
2. **Particles and atomic structure**
3. **Chemical formulae, equations and amount of substance**
4. **The Periodic Table and properties of elements**
5. **Bonding, structure and properties**
6. **Reactivity series and extraction of metals**
7. **Chemistry of acids**
8. **Energy changes in chemistry**
9. **Rate of chemical change and dynamic equilibrium**
10. **Carbon compounds**
11. **Production, use and disposal of important chemicals and materials**
12. **The Earth and its atmosphere**

1. PURE SUBSTANCES AND MIXTURES

Overview

This topic develops the concepts and terminology used in the classification of substances and explores how characteristic properties of different substances are exploited in laboratory methods used for their separation. The topic content provides opportunities for learners to use knowledge of the properties of substances to describe appropriate methods of separating the components of a mixture and of characterizing them. The usefulness of some commercially important mixtures is explored and exemplified.

Working scientifically

This topic offers opportunities for learners to develop their laboratory skills by selecting and manipulating a range of apparatus, having due regard for health and safety requirements, in order to separate, purify and characterize the substances in a mixture. It offers scope for learners to develop observational skills, of both a qualitative and quantitative nature, to record measurements systematically and to present them graphically. The topic also offers scope for learners to interpret and draw conclusions from the data they obtain.

Mathematical skills

In this topic, learners may use graphical methods (for example, cooling curves) to present and interpret the results of systematic measurements made in the laboratory. Physical properties are quantified and used as a means of identifying substances. For example, R_f values are calculated using the concept of ratio and are used to characterize substances that are separated by chromatography.

Learners should be able to:

(a) explain what is meant by the purity of a substance, distinguishing between the scientific and everyday use of the term 'pure'

(b) use melting point data to distinguish pure from impure substances

(c) explain the differences between elements, compounds and mixtures

(d) explain that many useful materials are formulations of mixtures, e.g. food and drink products, medicines, sunscreens, perfumes and paints

(e) describe, explain and exemplify the processes of filtration, crystallisation, simple distillation and fractional distillation

(f) recall that chromatography involves a stationary and a mobile phase and that separation depends on the distribution between the phases

(g) interpret chromatograms, including measuring R_f values

(h) suggest chromatographic methods for distinguishing pure from impure substances

(i) suggest suitable purification techniques given information about the substances involved

SPECIFIED PRACTICAL WORK

- SP1A Determination of a melting point, e.g. for naphthalene (pure substance) or candle wax (impure substance)
- SP1B Separation of liquids by distillation, e.g. ethanol from water, and by paper chromatography

2. PARTICLES AND ATOMIC STRUCTURE

Overview

The particulate model of matter is developed and used to help learners understand physical phenomena such as change of state. Differences between physical and chemical changes are emphasized. Subatomic structure is introduced in terms of the nuclear atom, contrasting the size of the atom and its nucleus. The properties of the principal subatomic particles are characterized. The differences between atoms of different elements are explored in terms of their subatomic structure and a link is made between electronic structure (in atoms of the first twenty elements) and the arrangement of elements in the Periodic Table. The concept of isotopes is introduced and their relationship to the relative atomic mass of an element is considered, leading to a further look at the criteria used to order the elements in the Periodic Table.

Working scientifically

This topic offers opportunities to show how scientific ideas change over time in response to new knowledge gathered in the laboratory, as exemplified by theories about the structure of the atom and by the attempts of Mendeleev and others to use atomic weights to order the elements in the Periodic Table.

Mathematical skills

Learners will use appropriate units, prefixes and powers of ten to quantify orders of magnitude, for example, when comparing the size of objects in the physical world and the size of particles and also when comparing the size of an atom and its nucleus. Tables of melting and boiling point data will be used to predict the state of a substance under given conditions.

Learners should be able to:

(a) recall and explain the main features of the particle model in terms of the states of matter and changes of state, distinguishing between physical and chemical changes

(b) use data to predict states of substances under given conditions

(c) explain the limitations of the particle model in relation to changes of state when particles are represented by inelastic spheres

(d) describe how the particle model does not explain why atoms of some elements react with one another

(e) recall that experimental observations suggest that atoms are mostly empty space with almost all the mass in a central nucleus

(f) describe the atom as a positively charged nucleus surrounded by negatively charged electrons, with the nuclear radius much smaller than that of the atomic radius

(g) recall that the nucleus includes protons and neutrons (except in the case of ^{1}H)

(h) recall that atoms and small molecules are typically around 10^{-10} m or 0.1 nm in diameter

(i) recall the relative charges and approximate relative masses of protons, neutrons and electrons

(j) explain why atoms as a whole have no electrical charge

(k) calculate numbers of protons, neutrons and electrons in atoms and ions, given atomic number and mass number of isotopes

(l) describe the electronic structure of the first 20 elements

(m) explain how the position of an element in the Periodic Table is related to the arrangement of electrons in its atoms and hence to its atomic number

(n) describe what is meant by isotopes and an element's relative atomic mass

(o) explain that the arrangement proposed by Mendeleev was based on 'atomic weights'; in some cases the order was not quite correct because different isotopes have different masses

3. CHEMICAL FORMULAE, EQUATIONS AND AMOUNT OF SUBSTANCE

Overview

This topic develops the learners' use of symbols in writing the formulae of chemical compounds and balanced symbol equations. A link is made between the formation of simple ions and the positions in the Periodic Table of the elements from which they are derived. Ionic symbols are then used in predicting the formulae of ionic compounds and in writing ionic equations. Quantitative chemistry is introduced using the concept of relative atomic mass and by carrying out simple calculations of relative formula mass. The relation between this and amount of substance is explored and leads to calculations of stoichiometry and of reacting masses. The molar volume of a gas is introduced to allow calculations involving reacting volumes of gases.

Working scientifically

Learners should recognise in this topic the importance of quantitative relationships when describing or investigating substances that are involved in chemical change. They should use scientific terminology and definitions accurately, interconvert units as necessary and use an appropriate number of significant figures in calculations.

Mathematical skills

Learners will balance equations, use ratio and carry out percentage and multistep calculations, e.g. when determining empirical formulae and performing calculations involving the mole. They will perform calculations with numbers written in standard form when using the Avogadro constant, change the subject of a formula and provide answers to an appropriate number of significant figures. They will convert units where appropriate, e.g. from mass to number of moles.

Learners should be able to:

(a) use chemical symbols to write the formulae of elements and simple covalent and ionic compounds

(b) deduce the empirical formula of a compound from the relative numbers of atoms present or from a model or a diagram and vice versa

(c) recall and use the law of conservation of mass

(d) use the names and symbols of common elements and compounds and the law of conservation of mass to write formulae and balanced chemical equations **and half equations**

(e) deduce the charge on ions of elements in groups 1, 2, 3, 6 and 7

(f) use the formulae of common ions to deduce the formula of a compound **and write balanced ionic equations**

(g) describe the physical states of products and reactants using state symbols (s, l, g and aq)

(h) calculate relative formula mass of species separately and in balanced chemical equations

(i) use a balanced equation to calculate masses of reactants or products

(j) calculate the empirical formula of a compound from reacting mass data

(k) deduce the stoichiometry of an equation from the masses of reactants and products and explain the effect of a limiting quantity of a reactant

(l) recall and use the definitions of the Avogadro constant (in standard form) and of the mole

(m) explain how the mass of a given substance is related to the amount of that substance in moles and vice versa

(n) describe the relationship between molar amounts of gases and their volumes and vice versa, and calculate the volumes of gases involved in reactions, using the molar gas volume of 24 dm^3 at room temperature and pressure

4. THE PERIODIC TABLE AND PROPERTIES OF ELEMENTS

Overview

The physical and chemical properties of elements of Groups 0, 1 and 7 of the Periodic Table are investigated in this topic as well as those of representative transition metals. Reactivity trends within groups 1 and 7 are deduced and are explained in terms of the electronic structures of the elements. Laboratory tests to identify simple chemical species are used as an introduction to chemical analysis. Instrumental analysis and the interpretation of its output are also considered. The Periodic Table is used throughout to classify elements and their positions within the Table are used to predict properties.

Working scientifically

This topic gives learners scope to make qualitative observations and to record the results of simple chemical tests. They interpret the results obtained from these tests and also make appropriate inferences from sample analytical data obtained by instrumental analysis. This topic also affords learners the opportunity to plan experiments to make observations. There are also opportunities for drawing inferences, identifying compounds and making reasoned judgements from the results of chemical testing. They use their knowledge and understanding of trends within the Periodic Table to predict the properties of unfamiliar elements.

Mathematical skills

Learners will extract and interpret information from charts, graphs and tables, for example those obtained using instrumental and spectroscopic techniques.

Learners should be able to:

(a) explain how the reactions of elements are related to the arrangement of electrons in their atoms and hence to their atomic number

(b) recall the trends in melting point/boiling point of elements in Groups 1, 7 and 0

(c) recall the reactions of Group 1 elements with Group 7 elements, with oxygen and with water

(d) interpret flame tests to identify ions of Group 1 and other metals [lithium, sodium, potassium, barium, calcium and copper(II)]

(e) describe the advantages of instrumental methods of analysis, such as atomic absorption spectroscopy (sensitivity, accuracy and speed)

(f) interpret an instrumental result given appropriate data in chart or tabular form, when accompanied by a reference set in the same form

(g) recall the reactions of Group 7 elements with Group 1 elements and with iron, and the displacement reactions of halogens

(h) describe tests to identify aqueous halide ions using silver nitrate solution

(i) recall that Group 0 elements are completely unreactive

(j) explain the reactivities (or otherwise) of these elements in terms of their electronic structures and the desire to attain/retain a full outer electron shell

(k) explain the trend in reactivities of elements on descending Group 1 and Group 7

(l) predict properties from trends within groups

(m) predict possible reactions and probable reactivity of elements from their positions in the Periodic Table

(n) describe tests to identify hydrogen, oxygen and chlorine gases

(o) interpret given data to identify species from test results

(p) describe metals and non-metals and explain the differences between them on the basis of their characteristic physical and chemical properties

(q) explain how the atomic structure of metals and non-metals relates to their position in the Periodic Table

(r) recall the general properties of transition metals (melting point, density, reactivity, formation of coloured ions with different charges and uses as catalysts) as exemplified by titanium, vanadium, iron and copper

SPECIFIED PRACTICAL WORK

- SP4 Identification of unknown substances using flame tests and chemical tests for ions and gases

5. BONDING, STRUCTURE AND PROPERTIES

Overview

This topic presents and later refines simple models of bonding in ionic and covalent substances. It introduces structural chemistry by describing examples of both simple and giant structures containing these bond types. Metallic bonding and structure is also introduced, as well as the concept of intermolecular forces. This leads to a consideration of how the properties of a substance are related to both its bonding and its structure. The allotropes of carbon, including fullerenes, are studied, with particular reference to links between their structures, properties and uses. The properties and usefulness of nano-materials are considered, quantifying the size of the particles these materials typically contain.

Working scientifically

This topic develops the terminology that learners need to describe the particulate nature of a wide range of substances. It offers scope for learners to interpret macroscopic properties in terms of models describing bonding and microstructure. The usefulness of new substances developed by scientists and engineers can be evaluated and weighed against possible disadvantages of their widespread use in society.

Mathematical skills

There are opportunities in this topic to relate size and scale of atoms to objects in the physical world. Information is translated between diagrammatic and numerical forms and learners are required to visualize three-dimensional shapes presented in two dimensions and vice versa, for example when studying the structures of carbon allotropes. Learners estimate the size and scale of atoms and, when describing these and nanoparticles, work with numbers written in standard form. They calculate surface areas and volumes of cubes and use ratios when considering relative sizes and surface area to volume comparisons.

Learners should be able to:

(a) describe and compare the nature and arrangement of chemical bonds in ionic compounds, simple molecules, giant covalent structures, polymers and metals

(b) explain ionic bonding in terms of electrostatic forces and the transfer of electrons

(c) construct dot and cross diagrams to show ionic bonding in simple ionic substances

(d) explain the physical properties of ionic compounds in terms of their lattice structure

(e) explain covalent bonding in terms of the sharing of electrons

(f) construct dot and cross diagrams to show covalent bonding in simple molecules

(g) explain the physical properties of simple covalent substances in terms of intermolecular bonding

(h) explain metallic bonding in terms of electrostatic forces between the ‘sea’ of electrons/lattice of positive ions

(i) explain the physical properties of metals in terms of the above model

(j) describe the limitations of the different representations and models of bonding, including dot and cross diagrams, ball and stick models and two and three dimensional representations

(k) recall that carbon atoms can form four covalent bonds

(l) explain that the huge number of natural and synthetic organic compounds we use today occur due to the ability of carbon to form families of similar compounds, chains and rings

(m) explain the properties of diamond, graphite, fullerenes and graphene in terms of their structure and bonding

(n) use ideas about energy transfers and the relative strength of chemical bonds and intermolecular forces to explain the different temperatures at which changes of state occur

(o) recognise that individual atoms do not have the same properties as bulk materials as demonstrated by the different properties of diamond, graphite, fullerenes and graphene, which all contain carbon atoms only, and by nano-scale silver particles exhibiting properties not seen in bulk silver

(p) recall the multiplying factors milli- (10^{-3}), micro- (10^{-6}) and nano- (10^{-9})

(q) compare nano-scale dimensions (in the range 1-100 nm) to typical dimensions of atoms and molecules

(r) describe the surface area to volume relationship for different-sized particles and describe how this affects properties

(s) describe how the uses of nano-scale particles of silver and titanium dioxide are related to their properties

(t) explain the possible risks associated with the use of nano-scale particles of silver and titanium dioxide, and of potential future developments in nanoscience

6. REACTIVITY SERIES AND EXTRACTION OF METALS

Overview

Displacement reactions are used to establish a reactivity series of metals. Such reactions are characterized as redox and appropriate definitions of reduction and oxidation are introduced. The relationship between the position of a metal in the reactivity series and the method used to extract it from its ore is considered, using the industrial production of iron and of aluminium as examples. Further examples of electrolysis involving electrolytes in their molten and aqueous states are used to deepen understanding of the electrode processes involved. The link between the properties and uses of metals is considered and some simple tests for metal ions in solution are introduced.

Working scientifically

This topic offers scope for learners to appreciate the relevance of chemistry to the industrial production of everyday metals and to evaluate the economic and environmental implications of industrial scale chemical processes. The use of symbol equations is extended to include the redox processes that take place at the electrodes during electrolysis.

Mathematical skills

Learners will balance symbol equations (including ionic equations) that represent a range of redox processes.

Learners should be able to:

(a) explain how the reactivity of metals with water or dilute acids is related to the tendency of the metal to form its positive ion

(b) investigate the relative reactivities of metals by displacement (e.g. iron nail in copper(II) chloride solution) and competition reactions (e.g. thermit reaction)

(c) deduce an order of reactivity of metals based on experimental results

(d) explain that the method used to extract a metal from its ore is linked to its position within the reactivity series in relation to carbon

(e) explain reduction and oxidation in terms of loss or gain of oxygen, identifying which species are oxidised and which are reduced e.g. during thermit reaction and in the blast furnace

(f) explain reduction and oxidation in terms of gain or loss of electrons, identifying which species are oxidised and which are reduced e.g. during displacement reactions and electrolysis

(g) explain the principles of extraction of iron from iron ore in the blast furnace, including reduction by carbon monoxide and the acid/base reaction that forms slag

(h) describe electrolysis of molten ionic compounds, e.g. lead(II) bromide, in terms of the ions present and reactions at the electrodes

(i) recall that metals (or hydrogen) are formed at the cathode and non-metals are formed at the anode in electrolysis using inert electrodes

(j) predict the products of electrolysis of binary ionic compounds in the molten state

(k) explain why and how electrolysis is used to extract reactive metals from their ores

(l) explain the principles of extraction of aluminium from aluminium ore (bauxite), including the use of cryolite

(m) evaluate the methods of bacterial metal extraction and phytoextraction

(n) describe electrolysis of water in terms of the ions present and reactions at the electrodes

(o) describe competing reactions in the electrolysis of aqueous solutions, e.g. copper(II) chloride, sodium chloride and sulfuric acid, in terms of the different species present

(p) recall the properties of aluminium, copper, iron and titanium

(q) explain how the properties of metals are related to their uses and select appropriate metals given details of the usage required

(r) describe tests to identify aqueous copper(II), iron(II) and iron(III) ions

SPECIFIED PRACTICAL WORK

- SP6A Determination of relative reactivities of metals through displacement reactions
- SP6B Investigation into electrolysis of aqueous solutions and electroplating

7. CHEMISTRY OF ACIDS

Overview

This topic offers opportunities for learners to investigate qualitatively the reaction of acids with metals, bases and carbonates and then to use these reactions in the preparation of soluble salts. Acids are defined in terms of their ability to donate hydrogen ions in water and the pH scale is introduced as a quantitative measure of acidity. **Higher tier learners acquire further understanding of pH as a logarithmic scale.** The titration method is introduced when preparing soluble salts from alkalis. The concentration of a solute in a solution is defined and expressed in units of mol / dm^3. It is used in calculations involving titrimetry.

Working scientifically

Preparative and titration work in this topic provides opportunities to select and manipulate a range of apparatus and to handle chemicals, having due regard to health and safety requirements. Learners make and repeat measurements and show awareness of their accuracy. Learners should also be able to apply their knowledge of sampling techniques to ensure any samples collected are representative (e.g. collecting a solid or liquid sample to check pH or test for the presence of ions). This topic also affords learners the opportunity to plan experiments or devise procedures to make observations, produce or characterise a substance, and check data. There are also opportunities for drawing inferences and making reasoned judgements from the results of chemical testing.

Mathematical skills

When processing titration data, learners will substitute numerical values into an equation and use appropriate units in the result. They will use an appropriate number of significant figures in the result of calculations, giving due regard to the accuracy of their measurements. They will change the subject of the formula used to calculate the concentration of a solution.

Learners should be able to:

(a) recall that acids react with some metals and with bases (including alkalis) and carbonates

(b) write equations predicting products from given reactants

(c) describe a test to identify carbon dioxide gas

(d) describe a test to identify carbonate ions using dilute acid

(e) recall that acids form hydrogen ions when they dissolve in water and solutions of alkalis contain hydroxide ions

(f) recall that acidity and alkalinity are measured by pH and how to measure pH using pH indicator chart and digitally

(g) describe neutralisation as acid reacting with base to form a salt plus water (or with carbonate to form a salt plus water and carbon dioxide

(h) prepare crystals of soluble salts from insoluble bases and carbonates

(i) use a titration method to prepare crystals of soluble salts and to determine relative concentrations of strong acids and strong alkalis

(j) describe test to identify aqueous sulfate ions using barium chloride solution

(k) recognise that aqueous neutralisation reactions can be generalised to hydrogen ions reacting with hydroxide ions to form water

$$H^+ + OH^- \rightarrow H_2O$$

(l) use and explain the terms dilute and concentrated (amount of substance) and weak and strong (degree of ionisation) in relation to acids

(m) describe the observed differences between reactions of strong acids and weak acids

(n) recall that as hydrogen ion concentration increases by a factor of ten the pH value of a solution decreases by one

(o) describe neutrality and relative acidity and alkalinity in terms of the effect of the concentration of hydrogen ions on the numerical value of pH (whole numbers only)

(p) explain how the mass/number of moles of a solute and the volume of the solution is related to the concentration of the solution

(q) explain how the concentration of a solution in mol/dm^3 is related to the mass of the solute and the volume of the solution

(r) explain the relationship between the volume of a solution of known concentration of a substance and the volume or concentration of another substance that react completely together

SPECIFIED PRACTICAL WORK

- SP7A Preparation of crystals of a soluble salt from an insoluble base or carbonate
- SP7B Titration of a strong acid against a strong base using an indicator

8. ENERGY CHANGES IN CHEMISTRY

Overview

By exploring some simple examples of exothermic and endothermic reactions, learners are introduced to the study of the energy changes that accompany chemical reactions. The energy profiles of reactions are presented and the concept of activation energy is developed. Bond energies are introduced and used to calculate the energy change during a chemical reaction. The production of electricity by reactions in electrochemical cells is introduced and the importance of fuel cells is considered.

Working scientifically

This topic gives learners scope to explore the everyday and technological applications of chemistry as evidenced, for example, in energy production industries. They begin to evaluate the social, economic and environmental implications of the need for energy in society.

Mathematical skills

Learners will carry out the arithmetical operations involved in calculations of energy change of reaction, selecting and using appropriate data. They will represent the energy change of a reaction graphically by means of an energy profile and interpret its main features.

Learners should be able to:

(a) distinguish between endothermic and exothermic reactions on the basis of the temperature change of the surroundings

(b) draw and label a reaction profile for an exothermic and an endothermic reaction, identifying activation energy

(c) explain activation energy as the energy needed for a reaction to occur

(d) **calculate energy changes in a chemical reaction by considering bond making and bond breaking energies**

(e) recall that a chemical cell produces a potential difference until the reactants are used up

(f) evaluate the advantages and disadvantages of hydrogen/oxygen and other fuel cells for given uses

SPECIFIED PRACTICAL WORK

- SP8 Determination of the amount of energy released by a fuel

9. RATE OF CHEMICAL CHANGE AND DYNAMIC EQUILIBRIUM

Overview

Learners consider the factors that affect the rate of a chemical reaction and use a range of appropriate laboratory methods to investigate the relationship between reaction rate and the identified key variables. They process the results of their investigations appropriately and explain observed patterns in terms of particle collisions. The effect upon reaction rate of catalysts, including enzymes, is also considered and explained in terms of the lower activation energy of the catalyzed reaction. Examples of reversible chemical reactions are introduced and the main characteristics of a dynamic equilibrium are identified. Learners may also make reasoned predictions of the effect of changing conditions of temperature and pressure upon the equilibrium state.

Working scientifically

Learners have wide scope in this topic to develop experimental skills and strategies. They will plan and investigate the effect upon reaction rate of changing a key variable while holding others constant, select and use necessary apparatus, and make a series of measurements using a range of appropriate methods. They analyse their results, identifying patterns and trends, and present reasoned explanations.

Mathematical skills

Learners will construct a graph to show the relationship between two variables (e.g. reaction time and a key variable) and thus convert numeric data into a graphical form. They will use the gradient of a curve on a graph as a measure of the rate of reaction. They deduce and interpret the relationship, shown graphically or otherwise, between two variables (e.g. reaction rate and a key variable). Learners calculate surface areas and volumes of cubes and use ratios when considering relative sizes and surface area to volume comparisons.

Learners should be able to:

(a) suggest practical methods for determining the rate of a given reaction – from gas collection, loss of mass and precipitation (including using data-logging apparatus)

(b) explain any observed changes in mass in non-enclosed systems during a chemical reaction using the particle model

(c) interpret rate of reaction graphs

(d) describe the effect of changes in temperature, concentration (pressure) and surface area on rate of reaction

(e) explain the effects on rates of reaction of changes in temperature and concentration (pressure) in terms of frequency and energy of collision between particles

(f) explain the effects on rates of reaction of changes in the size of the pieces of a reacting solid in terms of surface area to volume ratio

(g) describe the characteristics of catalysts and their effect on rates of reaction

(h) identify catalysts in reactions

(i) explain catalytic action in terms of activation energy

(j) recall that enzymes act as catalysts in biological systems

(k) recall that some reactions may be reversed by altering reaction conditions

(l) recall that dynamic equilibrium occurs when the rates of forward and reverse reactions are equal

(m) predict the effect of changing reaction conditions (concentration, temperature and pressure) on equilibrium position and suggest appropriate conditions to produce a particular product

SPECIFIED PRACTICAL WORK

- SP9A Investigation into the effect of one factor on the rate of a reaction using a gas collection method
- SP9B Investigation into the effect of one factor on the rate of the reaction between dilute hydrochloric acid and sodium thiosulfate
- SP9C Investigation into the effect of various catalysts on the decomposition of hydrogen peroxide

10. CARBON COMPOUNDS

Overview

The importance of crude oil as a source of hydrocarbon fuels and its separation by fractional distillation is explained. Cracking reactions are described as a means of obtaining valuable feedstock for the petrochemical industry. Learners investigate typical reactions of simple alkanes and alkenes and displayed structural formulae of members of each homologous series are introduced. The functional groups in alcohols and carboxylic acids are characterized and the oxidation of alcohols to carboxylic acids is exemplified. Learners study the addition polymerization of ethene and other unsaturated alkenes while those with appropriate skills extend this study to include condensation polymerization. Some important naturally occurring polymers are considered and their monomer units are identified.

Working scientifically

This topic gives learners scope to explore the everyday and technological applications of chemistry as evidenced in the oil and petrochemical industries. They evaluate the social, economic and environmental implications of the use of fossil fuels as an energy source and of the production of synthetic materials from crude oil derivatives.

Learners should be able to:

(a) recall that crude oil is a main source of hydrocarbons and is a feedstock for the petrochemical industry

(b) describe and explain the separation of crude oil by fractional distillation

(c) describe the fractions as largely a mixture of compounds of general formula C_nH_{2n+2} which are members of the alkane homologous series

(d) describe the production of materials that are more useful by cracking

(e) explain how modern life is crucially dependent upon hydrocarbons and recognise that crude oil is a finite resource

(f) recognise functional groups and identify members of the same homologous series

(g) name and draw the structural formulae, using fully displayed formulae, of the first four members of the straight chain alkanes, alkenes, alcohols and carboxylic acids

(h) predict the formulae and structures of products of reactions (combustion, addition across a double bond and oxidation of alcohols to carboxylic acids) of the first four and other given members of these homologous series

(i) recall that it is the generality of reactions of functional groups that determine the reactions of organic compounds

(j) recall the basic principles of addition polymerisation by reference to the functional group in the monomer and the repeating units in the polymer

(k) deduce the structure of an addition polymer from a simple alkene monomer and vice versa

(l) explain the basic principles of condensation polymerisation by reference to the functional groups of the monomers, the minimum number of functional groups within a monomer, the number of repeating units in the polymer, and simultaneous formation of a small molecule

(m) recall that DNA is a polymer made from four different monomers called nucleotides and that other important naturally-occurring polymers are based on sugars and amino acids

11. PRODUCTION, USE AND DISPOSAL OF IMPORTANT CHEMICALS AND MATERIALS

Overview

The importance in society of the chemical industry is exemplified in this topic by study of the Haber process. The use in agriculture of synthetic nitrogenous fertilizer is explained and there are opportunities for some learners to understand how the method of synthesis and operating conditions in industrial processes are chosen to optimize the production of chemicals. The properties and uses of metals and other manufactured materials are studied and methods of inhibiting corrosion in metals are considered. Learners also study the impact of manufactured materials on the environment. Life cycle analyses enable them to compare the properties and method of manufacture of a range of materials suitable for a particular use (including their ability to degrade and be recycled) and then to select an appropriate material with due regard for its impact on the environment.

Working scientifically

This topic offers further opportunities for learners to explain every day and technological applications of science and to evaluate their social, environmental and economic impacts. It gives scope to practise decision making based on the evaluation of technical data, evidence and arguments.

Mathematical skills

Learners will calculate the percentage yield of product and atom economy in key chemical processes. They will interpret data presented graphically or otherwise showing how yield from an industrial chemical process and its rate are dependent on operating conditions.

Learners should be able to:

(a) explain the importance of the Haber process in agricultural production

(b) recall the importance of nitrogen, phosphorus and potassium compounds in agricultural production and the potential drawbacks of over use

(c) describe the industrial production of fertilisers as several integrated processes using a variety of raw materials

(d) compare the industrial production of fertilisers with laboratory syntheses of the same products

(e) describe tests to identify ammonia gas and ammonium salts

(f) interpret graphs of reaction conditions versus rate

(g) explain the trade-off between rate of production of a desired product and position of equilibrium in some industrially important processes

(h) explain how the commercially used conditions for an industrial process are related to the availability and cost of raw materials and energy supplies, control of equilibrium position and rate

(i) describe the social and environmental impact of decisions made in siting chemical plants

(j) calculate the percentage yield of a reaction product from the actual yield of a reaction

(k) calculate the theoretical yield of a product from a given amount of reactant

(l) define the atom economy of a reaction

(m) calculate the atom economy of a reaction to form a desired product from the balanced equation

(n) explain why a particular reaction pathway is chosen to produce a specified product given appropriate data such as atom economy (if not calculated), yield, rate, equilibrium position and usefulness of by-products

(o) describe the conditions which cause corrosion and the process of corrosion, and explain how mitigation is achieved by creating a physical barrier to oxygen and water by sacrificial protection

(p) describe the composition of some important alloys in relation to their properties and uses

(q) compare quantitatively the physical properties of glass and clay ceramics, polymers, composites and metals

(r) explain how the properties of materials are related to their uses and select appropriate materials given details of the usage required

(s) describe the basic principles in carrying out a life cycle assessment of a material or product

(t) interpret data from a life-cycle assessment of a material or product

(u) describe a process where a material or product is recycled for a different use, and explain why this is viable

(v) evaluate factors that affect decisions on recycling

SPECIFIED PRACTICAL WORK

- SP11 Determination of the percentage of water in a hydrated salt, e.g. copper(II) sulfate

12. THE EARTH AND ITS ATMOSPHERE

Overview

The origin of the Earth's atmosphere and changes in its composition over geological time are introduced in this topic. Sources of present day atmospheric pollution are considered, with particular reference to the origins and global effects of greenhouse gases. Evidence for the effects on climate of greenhouse gas emissions is evaluated. Methods of mitigation of these emissions and the likely societal and economic impacts of such measures are also considered. The sources of other gaseous air pollutants and particulates are explained as well as their harmful effects. Learners also study and evaluate methods of increasing the global availability of potable water supplies.

Working scientifically

This topic offers opportunities for learners to understand that scientific evidence and understanding have a key role to play in the mitigation of the social, environmental and economic impacts of air and water pollution. It gives learners further scope to develop decision making skills based on the evaluation of a wide range of scientific and technical evidence relating to the impact of air pollution and climate change. Learners should also recognise the importance of peer review in validating scientific work. This topic also gives the opportunity to communicate results and information to a range of audiences.

Mathematical skills

Learners will extract and interpret information from charts, graphs and tables, for example in looking for correlation between carbon dioxide levels and average global temperature over time. They will use orders of magnitude to evaluate the significance of data.

Learners should be able to:

(a) interpret evidence for how it is thought the atmosphere was originally formed

(b) describe how it is thought that the an oxygen-rich atmosphere developed over geological time

(c) recall the approximate composition of the present day atmosphere

(d) describe the greenhouse effect in terms of the interaction of radiation with the Earth's atmosphere

(e) explain global warming in terms of an 'enhanced greenhouse effect'

(f) evaluate the evidence for man-made causes of climate change, including the correlation between change in atmospheric carbon dioxide concentration and the consumption of fossil fuels, and describe the uncertainties in the evidence base

(g) describe the potential effects of increased levels of carbon dioxide and methane on the Earth's climate and how these may be mitigated, including consideration of scale, risk and environmental implications

(h) describe the major sources of carbon monoxide, sulfur dioxide, oxides of nitrogen and particulates in the atmosphere and explain the problems caused by increased amounts of these substances

(i) describe the principal methods for increasing the availability of potable water in terms of the separation techniques used, including ease of treatment of waste water, ground water and salt water

2.2 Component 2

APPLICATIONS IN CHEMISTRY

Written examination: 1 hour 15 minutes
25% of qualification
60 marks

This component will assess the skills of learners in the context of the content of Component 1.

The assessment of this component will comprise two sections.

Section A Foundation Tier / Section B Higher Tier (45 marks)
This will contain a mix of short answer questions, structured questions, extended writing and data response questions, all set in a practical context. Some of the questions will be based on specified practical work whilst others will be set in a novel context.

Section B Foundation Tier / Section A Higher Tier (15 marks)
A resource booklet containing an unseen article will provide the basis for a mix of short answer questions, structured questions and data response questions.

3 ASSESSMENT

3.1 Assessment objectives and weightings

Below are the assessment objectives for this specification. Learners must:

AO1
Demonstrate knowledge and understanding of:
- scientific ideas
- scientific techniques and procedures

AO2
Apply knowledge and understanding of:
- scientific ideas
- scientific enquiry, techniques and procedures

AO3
Analyse information and ideas to:
- interpret and evaluate
- make judgements and draw conclusions
- develop and improve experimental procedures

The table below shows the weighting of each assessment objective for each component and for the qualification as a whole.

	AO1	AO2	AO3
Component 1	30%	30%	15%
Component 2	10%	10%	5%
Overall weighting	**40%**	**40%**	**20%**

For each series:
- The weighting for the assessment of mathematical skills will be a minimum of 20%
- The weighting for the assessment of practical skills will be a minimum of 15%

Learners will be expected to provide extended responses which are of sufficient length to allow them to demonstrate their ability to construct and develop a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.

3.2 Arrangements for practical work

The assessment of practical skills is a compulsory requirement of the course of study for GCSE Chemistry qualifications.

The content includes specified practical work that must be undertaken by learners in order that they are suitably prepared for the written examinations. The completion of this practical work will develop the skills listed in Appendix A.

In addition, by completing the specified practical work learners will experience each of the Practical Techniques listed in Appendix B which are a requirement of the qualification. Centres must also ensure that learners keep their own records of the practical work that they undertake.

When completing any practical work safety is of paramount concern. It is the responsibility of each centre to ensure that appropriate safety procedures are followed whenever their learners' complete practical work. Risk assessments are required for all practical work whether it takes place in the laboratory or out in the field.

For each assessment series each centre is required to submit a practical science statement (see Appendix D) to WJEC. The statement is confirmation from a centre that it has taken reasonable steps to ensure that each learner entered for that particular assessment series has completed the practical work listed in the specification. Also the centre has made a record of the specified practical work that each learner has undertaken and the knowledge, skills and understanding that the learner has derived from the completion of the practical work. The practical science statement must be submitted to WJEC for learners in a particular cohort before the awarding of their GCSE. This will be on a date published by WJEC and will fall before the end of May.

If a centre fails to submit a practical science statement to WJEC for an assessment series then it will be treated as a case of malpractice and/or maladministration.

Centres must have systems in place that enable them to ensure that private learners have completed the required specified practical work. It will be the responsibility of the centre entering private learners to validate that these learners have covered the full range of practical requirements described in the specification.

4 TECHNICAL INFORMATION

4.1 Making entries

This is a linear qualification in which all assessments must be taken at the end of the course. Candidates entered for this qualification must sit both components at either foundation or higher tier, in the same examination series. Assessment opportunities will be available in May/June each year, until the end of the life of this specification. summer 2018 will be the first assessment opportunity.

Where candidates wish to re-sit the qualification, all components must be re-taken.

The entry codes appear below.

WJEC Eduqas GCSE Chemistry (Foundation tier):	C410PF
WJEC Eduqas GCSE Chemistry (Higher tier):	C410PH

The current edition of our *Entry Procedures and Coding Information* gives up-to-date entry procedures.

4.2 Grading, awarding and reporting

GCSE qualifications are reported on a nine point scale from 1 to 9, where 9 is the highest grade. Results not attaining the minimum standard for the award will be reported as U (unclassified).

A candidate who takes higher tier assessments will be awarded a grade within the range of 4 to 9, or be unclassified. However, if the mark achieved by such a learner is a small number of marks below the 4/3 grade boundary that learner may be awarded a grade 3.

A candidate who takes foundation tier assessments will be awarded a grade within the range of 1 to 5, or be unclassified.

APPENDIX A

Working scientifically

1. Development of scientific thinking

- understand how scientific methods and theories develop over time
- use a variety of models such as representational, spatial, descriptive, computational and mathematical to solve problems, make predictions and to develop scientific explanations and understanding of familiar and unfamiliar facts
- appreciate the power and limitations of science and consider any ethical issues which may arise
- explain every day and technological applications of science; evaluate associated personal, social, economic and environmental implications; and make decisions based on the evaluation of evidence and arguments
- evaluate risks both in practical science and the wider societal context, including perception of risk in relation to data and consequences
- recognise the importance of peer review of results and of communicating results to a range of audiences.

2. Experimental skills and strategies

- use scientific theories and explanations to develop hypotheses
- plan experiments or devise procedures to make observations, produce or characterise a substance, test hypotheses, check data or explore phenomena
- apply a knowledge of a range of techniques, instruments, apparatus, and materials to select those appropriate to the experiment
- carry out experiments appropriately having due regard to the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations
- recognise when to apply a knowledge of sampling techniques to ensure any samples collected are representative
- make and record observations and measurements using a range of apparatus and methods
- evaluate methods and suggest possible improvements and further investigations.

3. Analysis and evaluation

- apply the cycle of collecting, presenting and analysing data, including:
  - presenting observations and other data using appropriate methods
  - translating data from one form to another
  - carrying out and represent mathematical and statistical analysis
  - representing distributions of results and make estimations of uncertainty
  - interpreting observations and other data (presented in verbal, diagrammatic, graphical, symbolic or numerical form), including identifying patterns and trends, making inferences and drawing conclusions
  - presenting reasoned explanations including relating data to hypotheses
  - being objective, evaluating data in terms of accuracy, precision, repeatability and reproducibility and identifying potential sources of random and systematic error
  - communicating the scientific rationale for investigations, methods used, findings and reasoned conclusions through paper-based and electronic reports and presentations using verbal, diagrammatic, graphical, numerical and symbolic forms.

4. Scientific vocabulary, quantities, units, symbols and nomenclature

- use scientific vocabulary, terminology and definitions
- recognise the importance of scientific quantities and understand how they are determined
- use SI units (e.g. kg, g, mg; km, m, mm; kJ, J) and IUPAC chemical nomenclature unless inappropriate
- use prefixes and powers of ten for orders of magnitude (e.g. tera, giga, mega, kilo, centi, milli, micro and nano)
- interconvert units
- use an appropriate number of significant figures in calculation.

APPENDIX B

Practical requirements and exemplification

All learners are expected to have carried out the **specified practical activities**. These develop skills in the use of the following apparatus and techniques.
The apparatus and techniques listed as 1 – 7 below are common with GCSE Combined Science. Statement 8 is for GCSE Chemistry only.

code	Practical technique
C1	Use of appropriate apparatus to make and record a range of measurements accurately, including mass, time, temperature, and volume of liquids and gases
C2	Safe use of appropriate heating devices and techniques including use of a Bunsen burner and a water bath or electric heater
C3	Use of appropriate apparatus and techniques for conducting and monitoring chemical reactions, including appropriate reagents and/or techniques for the measurement of pH in different situations
C4	Safe use of a range of equipment to purify and/or separate chemical mixtures including evaporation, filtration, crystallisation, chromatography and distillation
C5	Making and recording of appropriate observations during chemical reactions including changes in temperature and the measurement of rates of reaction by a variety of methods such as production of gas and colour change
C6	Safe use and careful handling of gases, liquids and solids, including careful mixing of reagents under controlled conditions, using appropriate apparatus to explore chemical changes and/or products
C7	Use of appropriate apparatus and techniques to draw, set up and use electrochemical cells for separation and production of elements and compounds
C8	Use of appropriate qualitative reagents and techniques to analyse and identify unknown samples or products including gas tests, flame tests, precipitation reactions, and the determination of concentrations of strong acids and strong alkalis

The list on the following page cross references the specified practical work against the apparatus and skills listed above. These include opportunities for choice and use of appropriate laboratory apparatus for a variety of experimental problem-solving and/or enquiry based activities.

Safety is an overriding requirement for all practical work. Centres are responsible for ensuring appropriate safety procedures are followed whenever their learners complete practical work.

Use and production of appropriate scientific diagrams to set up and record apparatus and procedures used in practical work is common to all science subjects and should be included wherever appropriate.

Specified practical work	Specification topic	Technique code
SP1A Determination of a melting point e.g. for naphthalene (pure substance) or candle wax (impure substance)	1	C1, C2, C6
SP1B Separation of liquids by distillation, e.g. ethanol from water, and by paper chromatography	1	C2, C4
SP4 Identification of unknown substances using flame tests and chemical tests for ions and gases	4	C8, C6
SP6A Determination of relative reactivities of metals through displacement reactions	6	C5
SP6B Investigation into electrolysis of aqueous solutions and electroplating	6	C3, C5, C6, C7
SP7A Preparation of crystals of a soluble salt from an insoluble base or carbonate	7	C2, C4
SP7B Titration of a strong acid against a strong base using an indicator	7	C1, C3, C6
SP8 Determination of the amount of energy released by a fuel	8	C1, C5, C6
SP9A Investigation into the effect of one factor on the rate of a reaction using a gas collection method	9	C1, C3, C5, C6
SP9B Investigation into the effect of one factor on the rate of the reaction between dilute hydrochloric acid and sodium thiosulfate	9	C1, C3, C5, C6
SP9C Investigation into the effect of various catalysts on the decomposition of hydrogen peroxide	9	C1, C3, C5, C6
SP11 Determination of the percentage of water in a hydrated salt, e.g. copper(II) sulfate	11	C1,C2, C6

Learners are expected to cover the **full** range of practical techniques using the specified practical work. WJEC will publish teacher/technician guidance sheets and learner worksheets for all the specified practical work which centres may use with their learners. These will ensure that all the techniques referred to in the above table are met. Centres may substitute the exemplar specified practical for another one of comparable standard. In such cases the same techniques cross referenced in the above **must** also be covered by the substituted practical. Learners **must** also be familiar with the same set of skills in this practical as required by the exemplar practical.

Centres should also note that WJEC will:

- review the specified practical work which it has set following any revision by the Secretary of State of the apparatus and/or techniques specified in respect of the qualification
- revise the specified practical work which it has set if appropriate
- promptly publish an amended specification if it makes any revision to the practical activities.

APPENDIX C

Mathematical skills

This table shows the mathematical skills which can be assessed.

	Mathematical skill
1	**Arithmetic and numerical computation**
a	Recognise and use expressions in decimal form
b	Recognise and use expressions in standard form
c	Use ratios, fractions and percentages
d	Make estimates of the results of simple calculations
2	**Handling data**
a	Use an appropriate number of significant figures
b	Find arithmetic means
c	Construct and interpret frequency tables and diagrams, bar charts and histograms
h	Make order of magnitude calculations
3	**Algebra**
a	Understand and use the symbols: =, <, <<, >>, >, ∝, ~
b	Change the subject of an equation
c	Substitute numerical values into algebraic equations using appropriate units for physical quantities
4	**Graphs**
a	Translate information between graphical and numeric form
b	Understand that $y = mx + c$ represents a linear relationship
c	Plot two variables from experimental or other data
d	Determine the slope and intercept of a linear graph
e	Draw and use the slope of a tangent to a curve as a measure of rate of change
5	**Geometry and trigonometry**
b	Visualise and represent 2D and 3D forms including two dimensional representations of 3D objects
c	Calculate areas of triangles and rectangles, surface areas and volumes of cubes.

Please note. Only mathematical skills required for GCSE Chemistry are shown in the table above.

APPENDIX D

Practical science statement

Practical Science Statement
GCSE Chemistry

Centre Name ....

Centre Number ....

Declaration by head of centre
I confirm that: *1. This centre has taken reasonable steps to ensure that each learner entered for assessment in this summer series has completed the specified practical work listed in the specification and they have kept a record of their work;* *2. This centre has made a record of the specified practical work that each learner has undertaken and the knowledge, skills and understanding that the learner has derived from the completion of the practical work.* ***Head of centre's name**: ....* ***Head of centre's signature**: .... Date ....*

Summer 20....