GCSE

Rewarding Learning

CCEA GCSE Specification in

Chemistry

For first teaching from September 2017
For first assessment in Summer 2018
For first award in Summer 2019
Subject Code: 1110

Contents

Subject Code 1110
QAN 603/1146/0

This specification is available online at www.ccea.org.uk

1 Introduction

This specification sets out the content and assessment details for our GCSE course in Chemistry. We have designed this specification to meet the requirements of:

- Northern Ireland GCSE Design Principles; and
- Northern Ireland GCE and GCSE Qualifications Criteria.

First teaching is from September 2017. We will make the first award based on this specification in Summer 2019.

This specification is a unitised course. The guided learning hours, as for all our GCSEs, are 120 hours.

The specification supports the aim of the Northern Ireland Curriculum to empower young people to achieve their potential and to make informed and responsible decisions throughout their lives, as well as its objectives:

- to develop the young person as an individual;
- to develop the young person as a contributor to society; and
- to develop the young person as a contributor to the economy and environment.

If there are any major changes to this specification, we will notify centres in writing. The online version of the specification will always be the most up to date; to view and download this please go to www.ccea.org.uk

1.1 Aims

This specification aims to encourage students to:

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

1.2 Key features

The following are important features of this specification.

- It offers opportunities to build on the skills and capabilities developed through the delivery of the Northern Ireland Curriculum at Key Stage 3.
- The course comprises two theory units (Units 1 and 2), which are designed to be taught in the first and second years of the course respectively, and a practical skills assessment unit (Unit 3), which is made up of Booklet A and Booklet B.
- Students carry out a variety of prescribed practical activities, which appear in italics throughout the specification. Two of these are assessed in Unit 3: Practical Skills Booklet A, which students carry out in class towards the end of the course.
- A timetabled examination, Booklet B, completes the practical skills assessment. This consists of a series of questions about the prescribed practicals and other practical activities throughout the specification.
- All units are externally marked.
- The specification allows students to develop transferable skills that will benefit them in vocational training and employment. It also enables them to progress to the study of science and related courses at GCE Advanced level and Advanced Subsidiary level.
- Details of the mathematical skills expected of students are given in Appendix 1.
- The content in this specification is assessed in the context of How Science Works (see Appendix 2).
- There is a range of support available for both teachers and students, including specimen papers, mark schemes and planning frameworks. You can download these from our Chemistry microsite at www.ccea.org.uk

1.3 Prior attainment

Students do not need to have reached a particular level of attainment before beginning to study this specification.

However, the specification builds on the knowledge, skills and understanding developed through the Northern Ireland Curriculum for science at Key Stage 3.

Before studying this specification, we expect students to have a level of skills in science, numeracy, literacy and communication that is commensurate with having studied science to Key Stage 3.

1.4 Classification codes and subject combinations

Every specification has a national classification code that indicates its subject area. The classification code for this qualification is 1110.

Please note that if a student takes two qualifications with the same classification code, schools, colleges and universities that they apply to may take the view that they have achieved only one of the two GCSEs. The same may occur with any two GCSE qualifications that have a significant overlap in content, even if the classification codes are different. Because of this, students who have any doubts about their subject combinations should check with the schools, colleges and universities that they would like to attend before beginning their studies.

2 Specification at a Glance

The table below summarises the structure of this GCSE course.

Content	Assessment	Weightings	Availability
Unit 1: Structures, Trends, Chemical Reactions, Quantitative Chemistry and Analysis	External written examination Students answer compulsory structured questions that require short responses, extended writing and calculations. There are two tiers of entry. Foundation Tier: 1 hour Higher Tier: 1 hour 15 mins	35%	Summer from 2018
Unit 2: Further Chemical Reactions, Rates and Equilibrium, Calculations and Organic Chemistry	External written examination Students answer compulsory structured questions that require short responses, extended writing and calculations. There are two tiers of entry. Foundation Tier: 1 hour 15 mins Higher Tier: 1 hour 30 mins	40%	Summer from 2019

Content	Assessment	Weightings	Availability
Unit 3: Practical Skills	**Booklet A** Externally marked Students carry out two pre-release practical tasks in the final year of study. There are two tiers of entry. Foundation and Higher Tiers: 2 hours	7.5%	Between 1 January and 1 May from 2019
	Booklet B External written examination Students answer compulsory structured questions that require short responses, extended writing and calculations, all set in a practical context. There are two tiers of entry. Foundation and Higher Tiers: 1 hour	17.5% (Unit 3 total: 25%)	Summer from 2019

Students must take at least 40 percent of the assessment (based on unit weightings) at the end of the course as terminal assessment.

3 Subject Content

We have divided this course into three units. The content of each unit and the respective learning outcomes appear below.

Content for the **Higher Tier only** is in **bold**.
Questions in Higher Tier papers may be set on any content in the specification.

Content for the Foundation Tier is in normal type.
Questions in Foundation Tier papers will only be set on this content.

The nine prescribed practicals, which are assessed in Booklets A and B of Unit 3: Practical Skills, are shown in *italics*.

3.1 Unit 1: Structures, Trends, Chemical Reactions, Quantitative Chemistry and Analysis

This unit introduces and explores safe practical and theoretical chemistry in terms of atomic structure, structure and bonding in traditional, new and nanoparticles, patterns in the Periodic Table, reactions of acids including preparation of pure, dry salts, solubility and chemical analysis. Students are expected to express themselves accurately in terms of formulae, ionic equations and balanced symbol equations. The section on quantitative chemistry includes calculations in terms of amounts in moles and percentage yield.

Content	Learning Outcomes
1.1 Atomic structure	Students should be able to: 1.1.1 demonstrate knowledge and understanding of how ideas about the atom changed over time, with reference to: • the Plum Pudding model; • Rutherford's model of a nucleus surrounded by electrons; and • the discovery of the neutron by Chadwick, leading to today's model of an atom; 1.1.2 describe the structure of an atom as a central positively charged nucleus containing protons and neutrons (most of the mass) surrounded by orbiting electrons in shells; 1.1.3 state the relative charges and approximate relative masses of protons, neutrons and electrons; and 1.1.4 define atomic number as the number of protons in an atom.

Content	Learning Outcomes
1.1 Atomic structure (cont.)	Students should be able to: 1.1.5 define mass number as the total number of protons and neutrons in an atom; 1.1.6 demonstrate knowledge and understanding that an atom as a whole has no electrical charge because the number of protons is equal to the number of electrons; 1.1.7 calculate the number of protons, neutrons and electrons in an atom or an ion and deduce the charge on an ion or determine the number of subatomic particles given the charge; 1.1.8 write and draw the electronic configuration (structure) of atoms and ions with atomic number 1–20; 1.1.9 recall that atoms have a radius of about 0.1 nm (1×10^{-10} m) and that the nucleus is less than 1/10 000 of that of the atom (less than 1×10^{-14} m); 1.1.10 define isotopes as atoms of an element with the same atomic number but a different mass number, indicating a different number of neutrons; 1.1.11 interpret data on the number of protons, neutrons and electrons to identify isotopes of an element; 1.1.12 calculate the relative atomic mass of elements from the mass number and abundances of its isotopes; 1.1.13 recall that a compound is two or more elements chemically combined;
1.2 Bonding **Ionic bonding**	1.2.1 demonstrate knowledge and understanding that an ion is a charged particle formed when an atom gains or loses electrons and a molecular ion is a charged particle containing more than one atom; and 1.2.2 define the terms cation and anion and explain, using dot and cross diagrams, how ions are formed and how ionic bonding takes place in simple ionic compounds, limited to elements in Groups 1 (I) and 2 (II) with elements in Groups 6 (VI) and 7 (VII), the ions of which have a noble gas electronic configuration.

Content	Learning Outcomes
Ionic bonding (cont.)	Students should be able to: 1.2.3 demonstrate knowledge and understanding that: • ionic bonding involves attraction between oppositely charged ions; • ionic bonds are strong; and • substantial energy is required to break ionic bonds; 1.2.4 recognise that ionic bonding is typical of metal compounds;
Covalent bonding	1.2.5 describe a single covalent bond as a shared pair of electrons; 1.2.6 explain, using dot and cross diagrams, how covalent bonding occurs in H_2, Cl_2, HCl, H_2O, NH_3, CH_4 and similar molecules and label lone pairs of electrons; 1.2.7 draw dot and cross diagrams and indicate the presence of multiple bonds in O_2, N_2 and CO_2; 1.2.8 recognise covalent bonding as typical of non-metallic elements and compounds; 1.2.9 demonstrate knowledge and understanding that a molecule is two or more atoms covalently bonded and that diatomic means that there are two atoms covalently bonded in a molecule; 1.2.10 demonstrate knowledge and understanding that covalent bonds are strong and that substantial energy is required to break covalent bonds; 1.2.11 demonstrate knowledge and understanding that a covalent bond may be represented by a line; and
Metallic bonding	1.2.12 demonstrate knowledge and understanding that metallic bonding results from the attraction between the positive ions in a regular lattice and the delocalised electrons.

Content	**Learning Outcomes**
1.3 Structures **Ionic structures**	Students should be able to: 1.3.1 use the accepted structural model for giant ionic lattices to explain the physical properties of ionic substances such as sodium chloride, including melting point, boiling point and electrical conductivity (drawing a diagram of a giant ionic lattice is not expected but students should be able to recognise it); 1.3.2 recall that most ionic compounds are soluble in water;
Molecular covalent structures	1.3.3 use the accepted structural model for molecular covalent structures to explain the physical properties of molecular covalent structures such as iodine and carbon dioxide, including melting point, boiling point and electrical conductivity; 1.3.4 demonstrate knowledge and understanding that the intermolecular forces between covalent molecules are weak forces called van der Waals' forces; 1.3.5 recall that many covalent molecular substances are insoluble in water;
Giant covalent structures	1.3.6 demonstrate knowledge and understanding of the giant covalent structure of carbon (diamond) and carbon (graphite), and predict and explain their physical properties, including: • electrical conductivity; • hardness; • melting point and boiling point; and • their uses in cutting tools (diamond), lubricants and pencils (graphite); and
Metallic structures	1.3.7 use the accepted structural model for metals to predict and explain their structure and physical properties including melting point, malleability, ductility and electrical conductivity.

Content	Learning Outcomes
Metallic structures (cont.)	Students should be able to: 1.3.8 demonstrate knowledge and understanding that an alloy is a mixture of two or more elements, at least one of which is a metal, and the resulting mixture has metallic properties; 1.3.9 demonstrate knowledge and understanding that the different sizes of atoms in an alloy distort the layers in the metallic structure, making it more difficult for them to slide over each other, and so alloys are harder than pure metals; 1.3.10 recall that gold used in jewellery is usually an alloy with silver, copper and zinc, that the proportion of gold is measured in carats, and that 24 carat gold indicates pure gold and 18 carat gold indicates 75% gold;
Structure and bonding of carbon	1.3.11 demonstrate knowledge and understanding that carbon can form four covalent bonds; 1.3.12 demonstrate knowledge and understanding of the structure of graphene (a single atom thick layer of graphite), explain its physical properties, including strength and electrical conductivity, and recall its uses such as those in batteries and solar cells; 1.3.13 demonstrate knowledge and understanding of the meaning of the term allotrope as applied to carbon (diamond), carbon (graphite) and graphene; and
Classification of structures	1.3.14 use given information to classify the structure of substances as giant ionic lattice, molecular covalent, giant covalent or metallic.

Content	**Learning Outcomes**
1.4 Nanoparticles	Students should be able to: 1.4.1 demonstrate knowledge and understanding that nanoparticles are structures that are 1–100 nm in size and contain a few hundred atoms; 1.4.2 demonstrate knowledge and understanding of surface area to volume relationships and that, as the side of a cube decreases by a factor of 10, the surface area to volume ratio increases by a factor of 10; 1.4.3 demonstrate knowledge and understanding that nanoparticles have properties different from those for the same material in bulk, due to their high surface area to volume ratio; 1.4.4 evaluate the benefits of nanoparticles in sun creams, including better skin coverage and more effective protection from the Sun's ultraviolet rays, and the risks, such as potential cell damage in the body and harmful effects on the environment;
1.5 Symbols, formulae and equations	1.5.1 recognise symbols and names for common elements and recall the diatomic elements; 1.5.2 interpret chemical formulae by naming the elements and stating the number of each type of atom present; 1.5.3 write chemical formulae of compounds; 1.5.4 demonstrate understanding that chemical reactions use up reactants and produce new substances called products; 1.5.5 construct word equations to describe the range of reactions covered in this specification; and 1.5.6 recognise that in a chemical reaction no atoms are lost or made but they are rearranged, and as a result we can write balanced symbol equations showing the atoms involved.

Content	**Learning Outcomes**
1.5 **Symbols, formulae and equations (cont.)**	Students should be able to: 1.5.7 write balanced symbol equations for all reactions covered in this specification and for unfamiliar chemical reactions when the names of the reactants and products are specified; 1.5.8 **write balanced ionic equations for reactions covered in this specification;** 1.5.9 **write half equations for reactions covered in this specification;** 1.5.10 demonstrate knowledge and understanding that in chemical equations the three states of matter are shown as (s), (l) and (g), with (aq) for aqueous solutions, and include appropriate state symbols in equations for the reactions in this specification;
1.6 **The Periodic Table** **Basic structure of the Periodic Table**	1.6.1 describe how Mendeleev arranged the elements in the Periodic Table and left gaps for elements that had not been discovered at that time, and how this enabled him to predict properties of undiscovered elements; 1.6.2 demonstrate knowledge and understanding of how scientific ideas have changed over time in terms of the differences and similarities between Mendeleev's Periodic Table and the modern Periodic Table; 1.6.3 describe an element as a substance that consists of only one type of atom and demonstrate understanding that elements cannot be broken down into simpler substances by chemical means; 1.6.4 demonstrate knowledge and understanding that a group is a vertical column in the Periodic Table and a period is a horizontal row; and 1.6.5 identify and recall the position of metals and non-metals in the Periodic Table and distinguish between them according to their properties, including conduction of heat and electricity, ductility, malleability, melting point and sonority.

Content	**Learning Outcomes**
Basic structure of the Periodic Table (cont.)	Students should be able to: 1.6.6 identify elements as solids, liquids and gases (at room temperature and pressure) in the Periodic Table; 1.6.7 demonstrate knowledge and understanding that elements in the same group in the Periodic Table have the same number of electrons in their outer shell and this gives them similar chemical properties; 1.6.8 recall that elements with similar properties appear in the same group (for example Group 1 (I) and Group 2 (II) are groups of reactive metals, Group 7 (VII) is a group of reactive non-metals and Group 0 is a group of non-reactive non-metals), locate these groups in the Periodic Table and recall the names of the groups;
Group 1 (I)	1.6.9 demonstrate knowledge and understanding that the alkali metals have low density and the first three are less dense than water; 1.6.10 assess and manage risks associated with the storage and use of alkali metals and recall that alkali metals are easily cut, are shiny when freshly cut and tarnish rapidly in air; 1.6.11 demonstrate knowledge and understanding that Group 1 (I) metals react with water to produce hydrogen and a metal hydroxide, and give observations for the reactions; 1.6.12 demonstrate knowledge and understanding that alkali metals have similar chemical properties because when they react an atom loses an electron to form a positive ion with a stable electronic configuration; 1.6.13 **write half equations for the formation of a Group 1 (I) ion from its atom;** and 1.6.14 demonstrate knowledge and understanding of how the trend in reactivity down the group depends on the outer shell electrons of the atoms.

Content	Learning Outcomes
Group 1 (I) (cont.)	Students should be able to: 1.6.15 demonstrate knowledge and understanding that most Group 1 (I) compounds are white and dissolve in water to give colourless solutions;
Group 7 (VII)	1.6.16 recall data about the colour, physical state at room temperature and pressure, diatomicity and toxicity of the elements in Group 7 (VII), interpret given data to establish trends within the group and make predictions based on these trends; 1.6.17 recall the observations when solid iodine sublimes on heating and demonstrate understanding of the term sublimation; 1.6.18 describe how to test for chlorine gas (damp universal indicator paper changes to red and then bleaches white); 1.6.19 investigate the displacement reactions of Group 7 (VII) elements with solutions of other halides to establish the trend in reactivity within the group and make predictions based on this trend; 1.6.20 demonstrate knowledge and understanding of how the reactivity down the group depends on the outer shell electrons of the atoms; 1.6.21 demonstrate knowledge and understanding that the halogens have similar chemical properties because when they react an atom gains an electron to form a negative ion with a stable electronic configuration; 1.6.22 **write half equations for the formation of a halide ion from a halogen molecule or atom;**
Group 0	1.6.23 use the concept of electronic configuration to explain the lack of reactivity and the stability of the noble gases; and 1.6.24 recall that the noble gases are colourless gases.

Content	**Learning Outcomes**
Group 0 (cont.)	Students should be able to: 1.6.25 demonstrate knowledge and understanding of the trend in boiling points of the noble gases going down the group;
Transition metals	1.6.26 compare the physical properties of the transition metals with Group 1 (I) elements, including melting point and density, and demonstrate understanding that the transition metals are much less reactive with water;
	1.6.27 demonstrate knowledge that transition elements form ions with different charges (for example iron(II) and iron(III)) and form coloured compounds: • copper(II) oxide is black; • copper(II) carbonate is green; • hydrated copper(II) sulfate is blue; and • copper(II) salts are usually blue in solution;
1.7 Quantitative chemistry **Formula mass**	1.7.1 recall that the relative atomic mass (A_r) of an atom is the mass of the atom compared with that of the carbon-12 isotope, which has a mass of exactly 12, and demonstrate knowledge and understanding that A_r is a weighted mean of the mass numbers (linked to 1.1.12);
	1.7.2 calculate the relative formula mass (M_r) (relative molecular mass) of a compound and the percentage of an element, by mass, in a compound;
The mole	1.7.3 demonstrate knowledge and understanding that chemical amounts are measured in moles and that the mass of one mole of a substance in grams is numerically equal to the relative formula mass;
	1.7.4 convert the given mass of a substance to the amount of the substance in moles (and vice versa) by using the relative atomic or formula mass; **and**
	1.7.5 **demonstrate knowledge and understanding of the importance of scale in chemistry in terms of calculating moles from masses given in tonnes and kilograms, for example in industrial processes.**

Content	Learning Outcomes
The mole (cont.)	Students should be able to: 1.7.6 **calculate the reacting masses of reactants or products, given a balanced symbol equation and using moles and simple ratio, including examples where there is a limiting reactant;**
Percentage yield	1.7.7 calculate **the theoretical yield and** the percentage yield of a chemical reaction given the actual yield; 1.7.8 recognise possible reasons why the percentage yield of a product is less than 100%, including loss of product in separation from the reaction mixture, as a result of side reactions or because the reaction is reversible and may not go to completion;
Calculation of the formulae of compounds	1.7.9 demonstrate knowledge and understanding of the terms empirical formula, molecular formula, hydrated, anhydrous and water of crystallisation; 1.7.10 demonstrate knowledge and understanding that water of crystallisation can be removed by heating to constant mass and any thermal decomposition may be carried out to completion by heating to constant mass; 1.7.11 calculate the relative formula mass of compounds containing water of crystallisation; 1.7.12 calculate the percentage of water of crystallisation in a compound; 1.7.13 **determine the empirical formulae of simple compounds and determine the moles of water of crystallisation present in a hydrated salt from percentage composition, mass composition or experimental data;** and • *determine the mass of water present in hydrated crystals (Prescribed Practical C1).*

Content	Learning Outcomes
1.8 **Acids, bases and salts** **Indicators and pH**	Students should be able to: 1.8.1 recall the colours of phenolphthalein and methyl orange in acidic, alkaline and neutral solutions; 1.8.2 describe the effects of acidic, alkaline and neutral solutions on indicator papers (red and blue litmus papers and universal indicator paper) and the use of a pH meter to give pH data to at least one decimal place; 1.8.3 interpret given data about universal indicator (colour or pH) to classify solutions as acidic, alkaline or neutral and to indicate the relative strengths of acidic and alkaline solutions according to the following classification: • pH 0–2 strong acid; • pH 3–6 weak acid; • pH 7 neutral; • pH 8–11 weak alkali; and • pH 12–14 strong alkali; 1.8.4 demonstrate knowledge and understanding that acids dissolve in water to produce hydrogen (H^+ (aq)) ions; 1.8.5 **recall that the higher the concentration of hydrogen ions in an acidic solution, the lower the pH;** 1.8.6 demonstrate knowledge and understanding that alkalis dissolve in water to produce hydroxide (OH^-(aq)) ions; 1.8.7 **demonstrate knowledge and understanding that strong acids and strong alkalis are completely ionised in water**, recall examples of strong acids (including hydrochloric acid, sulfuric acid and nitric acid) and recall examples of strong alkalis (including sodium hydroxide and potassium hydroxide); and 1.8.8 **demonstrate knowledge and understanding that weak acids and weak alkalis are partially ionised in water**, recall examples of weak acids (including ethanoic acid and carbonic acid) and recall examples of weak alkalis (including ammonia).

Content	Learning Outcomes
Indicators and pH (cont.)	Students should be able to: 1.8.9 **explain dilute and concentrated in terms of the amount of substances in solution;**
Reactions of acids	1.8.10 describe neutralisation as the reaction between the hydrogen ions in an acid and the hydroxide ions in an alkali to produce water **and recall the ionic equation as**: $\mathbf{H^+(aq) + OH^-(aq) \rightarrow H_2O(l)}$ 1.8.11 investigate the temperature change during neutralisation and demonstrate understanding that neutralisation reactions are exothermic (heat is given out); 1.8.12 recall that a base is a metal oxide or hydroxide which neutralises an acid to produce a salt and water and that an alkali is a soluble base; 1.8.13 demonstrate knowledge and understanding of and write observations on and equations for the general reactions of hydrochloric, sulfuric and nitric acids with: • metals; • bases; • carbonates; • hydrogencarbonates; and • ammonia; 1.8.14 describe how to test for hydrogen gas: apply a lighted splint and a popping sound results; 1.8.15 describe how to test for carbon dioxide: limewater (calcium hydroxide solution) will change from colourless to milky if the test is positive; and
Preparation of soluble salts	1.8.16 demonstrate knowledge and understanding that a salt is a compound formed when some or all of the hydrogen ions in an acid are replaced by metal ions or ammonium ions.

Content	Learning Outcomes
Preparation of soluble salts (cont.)	Students should be able to: 1.8.17 demonstrate knowledge and understanding that most Group 1 (I), Group 2 (II), aluminium and zinc salts are white and if they dissolve in water they give colourless solutions, and that transition metal salts are generally coloured; 1.8.18 demonstrate knowledge and understanding of how pure dry samples of soluble salts can be prepared by: • adding excess insoluble substances to acid; • adding alkali to acid, or vice versa, in the presence of an indicator; and • repeating without indicator or removing the indicator using charcoal (methods of drying to include placing in a desiccator or a low temperature oven or drying between two sheets of filter paper); 1.8.19 develop awareness of the importance of safety in the laboratory to assess potential risks, including the hazards associated with chemicals labelled with the GHS/CLP international chemical hazard labelling (including toxic, corrosive, flammable, explosive and caution); • *investigate the reactions of acids, including temperature changes that occur (Prescribed Practical C2)*; • *investigate the preparation of soluble salts (Prescribed Practical C3)*;
1.9 Chemical analysis **Assessing purity and separating mixtures**	1.9.1 demonstrate knowledge and understanding that a pure substance is a single element or compound not mixed with any other substance; and 1.9.2 demonstrate knowledge and understanding that pure elements and compounds melt and boil at specific temperatures and melting point and boiling point can be used to distinguish pure substances from mixtures.

Content	Learning Outcomes
Assessing purity and separating mixtures (cont.)	Students should be able to: 1.9.3 demonstrate knowledge and understanding that a formulation is a mixture that has been designed as a useful product and is formed by mixing together several different substances in carefully measured quantities to ensure the product has the required properties, for example alloys, medicines and fertilisers; 1.9.4 demonstrate knowledge and understanding of the terms soluble, insoluble, solute, solvent, solution, residue, filtrate, distillate, miscible, immiscible, evaporation and condensation; 1.9.5 investigate practically how mixtures can be separated using filtration, crystallisation, paper chromatography, simple distillation or fractional distillation (including using fractional distillation in the laboratory to separate miscible liquids, for example ethanol and water); 1.9.6 describe paper chromatography as the separation of mixtures of soluble substances by running a solvent (mobile phase) through the mixture on the paper (stationary phase), which causes the substances to move at different rates over the paper; 1.9.7 interpret a paper chromatogram including calculating R_f values; 1.9.8 analyse given data on mixtures to make judgements on the most effective methods of separation and plan experiments to carry out this separation; 1.9.9 describe how water can be made potable, including the need for filtration, sedimentation and chlorination; 1.9.10 describe how seawater can be made potable using distillation; and 1.9.11 use anhydrous copper(II) sulfate to test for water.

Content	Learning Outcomes
Tests for ions	Students should be able to: 1.9.12 describe how to carry out a flame test using nichrome wire and concentrated hydrochloric acid to identify metal ions; 1.9.13 demonstrate knowledge of the flame colours of different metal ions: • lithium (crimson); • sodium (yellow/orange); • potassium (lilac); • calcium (brick red); and • copper(II) (blue–green/green–blue); 1.9.14 describe the test for Cu^{2+}, Fe^{2+}, Fe^{3+}, Al^{3+}, Zn^{2+} and Mg^{2+} ions in solution using sodium hydroxide solution and ammonia solution; 1.9.15 describe the tests for the following: • chloride, bromide and iodide (using silver nitrate solution); • sulfate (using barium chloride solution); and • carbonate (using dilute acid and identifying the carbon dioxide evolved); 1.9.16 **write ionic equations for the halide and sulfate ion tests and tests for metal ions using sodium hydroxide solution;** 1.9.17 demonstrate knowledge and understanding that many tests for anions and cations are precipitation reactions; 1.9.18 plan experiments to identify cations and anions present in an unknown or a given compound; and • *identify the ions in an ionic compound using chemical tests (Prescribed Practical C4).*

Content	Learning Outcomes
1.10 Solubility	Students should be able to: 1.10.1 define solubility as the mass of solid required to saturate 100 g of water at a particular temperature; 1.10.2 use given data to calculate solubility values; 1.10.3 experimentally determine the solubility of a solid in water (other practical activity); 1.10.4 demonstrate knowledge and understanding that a saturated solution is one in which no more solute will dissolve at that temperature, **demonstrate understanding that when a hot concentrated solution is cooled some of the solute will be deposited, and calculate the mass of solute deposited;** 1.10.5 draw and interpret solubility curves (graph of solubility in g/100 g water against temperature in °C); and 1.10.6 demonstrate knowledge and understanding that the solubility of gases decreases as temperature increases, whereas the solubility of a solid generally increases as temperature increases.

3.2 Unit 2: Further Chemical Reactions, Rates and Equilibrium, Calculations and Organic Chemistry

In this unit, students extend their knowledge of safe practical and theoretical chemistry further to include reactivity series, redox, rates of reaction, energy changes in chemical reactions and gas chemistry. Students are introduced to organic chemistry, equilibrium in chemical reactions and electrochemistry. They also continue to write more complex equations and carry out increasingly complex calculations of amounts in moles involving solution and gas chemistry.

Content	Learning Outcomes
2.1 **Metals and reactivity series**	Students should be able to: 2.1.1 recall the reactivity series of metals, including K, Na, Ca, Mg, Al, Zn, Fe and Cu; 2.1.2 describe the reactions, if any, of the above metals with the following and describe how to collect the gas produced, where appropriate: • air; • water; and • steam; 2.1.3 explain how the reactivity of metals is related to the tendency of a metal to form its positive ion; 2.1.4 explain and describe the displacement reactions of metals with other metal ions in solution; 2.1.5 collect and/or analyse experimental data to predict where an unfamiliar element should be placed in the reactivity series or make predictions about how it will react; 2.1.6 examine the relationship between the extraction of a metal from its ore and its position in the reactivity series, for example: • aluminium, a reactive metal, is extracted by electrolysis; and • iron, a less reactive metal, is extracted by chemical reduction; **and** 2.1.7 **recall that the Earth's resources of metal ores are limited and that alternative extraction methods, such as phytomining, are used.**

Content	Learning Outcomes
Metals and reactivity series (cont.)	Students should be able to: 2.1.8 **recall the following aspects of phytomining:** • **plants are used to absorb metal compounds such as copper(II) compounds;** • **the plants are harvested, then burned to produce ash, which contains the metal compounds;** • **an acid is added to the ash to produce a solution containing dissolved metal compounds (leachate);** • **copper can be obtained from these solutions by displacement using scrap iron; and** • **this technique avoids traditional mining methods of digging, moving and disposing of large amounts of rock**; • *investigate the reactivity of metals (Prescribed Practical C5)*;
2.2 Redox, rusting and iron	2.2.1 recognise oxidation and reduction in terms of loss or gain of oxygen or hydrogen and identify in a reaction or symbol equation which species is oxidised and which is reduced (link to suitable industrial processes covered in this specification); 2.2.2 **recognise oxidation and reduction in terms of loss or gain of electrons and identify in a symbol equation, ionic equation or half equation which species is oxidised and which is reduced (link to suitable industrial processes covered in this specification);** 2.2.3 investigate experimentally rusting as a reaction of iron with water and air producing hydrated iron(III) oxide (other practical activity); and 2.2.4 demonstrate knowledge and understanding of the methods used to prevent iron from rusting, including barrier methods such as painting, oiling, plastic coating and suitable metal coating or plating (galvanising), and explain sacrificial protection of iron related to the reactivity series.

Content	Learning Outcomes
Redox, rusting and iron (cont.)	Students should be able to: 2.2.5 describe the extraction of iron from haematite including: • the production of the reducing agent; • the reduction of haematite; and • the removal of acidic impurities; 2.2.6 demonstrate knowledge and understanding that iron is used in bridges and structures due to its strength;
2.3 **Rates of reaction**	2.3.1 demonstrate knowledge and understanding that the rate of a reaction may be determined by measuring the loss of a reactant or gain of a product over time and use the equation: $\text{rate} = \frac{1}{\text{time}}$ 2.3.2 suggest appropriate practical methods to measure the rate of a reaction and collect reliable data (methods limited to measuring a change in mass, gas volume or formation of a precipitate against time) for the reaction of: • metals with dilute acid; • calcium carbonate/marble chips with dilute hydrochloric acid; • catalytic decomposition of hydrogen peroxide; and • sodium thiosulfate with acid (equation not required); 2.3.3 interpret experimental data quantitatively, for example drawing and interpreting appropriate graphs to determine the rate of reaction; **and** 2.3.4 **describe and explain the effects on rates of reaction when there are changes in:** • **temperature;** • **concentration;** • **frequency and energy of collisions between particles; and** • **changes in particle size in terms of surface area to volume ratio**.

Content	Learning Outcomes
Rates of reaction (cont.)	Students should be able to: 2.3.5 demonstrate knowledge and understanding that a catalyst is a substance which increases the rate of a reaction without being used up and recall that transition metals and their compounds are often used as catalysts; 2.3.6 explain catalytic action in terms of providing an alternative reaction pathway of lower activation energy; • *investigate how changing a variable changes the rate of reaction (Prescribed Practical C6)*;
2.4 Equilibrium	2.4.1 demonstrate knowledge and understanding that many chemical reactions are reversible and the direction of a reversible reaction can be changed by altering the reaction conditions; 2.4.2 demonstrate knowledge and understanding that dynamic equilibrium occurs in a closed system when the rates of forward and reverse reactions are equal and the amounts of reactants and products remain constant; 2.4.3 **state Le Châtelier's Principle and use it to predict the qualitative effects of changes of temperature, pressure and concentration on the position of equilibrium for a closed homogeneous system;** 2.4.4 **describe the Haber process as a reversible reaction between nitrogen and hydrogen to form ammonia, and describe and explain the conditions used and the trade-off between the rate of production and the position of equilibrium;** and
2.5 Organic chemistry	2.5.1 demonstrate knowledge and understanding that carbon can form four covalent bonds and there is a large number of carbon compounds, the study of which is simplified by grouping the compounds into homologous series.

Content	Learning Outcomes
2.5 Organic chemistry (cont.)	Students should be able to: 2.5.2 define a homologous series as a family of organic molecules that have the same general formula, show similar chemical properties, show a gradation in their physical properties and differ by a CH_2 group; 2.5.3 recall that a hydrocarbon is a compound/molecule consisting of hydrogen and carbon only; 2.5.4 recall the general formula of the alkanes and the molecular formula, structural formula and state at room temperature and pressure of methane, ethane, propane and butane; 2.5.5 recall that crude oil is a finite resource and is the main source of hydrocarbons and a feedstock for the petrochemical industry; 2.5.6 describe and explain the separation of crude oil by fractional distillation; 2.5.7 describe the fractions as largely a mixture of compounds of formula C_nH_{2n+2}, which are members of the alkane homologous series, and recall the names and uses of the following fractions: • refinery gases used for bottled gases; • petrol used as a fuel for cars; • naphtha used to manufacture chemicals and plastics; • kerosene as a fuel for aircraft; • diesel as a fuel for cars and trains; • fuel oils used as fuel for ships; and • bitumen used to surface roads and roofs; 2.5.8 explain that cracking involves the breakdown of larger saturated hydrocarbons (alkanes) into smaller more useful ones, some of which are unsaturated (alkenes); and 2.5.9 describe the complete combustion of alkanes to produce carbon dioxide and water, including observations and tests to identify the products.

Content	Learning Outcomes
2.5 Organic chemistry (cont.)	Students should be able to: 2.5.10 describe the incomplete combustion of alkanes to produce carbon monoxide and water and sometimes carbon (soot – equations for the production of soot are not required); 2.5.11 demonstrate knowledge and understanding that carbon monoxide is a toxic gas that combines with haemoglobin in the blood, reducing its capacity to carry oxygen; 2.5.12 recall the general formula of the alkenes and the molecular formula, structural formula and state at room temperature and pressure of ethene, propene, but-1-ene and but-2-ene; 2.5.13 describe the complete and incomplete combustion of alkenes; 2.5.14 demonstrate knowledge and understanding that a functional group is a reactive group in a molecule, recognise the functional groups of alkenes, **alcohols and carboxylic acids**, and recognise that alkanes do not have a functional group and so are less reactive; 2.5.15 recall and describe the addition reaction across a C=C double covalent bond, including the reaction of ethene with bromine, hydrogen and steam (name of the bromo product is not required); 2.5.16 determine the presence of a C=C using bromine water; 2.5.17 describe how monomers, for example ethene or chloroethene (vinyl chloride), can join together to form very long chain molecules called polymers and recall that the process is known as addition polymerisation; 2.5.18 **write equations for the polymerisation of ethene and chloroethene; and** 2.5.19 **deduce the structure of an addition polymer from a simple alkene monomer and vice versa.**

Content	Learning Outcomes
2.5 Organic chemistry (cont.)	Students should be able to: 2.5.20 demonstrate knowledge and understanding that addition polymers are non-biodegradable and evaluate the advantages and disadvantages of their disposal by landfill and incineration; 2.5.21 recall the general formula of the alcohols and the molecular formula, structural formula and state at room temperature and pressure of methanol, ethanol, propan-1-ol and propan-2-ol; 2.5.22 describe the complete and incomplete combustion of alcohols; 2.5.23 describe the preparation of ethanol from sugars by fermentation (equation for fermentation of sugars is not required), including the conditions required; 2.5.24 **recall the oxidation of alcohols when exposed to air and by the reaction with acidified potassium dichromate solution (equations are not required) and demonstrate understanding that methanol, ethanol and propan-1-ol are oxidised to the corresponding carboxylic acid (students should know that propan-2-ol can be oxidised but do not need to know the name or structure of the product);** 2.5.25 **recall the molecular formula, structural formula, state at room temperature and pressure of the carboxylic acids: methanoic acid, ethanoic acid, propanoic acid and butanoic acid;** 2.5.26 demonstrate knowledge that carboxylic acids are weak acids **as they are only partially ionised in solution**; and 2.5.27 investigate experimentally the reactions of carboxylic acids with carbonates, hydroxides and metals, test any gases produced **and write balanced symbol equations for these reactions**.

Content	Learning Outcomes
2.5 Organic chemistry (cont.)	Students should be able to: 2.5.28 demonstrate knowledge that the combustion of fuels is a major source of atmospheric pollution due to: • combustion of hydrocarbons producing carbon dioxide, which leads to the greenhouse effect causing sea level rises, flooding and climate change; • incomplete combustion producing carbon monoxide (toxic) and soot (carbon particles), which cause lung damage; and • presence of sulfur impurities in fuels, which leads to acid rain damaging buildings, destroying vegetation and killing fish; 2.5.29 identify alkanes, alkenes, **alcohols** and carboxylic acids using chemical tests (other practical activity); • *investigate the reactions of carboxylic acids (Prescribed Practical C7);*
2.6 Quantitative chemistry	2.6.1 **calculate the concentration of a solution in mol/dm^3 given the mass of solute and volume of solution;** 2.6.2 **calculate the number of moles or mass of solute in a given volume of solution of known concentration;** 2.6.3 demonstrate knowledge and understanding that the volumes of acid and alkali solutions that react together can be measured by titration using phenolphthalein or methyl orange; 2.6.4 carry out acid–base titrations using an indicator and record results to one decimal place, repeating for reliability and calculating the average titre from accurate titrations (details of the practical procedure and apparatus preparation are required); **and** 2.6.5 **collect data from primary and secondary sources for acid–base titration and use this data to calculate the concentrations of solutions in mol/dm^3 and g/dm^3.**

Content	Learning Outcomes
2.6 Quantitative chemistry (cont.)	Students should be able to: 2.6.6 **calculate concentrations of solutions and solution volumes in an acid–base titration, identify unknown compounds and determine the degree of hydration;** 2.6.7 **recall that the volume of one mole of any gas at room temperature and pressure (20°C and 1 atmosphere pressure) is 24 dm^3;** 2.6.8 **recall and use Avogadro's Law as equal volumes of gases at the same temperature and pressure contain the same number of particles/molecules;** 2.6.9 **calculate the volumes of gaseous reactants and products from the balanced equation for a reaction;** 2.6.10 calculate the atom economy of a reaction to form a desired product from the balanced equation: $\text{atom economy} = \frac{\text{mass of desired product}}{\text{total mass of products}} \times 100$ 2.6.11 **demonstrate knowledge and understanding that a high atom economy is important for sustainable development and economic reasons;** • *determine the reacting volumes of solutions of acid and alkali by titration* ***and determine the concentration of solutions of acid and alkali by titration*** *(Prescribed Practical C8)*;
2.7 Electrochemistry	2.7.1 explain the meaning of the terms electrolysis, inert electrode, anode, cathode and electrolyte and explain conduction in an electrolyte in terms of ions moving and carrying charge; and 2.7.2 predict the products of electrolysis of molten salts including lithium chloride and lead(II) bromide using graphite electrodes and state appropriate observations at the electrodes.

Content	Learning Outcomes
2.7 **Electrochemistry (cont.)**	Students should be able to: 2.7.3 **interpret and write half equations for the reactions occurring at the anode and cathode for the electrolysis processes listed in 2.7.2, for other molten halides and in the extraction of aluminium;** 2.7.4 recall the products of electrolysis of dilute sulfuric acid using inert electrodes **and the half equations for the reactions occurring at the anode and the cathode;** 2.7.5 describe the industrial extraction of aluminium from alumina, demonstrate knowledge and understanding that the alumina has been purified from the ore bauxite and demonstrate knowledge and understanding of the need to replace the anodes periodically; 2.7.6 demonstrate knowledge and understanding that recycling aluminium uses only a fraction of the energy needed to extract it from bauxite and saves waste;
2.8 **Energy changes in chemistry**	2.8.1 demonstrate knowledge and understanding that chemical reactions in which heat is given out are exothermic and that reactions in which heat is taken in are endothermic; 2.8.2 **draw and interpret reaction profile diagrams for exothermic and endothermic reactions identifying activation energy;** 2.8.3 explain activation energy as the minimum energy needed for a reaction to occur; 2.8.4 recall that bond breaking takes in energy and bond making releases energy, and demonstrate understanding that the overall energy change in a reaction is a balance of the energy taken in when bonds break in the reactants and the energy released when bonds form in the products; and 2.8.5 calculate energy changes in a chemical reaction from bond energies by considering bond making and bond breaking energies.

Content	Learning Outcomes
2.9 **Gas chemistry**	Students should be able to: 2.9.1 recall the composition of the gases in the atmosphere: • about 78% nitrogen; • about 21% oxygen; • about 0.03–0.04% carbon dioxide; • about 1% argon; • small proportions of other noble gases; and • varying proportions of water vapour; 2.9.2 recall the physical properties of nitrogen and describe its lack of reactivity due to its triple covalent bond; 2.9.3 demonstrate knowledge and understanding of using nitrogen as a coolant and in food packaging; 2.9.4 demonstrate knowledge and understanding of the test for ammonia, using a glass rod dipped in concentrated hydrochloric acid, and recall the use of ammonia in the manufacture of fertilisers by its reaction with acids; 2.9.5 describe the laboratory preparation and collection of hydrogen using zinc (or other suitable metal) and hydrochloric acid, and recall the physical properties of hydrogen and its uses, including weather balloons and hardening oils, and its potential as a clean fuel; 2.9.6 describe the laboratory preparation and collection of oxygen by the catalytic decomposition of hydrogen peroxide, and recall the physical properties of oxygen and its uses in medicine and welding; 2.9.7 describe the reaction of carbon, sulfur, magnesium, iron and copper with oxygen and classify the products as acidic or basic; and 2.9.8 describe the laboratory preparation and collection of carbon dioxide gas using calcium carbonate and hydrochloric acid, and recall the uses of carbon dioxide in fizzy drinks and fire extinguishers.

Content	Learning Outcomes
2.9 **Gas chemistry (cont.)**	Students should be able to: 2.9.9 investigate the chemical reactions of carbon dioxide with water producing carbonic acid and with calcium hydroxide (limewater) until carbon dioxide is in excess; and • *investigate the preparation, properties, tests and reactions of the gases hydrogen, oxygen and carbon dioxide (Prescribed Practical C9).*

3.3 Unit 3: Practical Skills

Units 1 and 2 include a number of practical tasks that students carry out during the course. Nine of these are prescribed practicals. This unit has two parts: Booklet A and Booklet B. We set and mark both booklets.

Booklet A is a practical skills assessment. It assesses students' ability to carry out **two** practical tasks based on but not identical to the nine prescribed practicals listed in this specification.

Booklet B is a written, externally assessed examination taken during the final year of study. It assesses students' knowledge and understanding of practical science. It consists of questions about planning and carrying out any of the prescribed practical tasks, together with more general questions about any practical situation that arises in Units 1 and 2 in this specification.

Content	Learning Outcomes
Planning an investigation	Students should be able to: • identify the dependent, independent and controlled variables in an investigation (if appropriate); • suggest a hypothesis for investigation in the context of How Science Works; • plan a method to allow a hypothesis to be tested or to allow an analysis to be carried out; • carry out a risk assessment on all planned practical activities; • select equipment or apparatus that is suitable and will contribute to obtaining accurate results; • produce a results table with appropriate headings (and units if appropriate) for recording a wide range of appropriate raw data including observations and deductions; • draw a diagram of the apparatus used in an experiment; and • demonstrate knowledge and understanding of the steps that must be taken to ensure the validity of the practical process and the reliability of data collected (if appropriate).

Content	Learning Outcomes
Carrying out an experiment	Students should be able to: • demonstrate the practical skills necessary to use the following apparatus correctly, skilfully and safely: – Bunsen burner and associated apparatus such as heatproof mat, tripod, gauze, pipeclay triangle, crucible and evaporating basin/dish; – general glassware such as beakers, conical flasks, test tubes, boiling tubes, glass rod, pipettes (disposable plastic pipettes may be used), filter funnels, watch glass and combustion tubes; – gas preparation apparatus including gas jar and lid, thistle funnel, delivery tubes, beehive shelf and trough (or basin); – electrolysis equipment including graphite electrodes, electrical wires, crocodile clips and d.c. power supply; – graduated glassware (volume) such as measuring cylinders of varying sizes; – titration apparatus including at least class B bulb pipettes and burettes (volume), burette holder/clamp and white tile; – gas syringe; – electronic balance (mass); – ruler (length); – stopclock or stopwatch (time); – thermometer or sensor (temperature); and – any other appropriate apparatus.

Content	Learning Outcomes
Analysing experimental data	Students should be able to: • record detailed observations or numerical data (where appropriate) during chemical reactions, including discrete or continuous variables; • demonstrate knowledge and understanding of the differences between accuracy (practical techniques or apparatus that helps to ensure accuracy), reliability (reproducibility of results) and validity (whether the experiment is suitable for the task); • demonstrate knowledge and understanding of the mathematical techniques that can be used to identify the relationships between variables; • use appropriate scales and axes labels when plotting a graph of experimental data; • demonstrate knowledge and understanding of what is meant by an anomalous result in a set of experimental data and how it should be treated; • plot data points accurately and draw the appropriate straight line or curve;
Drawing conclusions from an experiment	• make reasoned judgements and draw evidence-based conclusions; • analyse, interpret and critically evaluate a broad range of experimental data; • make deductions from given observations; • use reliable numerical data to carry out appropriate calculations of moles, mass, percentage by mass, gas volume, concentration, solution volume, degree of hydration and any other appropriate quantity; and • demonstrate understanding that for a graph of y against x, a straight line through (0,0) is an indicator of direct proportion.

Content	Learning Outcomes
Drawing conclusions from an experiment (cont.)	Students should be able to: • demonstrate understanding that for a graph of y against 1/x, a straight line through (0,0) is an indicator of inverse (indirect) proportion; • discuss in detail the areas of an investigation that could affect the reliability of the data or evidence collected; • develop and defend a hypothesis with appropriate and detailed scientific reasoning; and • develop arguments and explanations, taking account of the limitations of the available evidence.

Content	**Learning Outcomes**
Prescribed practicals	Below is a list of prescribed practicals that may be assessed in Unit 3. Students should be able to: • determine the mass of water present in hydrated crystals (Prescribed Practical C1); • investigate the reactions of acids, including temperature changes that occur (Prescribed Practical C2); • investigate the preparation of soluble salts (Prescribed Practical C3); • identify the ions in an ionic compound using chemical tests (Prescribed Practical C4); • investigate the reactivity of metals (Prescribed Practical C5); • investigate how changing a variable changes the rate of reaction (Prescribed Practical C6); • investigate the reactions of carboxylic acids (Prescribed Practical C7); • determine the reacting volumes of solutions of acid and alkali by titration **and determine the concentration of solutions of acid and alkali by titration** (Prescribed Practical C8); and • investigate the preparation, properties, tests and reactions of the gases hydrogen, oxygen and carbon dioxide (Prescribed Practical C9).

4 Scheme of Assessment

4.1 Assessment opportunities

For the availability of examinations and assessment, see Section 2.

This is a unitised specification; candidates must complete at least 40 percent of the overall assessment requirements at the end of the course, in the examination series in which they request a final subject grade. This is the terminal rule.

Candidates may resit individual assessment units once before cash-in. The better of the two results will count towards their final GCSE grade unless a unit is required to meet the 40 percent terminal rule. If it is, the more recent mark will count (whether or not it is the better result). Results for individual assessment units remain available to count towards a GCSE qualification until we withdraw the specification.

4.2 Assessment objectives

There are three assessment objectives (AO1, AO2 and AO3) for this specification. Candidates must:

AO1 demonstrate knowledge and understanding of:
- scientific ideas; and
- scientific techniques and procedures;

AO2 apply knowledge and understanding of and develop skills in:
- scientific ideas; and
- scientific enquiry, techniques and procedures; and

AO3 analyse scientific information and ideas to:
- interpret and evaluate;
- make judgements and draw conclusions; and
- develop and improve experimental procedures.

4.3 Assessment objective weightings

The table below sets out the approximate assessment objective weightings for each assessment component and the overall GCSE qualification.

Assessment Objective	Unit Weighting (%)			Overall Weighting (%)
	Unit 1	Unit 2	Unit 3	
AO1	15	16	9	40
AO2	15	17	8	40
AO3	5	7	8	20
Total Weighting	35	40	25	100

4.4 Quality of written communication

In GCSE Chemistry, candidates must demonstrate their quality of written communication. They need to:

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

Quality of written communication is assessed in responses to questions and tasks that require extended writing.

Units 1, 2 and Booklet B of Unit 3 each have **one** question that has 6 marks allocated to a candidate's quality of written communication. These questions are marked using a three tier banded mark scheme that stipulates the minimum number of marks required for each band. Quality of written communication is then assessed within each individual band.

4.5 Reporting and grading

We report the results of individual assessment units on a uniform mark scale that reflects the assessment weighting of each unit.

We determine the grades awarded by aggregating the uniform marks that candidates obtain in individual assessment units. We award GCSE qualifications on a grade scale from A* to G, with A* being the highest. The nine grades available are as follows:

Grade	A*	A	B	C*	C	D	E	F	G

If candidates fail to attain a grade G or above, we report their result as unclassified (U).

5 Grade Descriptions

Grade descriptions are provided to give a general indication of the standards of achievement likely to have been shown by candidates awarded particular grades. The descriptions must be interpreted in relation to the content in the specification; they are not designed to define that content. The grade awarded depends in practice upon the extent to which the candidate has met the assessment objectives overall. Shortcomings in some aspects of candidates' performance in the assessment may be balanced by better performances in others.

Grade	Description
A	Candidates recall, select and communicate precise knowledge and detailed understanding of chemistry. They demonstrate a comprehensive understanding of the nature of chemistry, its laws, its principles and applications and the relationship between chemistry and society. They understand the relationships between scientific advances, their ethical implications and the benefits and risks associated with them. They use scientific and technical knowledge, terminology and conventions appropriately and consistently, showing a detailed understanding of scale in terms of time, size and space. They apply appropriate skills, including communication, mathematical, technical and observational skills, knowledge and understanding effectively in a wide range of practical and other contexts. They show a comprehensive understanding of the relationships between hypotheses, evidence, theories and explanations and make effective use of models, including mathematical models, to explain abstract ideas, phenomena, events and processes. They use a wide range of appropriate methods, sources of information and data consistently, applying relevant skills to address scientific questions, solve problems and test hypotheses. Candidates analyse, interpret and critically evaluate a broad range of quantitative and qualitative data and information. They evaluate information systematically to develop arguments and explanations, taking account of the limitations of the available evidence. They make reasoned judgements consistently and draw detailed, evidence-based conclusions.

Grade	Description
C	Candidates recall, select and communicate secure knowledge and understanding of chemistry. They demonstrate understanding of the nature of chemistry, its laws, its principles and applications and the relationship between chemistry and society. They understand that scientific advances may have ethical implications, benefits and risks. They use scientific and technical knowledge, terminology and conventions appropriately, showing understanding of scale in terms of time, size and space. They apply appropriate skills, including communication, mathematical, technical and observational skills, knowledge and understanding in a range of practical and other contexts. They show understanding of the relationships between hypotheses, evidence, theories and explanations and use models, including mathematical models, to describe abstract ideas, phenomena, events and processes. They use a range of appropriate methods, sources of information and data, applying their skills to address scientific questions, solve problems and test hypotheses. Candidates analyse, interpret and evaluate a range of quantitative and qualitative data and information. They understand the limitations of evidence and use evidence and information to develop arguments with supporting explanations. They draw conclusions based on the available evidence.

Grade	Description
F	Candidates recall, select and communicate limited knowledge and understanding of chemistry. They recognise simple interrelationships between chemistry and society. They show a limited understanding that scientific advances may have ethical implications, benefits and risks. They use limited scientific and technical knowledge, terminology and conventions, showing some understanding of scale in terms of time, size and space. They apply skills, including limited communication, mathematical, technical and observational skills, knowledge and understanding in practical and some other contexts. They recognise and use hypotheses, evidence and explanations and can explain straightforward models of phenomena, events and processes. They use a limited range of methods, sources of information and data to address straightforward scientific questions, problems and hypotheses. Candidates interpret and evaluate limited quantitative and qualitative data and information from a narrow range of sources. They can draw elementary conclusions having collected limited evidence.

6 Guidance on Practical Skills Assessment

6.1 Overview

Unit 3 assesses practical skills. It has two parts: Booklet A is a practical skills assessment and Booklet B is an examination.

All of the nine prescribed practicals should be taught throughout the course. Booklet A consists of **two** pre-release practical assessment tasks based on but not identical to those on the list of nine prescribed practicals. We change the two assessed practicals every year to ensure that they continue to set an appropriate challenge and remain valid, reliable and stimulating.

For Booklet A, candidates carry out **two** practical tasks in the laboratory. Booklet A is a practical skills assessment and should be carried out under a high level of control, with teacher and invigilator supervision to comply with health and safety regulations.

We send centres a list of the materials required for Booklet A in the December before the Summer submission. We send Booklet A to centres in January of the final year of study.

Candidates collect qualitative or quantitative results depending on the demands of the practical skills assessment. We will publish a timetabled period for this practical skills assessment on the examinations timetable. Centres must send Booklet A to us for marking.

Booklet B is a timetabled, externally assessed examination taken at the end of the final year of study. It consists of questions about planning and carrying out any of the prescribed practical tasks. It also has more general questions about any practical situation that arises from this specification.

6.2 Skills assessed by Unit 3

The following skills are assessed:

- planning an investigation;
- carrying out an experiment;
- analysing experimental data; and
- drawing conclusions from an experiment.

6.3 Task taking in Booklet A

Booklet A is a practical skills assessment and must be carried out under a high level of control.

An appropriate teacher should be present with an invigilator to ensure compliance with health and safety regulations.

Teachers and invigilators should **not** offer direction or guidance to candidates where this would assist them in completing Booklet A.

Candidates may work collaboratively in groups of up to three when carrying out the practical tasks, but they must work individually and independently to complete Booklet A.

Candidates have **2 hours** to complete Booklet A, and it must be completed in a single session.

Foundation and Higher Tier candidates may carry out the practical skills assessment in the same room but can only work with others taking the same tier.

The examinations officer must keep all Booklet A papers (completed and unused) securely at all times.

Centres must return Booklet A papers to us for marking after 1 May.

We will provide additional information relating to Booklet A as a support document.

For Booklet A, the level of control for task taking is **high**. The table below exemplifies high levels of control for this practical skills assessment.

Areas of Control	Detail of Control
Authenticity	• Booklet A is an externally set and externally marked practical skills assessment. • Teachers must ensure that all candidates are in direct sight of the supervisor at all times. • Interaction between candidates is tightly prescribed during the practical tasks. • They should not communicate with each other when completing their response in Booklet A. • We will publish a timetabled period for this practical skills assessment on the examinations timetable. • Candidates must carry out the practical tasks and complete Booklet A in 2 hours. • We send an apparatus and materials list to examinations officers in December of the final year of study. They should distribute this list to the relevant head of department.
Feedback	• Teachers should not provide guidance or feedback during the practical skills assessment except to intervene on the grounds of health and safety.
Page Limit	• We set Booklet A. It has no prescribed page limit.
Collaboration	• Candidates for the same tier of entry may work collaboratively to carry out the practical tasks, but they must provide an individual response in Booklet A.
Resources	• The only allowed additional resource is the GCSE Data Leaflet that appears in Appendix 3, if required.

For up-to-date advice on plagiarism, or any kind of candidate malpractice, see *Suspected Malpractice in Examinations and Assessments: Policies and Procedures* on the Joint Council for Qualifications website at www.jcq.org.uk

6.4 Task marking

Our examiners mark the tasks.

7 Curriculum Objectives

This specification builds on the learning experiences from Key Stage 3 as required for the statutory Northern Ireland Curriculum. It also offers opportunities for students to contribute to the aim and objectives of the Curriculum at Key Stage 4, and to continue to develop the Cross-Curricular Skills and the Thinking Skills and Personal Capabilities. The extent of the development of these skills and capabilities will be dependent on the teaching and learning methodology used.

7.1 Cross-Curricular Skills at Key Stage 4

Communication

Students should be able to:

- communicate meaning, feelings and viewpoints in a logical and coherent manner, *for example outline examples of how modern life is dependent on hydrocarbons and crude oil;*
- make oral and written summaries, reports and presentations, taking account of audience and purpose, *for example produce a presentation on the importance of nanomaterials and their uses, including benefits and risks;*
- participate in discussions, debates and interviews, *for example debate disposing of polymers by incineration or landfill, or discuss the environmental effects of fossil fuel combustion;*
- interpret, analyse and present information in oral, written and ICT formats, *for example prepare a PowerPoint presentation or a poster about acid rain and its causes, its environmental impact and society's responsibility to minimise it on an international scale;* and
- explore and respond, both imaginatively and critically, to a variety of texts, *for example review several articles about the use of catalysts in industrial processes*.

Using Mathematics
Students should be able to: • use mathematical language and notation with confidence, *for example use appropriate units, measurements and calculations to determine mass, degree of hydration, concentration, empirical formula or identity of an unknown compound;* • use mental computation to calculate, estimate and make predictions in a range of simulated and real-life contexts*, for example estimate temperature changes during neutralisation and displacement reactions;* • select and apply mathematical concepts and problem-solving strategies in a range of simulated and real-life contexts, *for example apply the general formula for a homologous series and apply this determined formula to combustion reactions;* • interpret and analyse a wide range of mathematical data, *for example compare pH values to identify substances as being strong or weak acids or alkalis;* • assess probability and risk in a range of simulated and real-life contexts, *for example assess risk through risk assessment of practical activities;* and • present mathematical data in a variety of formats which take account of audience and purpose, *for example present tables of titration results and use standard form.*
Using ICT
Students should be able to make effective use of information and communications technology in a wide range of contexts to access, manage, select and present information, including mathematical information, *for example use a spreadsheet to plot rates of reaction data from a variety of groups carrying out experiments with different concentrations of a solution such as hydrochloric acid.*

7.2 Thinking Skills and Personal Capabilities at Key Stage 4

Self-Management
Students should be able to: • plan work; • set personal learning goals and targets to meet deadlines; • monitor, review and evaluate their progress and improve their learning; and • effectively manage their time, *for example carry out an individual project or assignment that collates the data on reactions of metals with air and with water, along with displacement reactions carried out in class, to develop a reactivity series.*
Working with Others
Students should be able to: • learn with and from others through co-operation; • participate in effective teams and accept responsibility for achieving collective goals; and • listen actively to others and influence group thinking and decision-making, taking account of others' opinions, *for example investigate the reactions of acids with metals, metal oxides, metal hydroxides and metal carbonates as a circuit of experiments that are combined to consolidate the output of the observations and equations for the reactions involved.*

Problem Solving
Students should be able to: • identify and analyse relationships and patterns, *for example interpret data to determine and state trends such as the reactivity of metals or solubility;* • propose justified explanations, *for example determine the identity of cations and anions from the observations of precipitation reactions and flame tests;* • analyse and evaluate multiple perspectives, *for example evaluate the idea of yield versus rate in industrial processes as a chemical engineer as opposed to a chemist in maximising profit;* • explore unfamiliar views without prejudice, *for example research the use of nanomaterials, including their benefits, risks and withdrawal;* • weigh up options and justify decisions*, for example outline the advantages and disadvantages of recycling aluminium when compared to extraction from aluminium ore;* and • apply and evaluate a range of approaches to solve problems in familiar and novel contexts, *for example explore salt preparation methods.*

Although not referred to separately as a statutory requirement at Key Stage 4 in the Northern Ireland Curriculum, **Managing Information** and **Being Creative** may also remain relevant to learning.

8 Links and Support

8.1 Support

The following resources are available to support this specification:

- our Chemistry microsite at www.ccea.org.uk and
- specimen assessment materials.

We also intend to provide:

- past papers;
- mark schemes;
- Chief Examiner's reports;
- Principal Moderator's reports;
- guidance on progression from Key Stage 3;
- planning frameworks;
- centre support visits;
- support days for teachers;
- practical skills assessment guidance for teachers;
- practical skills assessment guidance for candidates;
- a resource list; and
- exemplification of examination performance.

8.2 Examination entries

Entry codes for this subject and details on how to make entries are available on our Qualifications Administration Handbook microsite, which you can access at www.ccea.org.uk

Alternatively, you can telephone our Examination Entries, Results and Certification team using the contact details provided.

8.3 Equality and inclusion

We have considered the requirements of equality legislation in developing this specification and designed it to be as free as possible from ethnic, sexual orientation, gender, religious, political and other forms of bias.

GCSE qualifications often require the assessment of a broad range of competences. This is because they are general qualifications that prepare students for a wide range of occupations and higher level courses.

During the development process, an external equality panel reviewed the specification to identify any potential barriers to equality and inclusion. Where appropriate, we have considered measures to support access and mitigate barriers.

We can make reasonable adjustments for students with disabilities to reduce barriers to accessing assessments. For this reason, very few students will have a complete barrier to any part of the assessment.

Students with a physical impairment may instruct a practical assistant to set up equipment but may have difficulty in making observations and in manipulating the equipment to carry out the experiment.

Students with a visual impairment may find elements of the assessment difficult, but technology may help visually impaired students to take readings and make observations. Therefore, the assessments should not pose a difficulty for these students.

It is important to note that where access arrangements are permitted, they must not be used in any way that undermines the integrity of the assessment. You can find information on reasonable adjustments in the Joint Council for Qualifications document *Access Arrangements and Reasonable Adjustments*, available at www.jcq.org.uk

8.4 Contact details

If you have any queries about this specification, please contact the relevant CCEA staff member or department:

- Specification Support Officer: Nuala Tierney
  (telephone: (028) 9026 1200, extension 2292, email: ntierney@ccea.org.uk)

- Subject Officer: Elaine Lennox
  (telephone: (028) 9026 1200, extension 2320, email: elennox@ccea.org.uk)

- Examination Entries, Results and Certification
  (telephone: (028) 9026 1262, email: entriesandresults@ccea.org.uk)

- Examiner Recruitment
  (telephone: (028) 9026 1243, email: appointments@ccea.org.uk)

- Distribution
  (telephone: (028) 9026 1242, email: cceadistribution@ccea.org.uk)

- Support Events Administration
  (telephone: (028) 9026 1401, email: events@ccea.org.uk)

- Moderation
  (telephone: (028) 9026 1200, extension 2236, email: moderationteam@ccea.org.uk)

- Business Assurance (Complaints and Appeals)
  (telephone: (028) 9026 1244, email: complaints@ccea.org.uk or appealsmanager@ccea.org.uk).

Appendix 1

Mathematical Content

The mathematics that must form part of GCSE Chemistry should be at levels up to, but not beyond, the requirements specified in GCSE Mathematics for the appropriate tier.

This specification ensures that the number of marks used to credit the relevant mathematical skills is no less than 20 percent of the total marks for the qualification.

Students need to be familiar with and competent in the following areas of mathematics to develop their skills, knowledge and understanding in Chemistry.

Mathematical Skills
Arithmetic and numerical computation
Recognise and use expressions in decimal form
Recognise and use expressions in standard form
Use ratios, fractions and percentages
Make estimates of the results of simple calculations
Handling data
Use an appropriate number of significant figures
Find arithmetic means
Understand the principles of sampling as applied to scientific data
Understand the term mean (average)
Use a scatter diagram to identify a correlation between two variables
Make order of magnitude calculations
Algebra
Change the subject of an equation
Substitute numerical values into algebraic equations using appropriate units for physical quantities
Solve simple algebraic equations
Graphs
Translate information between graphical and numeric form
Plot two variables from experimental or other data

Physical quantities, units and unit abbreviations

The table below gives the physical quantities, units and abbreviations commonly used for GCSE Chemistry.

Students should also understand the prefixes femto (f), pico (p), nano (n), milli (m), centi (c), deci (d) and kilo (k) where appropriate.

Physical Quantity	Unit	Abbreviation for Unit
Amount	mole	mol
Concentration	mole per cubic decimetre gram per cubic decimetre	mol/dm^3 g/dm^3
Energy	joule kilojoule	J kJ
Length	metre centimetre millimetre nanometre picometre femtometre kilometre	m cm mm nm pm fm km
Mass	gram kilogram tonne	g kg t
Pressure	atmosphere	atm
Temperature	degree Celsius	°C
Time	second minute hour	s min h
Volume	cubic decimetre cubic centimetre cubic metre	dm^3 cm^3 m^3

Appendix 2

How Science Works

We assess students' practical skills through written examinations and practical assessments. This specification emphasises the importance of practical work. The content in this specification is assessed in the context of How Science Works and assesses students' abilities in the following skills.

Students should be able to:

- 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, to 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 that may arise;
- explain everyday 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 in 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;
- 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 knowledge of a range of techniques, instruments, apparatus and materials to select those appropriate to the experiment;
- carry out experiments with the appropriate manipulation of apparatus, taking accurate measurements and considering health and safety;
- recognise when to apply knowledge of sampling techniques to ensure any samples collected are representative; and
- make and record observations and measurements using a range of apparatus and methods.

Students should be able to:

- evaluate methods and suggest possible improvements and further investigations;
- present observations and other data using appropriate methods;
- translate data from one form to another;
- carry out and represent mathematical and statistical analysis;
- represent the distribution of results and make estimations of uncertainty;
- interpret observations and other data (presented in verbal, diagrammatic, graphical, symbolic or numerical form), including identifying patterns and trends, making inferences and drawing conclusions;
- present reasoned explanations including relating data to hypotheses;
- be objective, evaluate data in terms of accuracy, precision, repeatability and reproducibility and identify potential sources of random and systematic error;
- communicate the scientific rationale for investigations, methods used, findings and reasoned conclusions through written and electronic reports and presentations using verbal, diagrammatic, graphical, numerical and symbolic forms;
- use scientific vocabulary, terminology and definitions;
- recognise the importance of scientific quantities and understand how they are determined;
- use SI units (for example kg, g, mg; km, m, mm; kJ, J) and IUPAC chemical nomenclature if appropriate;
- use prefixes and powers of 10 for orders of magnitude (for example tera, giga, mega, kilo, centi, milli, micro, nano, pico and femto);
- interconvert units; and
- use an appropriate number of significant figures in calculations.

Appendix 3

Data Leaflet including the Periodic Table of the Elements

This data leaflet is for use with the specimen assessment materials. The same information will be provided with live examination papers and may be subject to updates as required.

SYMBOLS OF SELECTED IONS

Positive ions

Name	Symbol
Ammonium	NH_4^+
Chromium(III)	Cr^{3+}
Copper(II)	Cu^{2+}
Iron(II)	Fe^{2+}
Iron(III)	Fe^{3+}
Lead(II)	Pb^{2+}
Silver	Ag^+
Zinc	Zn^{2+}

Negative ions

Name	Symbol
Butanoate	$C_3H_7COO^-$
Carbonate	CO_3^{2-}
Dichromate	$Cr_2O_7^{2-}$
Ethanoate	CH_3COO^-
Hydrogencarbonate	HCO_3^-
Hydroxide	OH^-
Methanoate	$HCOO^-$
Nitrate	NO_3^-
Propanoate	$C_2H_5COO^-$
Sulfate	SO_4^{2-}
Sulfite	SO_3^{2-}

SOLUBILITY IN COLD WATER OF COMMON SALTS, HYDROXIDES AND OXIDES

Soluble
All sodium, potassium and ammonium salts
All nitrates
Most chlorides, bromides and iodides EXCEPT silver and lead chlorides, bromides and iodides
Most sulfates EXCEPT lead and barium sulfates Calcium sulfate is slightly soluble

Insoluble
Most carbonates EXCEPT sodium, potassium and ammonium carbonates
Most hydroxides EXCEPT sodium, potassium and ammonium hydroxides
Most oxides EXCEPT sodium, potassium and calcium oxides which react with water

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Rewarding Learning

GCSE

DATA LEAFLET
CHEMISTRY

Including the Periodic Table of the Elements

For the use of candidates taking
Science: Chemistry,
Science: Double Award
or Science: Single Award

Copies must be free from notes or additions of any kind. No other type of data booklet or information sheet is authorised for use in the examinations.

Rewarding Learning

THE PERIODIC TABLE OF ELEMENTS

Group

1	2											3	4	5	6	7	0
							1 H Hydrogen 1										4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 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	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac† Actinium 89	261 Rf Rutherfordium 104	262 Db Dubnium 105	266 Sg Seaborgium 106	264 Bh Bohrium 107	277 Hs Hassium 108	268 Mt Meitnerium 109	271 Ds Darmstadtium 110	272 Rg Roentgenium 111	285 Cn Copernicium 112						

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	145 Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	231 Pa Protactinium 91	238 U Uranium 92	237 Np Neptunium 93	242 Pu Plutonium 94	243 Am Americium 95	247 Cm Curium 96	245 Bk Berkelium 97	251 Cf Californium 98	254 Es Einsteinium 99	253 Fm Fermium 100	256 Md Mendelevium 101	254 No Nobelium 102	257 Lr Lawrencium 103

* 58 – 71 Lanthanum series
† 90 – 103 Actinium series

$^{a}_{b}x$ a = relative atomic mass (approx)
x = atomic symbol
b = atomic number

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