N5

National 5
Course
Specification

SQA

National 5 Chemistry

Course code:	C813 75
Course assessment code:	X813 75
SCQF:	level 5 (24 SCQF credit points)
Valid from:	session 2017–18

The course specification provides detailed information about the course and course assessment to ensure consistent and transparent assessment year on year. It describes the structure of the course and the course assessment in terms of the skills, knowledge and understanding that are assessed.

This document is for teachers and lecturers and contains all the mandatory information you need to deliver the course.

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Contents

Course overview

The course consists of 24 SCQF credit points which includes time for preparation for course assessment. The notional length of time for a candidate to complete the course is 160 hours.

The course assessment has two components.

Component	Marks	Scaled mark	Duration
Component 1: question paper	100	n/a	2 hours and 30 minutes
Component 2: assignment	20	25	8 hours, of which a maximum of 1 hour and 30 minutes is allowed for the report stage — see course assessment section

Recommended entry	Progression
Entry to this course is at the discretion of the centre. Candidates should have achieved the fourth curriculum level or the National 4 Chemistry course or equivalent qualifications and/or experience prior to starting this course. Candidates may also progress from relevant biology, environmental science, physics or science courses.	♦ other qualifications in chemistry or related areas ♦ further study, employment or training

Conditions of award

The grade awarded is based on the total marks achieved across all course assessment components.

Course rationale

National Courses reflect Curriculum for Excellence values, purposes and principles. They offer flexibility, provide more time for learning, more focus on skills and applying learning, and scope for personalisation and choice.

Every course provides opportunities for candidates to develop breadth, challenge and application. The focus and balance of assessment is tailored to each subject area.

Chemistry is the study of matter at the level of atoms, molecules, ions and compounds. These substances are the building blocks of life and all of the materials that surround us. Chemists play a vital role in the production of everyday commodities. Chemistry research and development is essential for the introduction of new products. The study of chemistry is of benefit not only to those intending to pursue a career in science, but also to those intending to work in areas such as the food, health, textile or manufacturing industries.

An experimental and investigative approach is used to develop knowledge and understanding of chemical concepts.

Purpose and aims

The purpose of the course is to develop candidates' curiosity, interest and enthusiasm for chemistry in a range of contexts. The skills of scientific inquiry are integrated and developed throughout the course. The relevance of chemistry is highlighted by the study of the applications of chemistry in everyday contexts. This enables candidates to become scientifically literate citizens, able to review the science-based claims they will meet.

The course offers opportunities for candidates to develop the ability to think analytically and to make reasoned evaluations. The course covers a variety of relevant contexts including the chemistry of the Earth's resources, the chemistry of everyday products and chemical analysis. The course allows flexibility and personalisation by offering candidates the choice of topic for their assignment. It develops a broad, versatile and adaptable skill set which is valued in the workplace, forms the basis for progression to the study of chemistry at a higher level, and provides knowledge useful in the study of all of the sciences.

The aims of the course are for candidates to:

- develop and apply knowledge and understanding of chemistry
- develop an understanding of the impact of chemistry on everyday life
- develop an understanding of chemistry's role in scientific issues and relevant applications of chemistry, including the impact these could make on society and the environment
- develop scientific inquiry and investigative skills
- develop scientific analytical thinking skills in a chemistry context
- develop the skills to use technology, equipment and materials, safely, in practical scientific activities
- develop planning skills
- develop problem-solving skills in a chemistry context

- use and understand scientific literacy, in everyday contexts, to communicate ideas and issues and to make scientifically informed choices
- develop the knowledge and skills for more advanced learning in chemistry
- develop skills of independent working

The course enables candidates to make their own decisions on issues within a modern society, where the body of scientific knowledge and its applications and implications are ever developing.

Who is this course for?

The course is suitable for learners who have experienced learning across the sciences experiences and outcomes. The course may be suitable for those wishing to study chemistry for the first time.

This course has a skills-based approach to learning. It takes account of the needs of all learners and provides sufficient flexibility to enable learners to achieve in different ways.

Course content

Candidates gain an understanding of chemistry and develop this through a variety of approaches, including practical activities, investigations and problem solving. Candidates research topics, apply scientific skills and communicate information related to their findings, which develops skills of scientific literacy.

The course content includes the following areas of chemistry:

Chemical changes and structure
In this area, topics covered are: rates of reaction; atomic structure and bonding related to properties of materials; formulae and reacting quantities; acids and bases.

Nature's chemistry
In this area, topics covered are: homologous series; everyday consumer products; energy from fuels.

Chemistry in society
In this area, topics covered are: metals; plastics; fertilisers; nuclear chemistry; chemical analysis.

Skills, knowledge and understanding

Skills, knowledge and understanding for the course

The following provides a broad overview of the subject skills, knowledge and understanding developed in the course:

- demonstrating knowledge and understanding of chemistry by making accurate statements
- demonstrating knowledge and understanding of chemistry by describing information and providing explanations and integrating knowledge
- applying knowledge of chemistry to new situations, interpreting information and solving problems
- planning or designing experiments to test given hypotheses or to illustrate particular effects, including safety measures
- carrying out experimental procedures safely
- selecting information from a variety of sources
- presenting information appropriately in a variety of forms
- processing information (using calculations and units, where appropriate)
- making predictions and generalisations based on evidence/information
- drawing valid conclusions and giving explanations supported by evidence/justification
- evaluating experimental procedures
- suggesting improvements to experiments/practical investigations
- communicating findings/information

Skills, knowledge and understanding for the course assessment

The following provides details of skills, knowledge and understanding sampled in the course assessment:

Chemical changes and structure

Rates of reaction

To follow the progress of chemical reactions, changes in mass, volume and other quantities can be measured. Graphs can then be drawn and be interpreted in terms of:

- end-point of a reaction
- quantity of product
- quantity of reactant used
- effect of changing conditions

Rates of reaction can be increased:

- by increasing the temperature
- by increasing the concentration of a reactant
- by increasing surface area/decreasing particle size
- through the use of a catalyst

Catalysts are substances that speed up chemical reactions but can be recovered chemically unchanged at the end of the reaction.
The average rate of a chemical reaction can be calculated, with appropriate units, using the equation:

$$rate = \frac{\Delta quantity}{\Delta t}$$

The rate of a reaction can be shown to decrease over time by calculating the average rate at different stages of the reaction.

Atomic structure and bonding related to properties of materials

Periodic Table and atoms

Elements in the Periodic Table are arranged in order of increasing atomic number.
The Periodic Table can be used to determine whether an element is a metal or non-metal.
Groups are columns in the Periodic Table containing elements with the same number of outer electrons, indicated by the group number.
Elements within a group share the same valency and have similar chemical properties because they have the same number of electrons in their outer energy levels.
The electron arrangement of the first 20 elements can be written.
An atom has a nucleus, containing protons and neutrons, and electrons that orbit the nucleus.
Protons have a charge of one-positive, neutrons are neutral and electrons have a charge of one-negative. Protons and neutrons have an approximate mass of one atomic mass unit and electrons, in comparison, have virtually no mass.
The number of protons in an atom is given by the atomic number.
In a neutral atom the number of electrons is equal to the number of protons.

Chemical changes and structure

The mass number of an atom is equal to the number of protons added to the number of neutrons.

Isotopes are defined as atoms with the same atomic number but different mass numbers, or as atoms with the same number of protons but different numbers of neutrons.

Nuclide notation is used to show the atomic number, mass number (and charge) of atoms (ions) from which the number of protons, electrons and neutrons can be determined.

Most elements have two or more isotopes. The average atomic mass has been calculated for each element using the mass and proportion of each isotope present. These values are known as relative atomic masses.

Covalent bonding

Covalent bonds form between non-metal atoms.

A covalent bond forms when two positive nuclei are held together by their common attraction for a shared pair of electrons.

Diagrams can be drawn to show how outer electrons are shared to form the covalent bond(s) in a molecule.

7 elements exist as diatomic molecules through the formation of covalent bonds: H_2, N_2, O_2, F_2, Cl_2, Br_2, I_2.

The shape of simple covalent molecules depends on the number of bonds and the orientation of these bonds around the central atom. These molecules can be described as linear, angular, trigonal pyramidal or tetrahedral.

More than one bond can be formed between atoms leading to double and triple covalent bonds.

Covalent substances can form either discrete molecular or giant network structures.

Covalent molecular substances:

- have strong covalent bonds within the molecules and only weak attractions between the molecules
- have low melting and boiling points as only weak forces of attraction between the molecules are broken when a substance changes state
- do not conduct electricity because they do not have charged particles which are free to move

Covalent molecular substances which are insoluble in water may dissolve in other solvents.

Covalent network structures:

- have a network of strong covalent bonds within one giant structure
- have very high melting and boiling points because the network of strong covalent bonds is not easily broken
- do not dissolve

In general, covalent network substances do not conduct electricity. This is because they do not have charged particles which are free to move.

Chemical changes and structure

Ionic compounds

Ions are formed when atoms lose or gain electrons to obtain the stable electron arrangement of a noble gas.

In general, metal atoms lose electrons forming positive ions and non-metal atoms gain electrons forming negative ions.

Ion-electron equations can be written to show the formation of ions through loss or gain of electrons.

Ionic bonds are the electrostatic attraction between positive and negative ions.

Ionic compounds form lattice structures of oppositely charged ions with each positive ion surrounded by negative ions and each negative ion surrounded by positive ions.

Ionic compounds have high melting and boiling points because strong ionic bonds must be broken in order to break up the lattice.

Many ionic compounds are soluble in water. As they dissolve the lattice structure breaks up allowing water molecules to surround the separated ions.

Ionic compounds conduct electricity only when molten or in solution as the lattice structure breaks up allowing the ions to be free to move.

Conduction in ionic compounds can be explained by the movement of ions towards oppositely charged electrodes.

Formulae and reacting quantities

Chemical formulae

Compound names are derived from the names of the elements from which they are formed. Most compounds with a name ending in ‘-ide’ contain the two elements indicated. The ending ‘-ite’ or ‘-ate’ indicates that oxygen is also present.

Chemical formulae can be written for two element compounds using valency rules and a Periodic Table.

Roman numerals can be used, in the name of a compound, to indicate the valency of an element.

The chemical formula can also be determined from names with prefixes.

The chemical formula of a covalent molecular substance gives the number of each type of atom present in a molecule.

The formula of a covalent network gives the simplest ratio of each type of atom in the substance.

Ions containing more than one type of atom are often referred to as group ions.

Chemical formulae can be written for compounds containing group ions using valency rules and the data booklet.

Ionic formulae give the simplest ratio of each type of ion in the substance and can show the charges on each ion, if required.

In formulae, charges must be superscript and numbers of atoms/ions must be subscript.

Calculations involving the mole and balanced equations

Chemical equations, using formulae and state symbols, can be written and balanced.

The mass of a mole of any substance, in grams (g), is equal to the gram formula mass and can be calculated using relative atomic masses.

Calculations can be performed using the relationship between the mass and the number of moles of a substance.

A solution is formed when a solute is dissolved in a solvent.

Chemical changes and structure

For solutions, the mass of solute (grams or g), the number of moles of solute (moles or mol), the volume of solution (litres or l) or the concentration of the solution (moles per litre or mol l^{-1}) can be calculated from data provided.
Given a balanced equation, the mass or number of moles of a substance can be calculated given the mass or number of moles of another substance in the reaction.

Percentage composition

The percentage composition of an element in any compound can be calculated from the formula of the compound.

Acids and bases

pH

The pH scale is an indication of the hydrogen ion concentration and runs from below 0 to above 14.
A neutral solution has equal concentrations of H^+(aq) and OH^-(aq) ions.
Water is neutral as it dissociates according to the equation

$$H_2O(\ell) \rightleftharpoons H^+(aq) + OH^-(aq)$$

producing equal concentrations of hydrogen and hydroxide ions. At any time, only a few water molecules are dissociated into free ions.
The $\rightleftharpoons$ symbol indicates that a reaction is reversible and occurs in both directions.
Acidic solutions have a higher concentration of H^+(aq) ions than OH^-(aq) and have a pH below 7.
Alkaline solutions have a higher concentration of OH^-(aq) ions than H^+(aq) ions and have a pH above 7.
Dilution of an acidic solution with water will decrease the concentration of H^+(aq) and the pH will increase towards 7.
Dilution of an alkaline solution with water will decrease the concentration of OH^-(aq) and the pH will decrease towards 7.
Soluble non-metal oxides dissolve in water forming acidic solutions.
Soluble metal oxides dissolve in water to form alkaline solutions:

metal oxide + water → metal hydroxide

Metal oxides, metal hydroxides, metal carbonates and ammonia neutralise acids and are called bases. Those bases that dissolve in water form alkaline solutions.

Neutralisation reactions

A neutralisation reaction is one in which a base reacts with an acid to form water. A salt is also formed in this reaction.

Equations can be written for the following neutralisation reactions:

a metal oxide + an acid → a salt + water
a metal hydroxide + an acid → a salt + water
a metal carbonate + an acid → a salt + water + carbon dioxide

The name of the salt produced depends on the acid and base used. Hydrochloric acid produces chlorides, sulfuric acid produces sulfates and nitric acid produces nitrates.

Spectator ions are ions that remain unchanged by the reaction.
Reaction equations can be used to identify spectator ions.

Chemical changes and structure

For neutralisation reactions, equations can be written omitting spectator ions:

$2H^+(aq) + O^{2-}(s) \rightarrow H_2O(\ell)$ for metal oxides
$H^+(aq) + OH^-(aq) \rightarrow H_2O(\ell)$ for metal hydroxides
$2H^+(aq) + CO_3^{2-}(aq) \rightarrow H_2O(\ell) + CO_2(g)$ for aqueous metal carbonates
$2H^+(aq) + CO_3^{2-}(s) \rightarrow H_2O(\ell) + CO_2(g)$ for insoluble metal carbonates

In an acid-base titration, the concentration of the acid or base is determined by accurately measuring the volumes used in the neutralisation reaction. An indicator can be added to show the end-point of the reaction.

Given a balanced equation for the reaction occurring in any titration:

- the concentration of one reactant can be calculated given the concentration of the other reactant and the volumes of both solutions
- the volume of one reactant can be calculated given the volume of the other reactant and the concentrations of both solutions

Neutralisation reactions can be used to prepare soluble salts

Titration can be used to produce a soluble salt. Once the volumes of acid and alkali have been noted, the reaction can be repeated without the indicator to produce an uncontaminated salt solution. The solution can then be evaporated to dryness.

Insoluble metal carbonates and insoluble metal oxides can be used to produce soluble salts. Excess base is added to the appropriate acid, the mixture is filtered and the filtrate evaporated to dryness.

Nature’s chemistry

Homologous series

Systematic carbon chemistry

A homologous series is a family of compounds with the same general formula and similar chemical properties.

Patterns are often seen in the physical properties of the members of a homologous series. The subsequent members of a homologous series show a general increase in their melting and boiling points. This pattern is attributed to increasing strength of the intermolecular forces as the molecular size increases. The type of intermolecular force does not need to be identified.

Hydrocarbons are compounds containing only hydrogen and carbon atoms.

Compounds containing only single carbon–carbon bonds are described as saturated.

Compounds containing at least one carbon–carbon double bond are described as unsaturated.

It is possible to distinguish an unsaturated compound from a saturated compound using bromine solution. Unsaturated compounds decolourise bromine solution quickly.

The structure of any molecule can be drawn as a full or a shortened structural formula.

Isomers:

- are compounds with the same molecular formula but different structural formulae
- may belong to different homologous series
- usually have different physical properties

Given a structural formula for a compound, an isomer can be drawn.

Isomers can be drawn for a given molecular formula.

Alkanes

Alkanes:

- are a homologous series of saturated hydrocarbons
- are commonly used as fuels
- are insoluble in water
- can be represented by the general formula C_nH_{2n+2}

Straight-chain and branched alkanes can be systematically named from structural formulae containing no more than 8 carbons in the longest chain.

Molecular formulae can be written and structural formulae can be drawn, from the systematic names of straight-chain and branched alkanes, containing no more than 8 carbons in the longest chain.

Cycloalkanes

Cycloalkanes:

- are a homologous series of saturated, cyclic hydrocarbons
- are used as fuels and solvents
- are insoluble in water
- can be represented by the general formula C_nH_{2n}

Nature’s chemistry

Cycloalkanes (C_3–C_8) can be systematically named from structural formulae. Branched cycloalkanes are not required.
Molecular formulae can be written and structural formulae can be drawn from the systematic names of un-branched cycloalkanes.

Alkenes

Alkenes:

- are a homologous series of unsaturated hydrocarbons
- are used to make polymers and alcohols
- are insoluble in water
- contain the C=C double bond functional group
- can be represented by the general formula C_nH_{2n}

Straight-chain and branched alkenes can be systematically named indicating the position of the double bond, from structural formulae containing no more than 8 carbon atoms in the longest chain.
Molecular formulae can be written and structural formulae can be drawn, from the systematic names of straight-chain and branched alkenes, containing no more than 8 carbons in the longest chain.
Chemical equations can be written for the addition reactions of alkenes, using molecular or structural formulae.

Alkenes undergo addition reactions:

- with hydrogen forming alkanes, known as hydrogenation
- with halogens forming dihaloalkanes
- with water forming alcohols, known as hydration

Everyday consumer products

Alcohols

Alcohols are used as fuels as they are highly flammable and burn with very clean flames.
Alcohols are often used as solvents.
Methanol, ethanol and propanol are miscible with water, thereafter the solubility decreases as size increases.
As alcohols increase in size their melting and boiling points increase due to the increasing strength of the intermolecular forces. The type of intermolecular force does not need to be identified.
An alcohol is a molecule containing a hydroxyl functional group, –OH group.
Saturated, straight-chain alcohols can be represented by the general formula $C_nH_{2n+1}OH$.
Straight-chain alcohols can be systematically named indicating the position of the hydroxyl group from structural formulae containing no more than 8 carbon atoms.
Molecular formulae can be written and structural formulae can be drawn, from the systematic names of straight-chain alcohols, containing no more than 8 carbons.

Nature’s chemistry

Carboxylic acids

Carboxylic acids are used in the preparation of preservatives, soaps and medicines.

Vinegar is a solution of ethanoic acid, with molecular formula CH_3COOH. Vinegar is used in household cleaning products as it is a non-toxic acid so can be used safely in household situations.

Methanoic, ethanoic, propanoic and butanoic acid are miscible in water, thereafter the solubility decreases as size increases.

As carboxylic acids increase in size their melting and boiling points increase due to the increasing strength of the intermolecular forces. The type of intermolecular force does not need to be identified.

Carboxylic acids can be identified by the carboxyl functional group, $-COOH$.

Carboxylic acids can be represented by the general formula $C_nH_{2n+1}COOH$.

Straight-chain carboxylic acids can be systematically named from structural formulae containing no more than 8 carbons.

Molecular formulae can be written and structural formulae drawn, from the systematic names of straight-chain carboxylic acids, containing no more than 8 carbons.

Solutions of carboxylic acids have a pH less than 7 and like other acids, can react with metals, metal oxides, hydroxides and carbonates forming salts. Salts formed from straight-chain carboxylic acids containing no more than 8 carbons, can be named.

Energy from fuels

A reaction or process that releases heat energy is described as exothermic. A reaction or process that takes in heat energy is described as endothermic.

In combustion, a substance reacts with oxygen releasing energy.

Hydrocarbons and alcohols burn in a plentiful supply of oxygen to produce carbon dioxide and water. Equations can be written for the complete combustion of hydrocarbons and alcohols.

Fuels burn releasing different quantities of energy.

The quantity of heat energy released can be determined experimentally and calculated using, $E_h = cm\Delta T$.

The quantities E_h, c, m or ΔT can be calculated, in the correct units, given relevant data. Calculations can involve heating substances other than water. It is not necessary to calculate the enthalpy per mole of substance burned.

Chemistry in society

Metals

Metallic bonding

Metallic bonding is the electrostatic force of attraction between positively charged ions and delocalised electrons.
Metallic elements are conductors of electricity because they contain delocalised electrons.

Reactions of metals

Equations, involving formulae, can be written to show the reaction of metals with oxygen, water, and dilute acids:

metal + oxygen → metal oxide
metal + water → metal hydroxide + hydrogen
metal + dilute acid → salt + hydrogen

Metals can be arranged in order of reactivity by comparing the rates at which they react.
Metals can be used to produce soluble salts. Excess metal is added to the appropriate acid, the mixture is filtered and the filtrate evaporated to dryness.

Redox

Reduction is a gain of electrons by a reactant in any reaction.
Oxidation is a loss of electrons by a reactant in any reaction.
In a redox reaction, reduction and oxidation take place at the same time.
Ion-electron equations can be written for reduction and oxidation reactions.
Ion-electron equations can be combined to produce redox equations.

Extraction of metals

During the extraction of metals, metal ions are reduced forming metal atoms.
The method used to extract a metal from its ore depends on the position of the metal in the reactivity series. Equations can be written to show the extraction of metals.
Methods used are:

- heat alone (for extraction of Ag, Au and Hg)
- heating with carbon or carbon monoxide (for extraction of Cu, Pb, Sn, Fe and Zn)
- electrolysis (for extraction of more reactive metals including aluminium)

Electrolysis is the decomposition of an ionic compound into its elements using electricity.
A d.c. supply must be used if the products of electrolysis are to be identified.
Positive ions gain electrons at the negative electrode and negative ions lose electrons at the positive electrode.

Electrochemical cells

Electrically conducting solutions containing ions are known as electrolytes.
A simple cell can be made by placing two metals in an electrolyte.
Another type of cell can be made using two half-cells (metals in solutions of their own ions).

An ‘ion bridge’ (salt bridge) can be used to link the half-cells. Ions can move across the bridge to complete an electrical circuit.
Electricity can be produced in cells where at least one of the half-cells does not involve metal atoms/ions. A graphite rod can be used as the electrode in such half-cells.

Chemistry in society

Different pairs of metals produce different voltages. These voltages can be used to arrange the elements into an electrochemical series.
The further apart elements are in the electrochemical series, the greater the voltage produced when they are used to make an electrochemical cell.
Electrons flow in the external circuit from the species higher in the electrochemical series to the one lower in the electrochemical series.
For an electrochemical cell, including those involving non-metals, ion-electron equations can be written for:

- the oxidation reaction
- the reduction reaction
- the overall redox reactions

The direction of electron flow can be deduced for electrochemical cells including those involving non-metal electrodes.

Plastics

Addition polymerisation

Plastics are examples of materials known as polymers.
Polymers are long chain molecules formed by joining together a large number of small molecules called monomers.
Addition polymerisation is the name given to a chemical reaction in which unsaturated monomers are joined, forming a polymer.
The names of addition polymers are derived from the name of the monomer used.
Note: brackets can be used in polymer names to aid identification of the monomer unit.

Representation of the structure of monomers and polymers

A repeating unit is the shortest section of polymer chain which, if repeated, would yield the complete polymer chain (except for the end-groups).
The structure of a polymer can be drawn given either the structure of the monomer or the repeating unit.
From the structure of a polymer, the monomer or repeating unit can be drawn.

Fertilisers

Commercial production of fertilisers

Growing plants require nutrients, including compounds containing nitrogen, phosphorus or potassium.
Fertilisers are substances which restore elements, essential for healthy plant growth, to the soil.
Ammonia and nitric acid are important compounds used to produce soluble, nitrogen-containing salts that can be used as fertilisers.
Ammonia is a pungent, clear, colourless gas which dissolves in water to produce an alkaline solution.
Ammonia solutions react with acids to form soluble salts.

ammonia solution + an acid → an ammonium salt + water

Chemistry in society

Haber and Ostwald processes

The Haber process is used to produce the ammonia required for fertiliser production.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

At low temperatures the forward reaction is too slow to be economical. If the temperature is increased, the rate of reaction increases but, as the temperature increases, the backward reaction becomes more dominant. An iron catalyst is used to increase reaction rate.
Ammonia is the starting material for the commercial production of nitric acid.

The Ostwald process uses ammonia, oxygen and water to produce nitric acid. A platinum catalyst is used in this process.

Nuclear chemistry

Radiation

Radioactive decay involves changes in the nuclei of atoms. Unstable nuclei (radioisotopes) can become more stable nuclei by giving out alpha, beta or gamma radiation.
Alpha particles (α) consist of two protons and two neutrons and carry a double positive charge. They have a range of only a few centimetres in air and are stopped by a piece of paper. Alpha particles will be attracted towards a negatively charged plate.
Beta particles (β) are electrons ejected from the nucleus of an atom. They are able to travel over a metre in air but can be stopped by a thin sheet of aluminium. Beta particles will be attracted towards a positively charged plate.
Gamma rays (γ) are electromagnetic waves emitted from within the nucleus of an atom. They are able to travel great distances in air. They can be stopped by barriers made of materials such as lead or concrete. Gamma rays are not deflected by an electric field.

Nuclear equations

Balanced nuclear equations can be written using nuclide notation.
In nuclear equations:

- an alpha particle can be represented as ${}^{4}_{2}\mathrm{He}$
- a beta particle can be represented as ${}^{0}_{-1}\mathrm{e}$
- a proton can be represented as ${}^{1}_{1}\mathrm{p}$
- a neutron can be represented as ${}^{1}_{0}\mathrm{n}$

In the course of any nuclear reaction:

- The sum of the atomic numbers on the left of the reaction arrow is equal to the sum of the atomic numbers on the right of the reaction arrow.
- The sum of the mass numbers on the left of the reaction arrow is equal to the sum of the mass numbers on the right of the reaction arrow.

Candidates do not need to show electrical charges when writing balanced equations representing nuclear reactions.

Chemistry in society

Half-life

Half-life is the time for half of the nuclei of a particular isotope to decay.
The half-life of an isotope is a constant, unaffected by chemical or physical conditions.
Radioactive isotopes can be used to date materials.
The half-life of an isotope can be determined from a graph showing a decay curve.
Calculations can be performed using the link between the number of half-lives, time and the proportion of a radioisotope remaining.

Use of radioactive isotopes

Radioisotopes have a range of uses in medicine and in industry.
Candidates do not need to be able to name the isotope used in a particular application.
Given information on the type of radiation emitted and/or half-lives, the suitability of an isotope for a particular application can be evaluated.

Chemical analysis

Common chemical apparatus

Candidates must be familiar with the use(s) of the following types of apparatus:

- conical flask
- beaker
- measuring cylinder
- delivery tube
- dropper
- test tubes/boiling tubes
- funnel
- filter paper
- evaporating basin
- pipette with safety filler
- burette
- thermometer

Chemistry in society

General practical techniques

Candidates must be familiar with the following practical techniques:

- simple filtration using filter paper and a funnel to separate the residue from the filtrate
- use of a balance
- methods for the collection of gases including:
  - collection over water (for relatively insoluble gases)
  - downward displacement of air (for soluble gases that are less dense than air)
  - upward displacement of air (for soluble gases that are more dense than air)
- methods of heating using Bunsen burners and electric hotplates
- preparation of soluble salts by the reaction of acids with metals, metal oxides, metal hydroxides and metal carbonates
- preparation of insoluble salts by precipitation
- testing the electrical conductivity of solids and solutions
- setting up an electrochemical cell using a salt bridge and either metal or carbon electrodes
- electrolysis of solutions using a d.c. supply
- determination of E_h

Analytical methods

Titration is used to determine, accurately, the volumes of solution required to reach the end-point of a chemical reaction. An indicator is normally used to show when the end-point is reached. Titre volumes within 0·2 cm^3 are considered concordant. Solutions of accurately known concentration are known as standard solutions.

Flame tests can identify metals present in a sample.

Simple tests can be used to identify oxygen, hydrogen and carbon dioxide gases.

Precipitation is the reaction of two solutions to form an insoluble salt called a precipitate. Information on the solubility of compounds can be used to predict when a precipitate will form. The formation of a precipitate can be used to identify the presence of a particular ion.

Reporting experimental work

Labelled, sectional diagrams can be drawn for common chemical apparatus.
Data can be presented in tabular form with appropriate headings and units of measurement.
Data can be presented as a bar, line or scatter graph with suitable scale(s) and labels.
A line of best fit (straight or curved) can be used to represent the trend observed in experimental data.
Average (mean) values can be calculated from data.
Given a description of an experimental procedure and/or experimental results, an improvement to the experimental method can be suggested and justified.

Skills, knowledge and understanding included in the course are appropriate to the SCQF level of the course. The SCQF level descriptors give further information on characteristics and expected performance at each SCQF level (www.scqf.org.uk).

Skills for learning, skills for life and skills for work

This course helps candidates to develop broad, generic skills. These skills are based on SQA’s Skills Framework: Skills for Learning, Skills for Life and Skills for Work and draw from the following main skills areas:

2 Numeracy

2.1 Number processes
2.2 Money, time and measurement
2.3 Information handling

5 Thinking skills

5.3 Applying
5.4 Analysing and evaluating

These skills must be built into the course where there are appropriate opportunities and the level should be appropriate to the level of the course.

Further information on building in skills for learning, skills for life and skills for work is given in the course support notes.

Course assessment

Course assessment is based on the information provided in this document.

The course assessment meets the key purposes and aims of the course by addressing:

- breadth — drawing on knowledge and skills from across the course
- challenge — requiring greater depth or extension of knowledge and/or skills
- application — requiring application of knowledge and/or skills in practical or theoretical contexts as appropriate

This enables candidates to:

- apply breadth and depth of skills, knowledge and understanding from across the course to answer questions in chemistry
- apply skills of scientific inquiry, using related knowledge, to carry out a meaningful and appropriately challenging investigation in chemistry and communicate findings

The course assessment has two components, a question paper and an assignment. The relationship between these two components is complementary, to ensure full coverage of the knowledge and skills of the course.

Course assessment structure: question paper

Question paper 100 marks

The purpose of the question paper is to assess breadth, challenge and application of skills, knowledge and understanding from across the course.

The question paper also assesses scientific inquiry skills and analytical thinking skills.

The question paper gives candidates an opportunity to demonstrate skills, knowledge and understanding by:

- making accurate statements
- providing descriptions and explanations
- applying knowledge of chemistry to new situations, interpreting information and solving problems
- planning or designing experiments to test given hypotheses or to illustrate particular effects, including safety measures
- selecting information
- presenting information appropriately in a variety of forms
- processing information (using calculations and units, where appropriate)
- making predictions and generalisations based on evidence/information
- drawing valid conclusions and giving explanations supported by evidence/justification
- evaluating experimental procedures

The question paper has a total of 100 marks and is worth 80% of the overall marks for external assessment.

The question paper has two sections.

- Section 1 (objective test) has 25 marks.
- Section 2 contains restricted and extended response questions and has 75 marks.

The majority of marks are awarded for demonstrating and applying knowledge and understanding. The other marks are awarded for applying scientific inquiry and analytical thinking skills.

A data booklet containing relevant data and formulae is provided.

Setting, conducting and marking the question paper

The question paper is set and marked by SQA, and conducted in centres under conditions specified for external examinations by SQA. The question paper is 2 hours and 30 minutes in duration.

Specimen question papers for National 5 courses are published on SQA’s website. These illustrate the standard, structure and requirements of the question papers candidates sit. The specimen papers also include marking instructions.

Course assessment structure: assignment

Assignment 20 marks

The purpose of the assignment is to assess the application of skills of scientific inquiry and related chemistry knowledge and understanding.

This component allows assessment of skills which cannot be assessed through the question paper, for example the handling and processing of data gathered as a result of experimental work and research skills.

Assignment overview

The assignment gives candidates an opportunity to demonstrate the following skills, knowledge and understanding:

- applying knowledge of chemistry to new situations, interpreting information and solving problems
- planning, designing and safely carrying out experiments/practical investigations to test given hypotheses or to illustrate particular effects
- selecting information from a variety of sources
- presenting information appropriately in a variety of forms
- processing the information (using calculations and units, where appropriate)
- making predictions and generalisations based on evidence/information
- drawing valid conclusions and giving explanations supported by evidence/justification
- suggesting improvements to experiments/practical investigations
- communicating findings/information

The assignment offers challenge by requiring skills, knowledge and understanding to be applied in a context that is one or more of the following:

- unfamiliar
- familiar but investigated in greater depth
- familiar but integrates a number of concepts

Candidates will research and report on a topic that allows them to apply skills and knowledge in chemistry at a level appropriate to National 5.

The topic should be chosen with guidance from the teacher/lecturer and must involve experimental work.

The assignment has two stages:

- research
- report

The research stage must involve an experiment that allows measurements to be made. Candidates must also gather data from the internet, books or journals to compare against their experimental results. The candidate's research may also involve gathering extracts from internet/literature sources to support their descriptions and/or explanations of the underlying chemistry.

Candidates must produce a report on their research.

Setting, conducting and marking the assignment

Setting

The assignment is:

- set by centres within SQA guidelines
- set at a time appropriate to the candidates' needs
- set within teaching and learning and includes experimental work at a level appropriate to National 5

Conducting

The assignment is:

- an individually produced piece of work from each candidate
- started at an appropriate point in the course
- conducted under controlled conditions

Marking

The assignment has a total of 20 marks. The table below gives details of the mark allocation for each section of the report.

Section	**Expected response**	**Max marks**
Title	An informative title.	1
Aim	An aim that describes clearly the purpose of the investigation.	1
Underlying chemistry	An account of the chemistry relevant to the aim.	3
Data collection and handling	A brief description of the approach used to collect experimental data.	1
	Sufficient raw data from the candidate's experiment.	1
	Data presented in a correctly produced table.	1
	Mean and/or derived values calculated correctly.	1
	Data relevant to the experiment from an internet/literature source.	1
	A reference for the source of the internet/literature data.	1
Graphical presentation	An appropriate format from the options of scatter graph, line graph or bar graph.	1
	The axis/axes of the graph has/have suitable scales.	1
	The axes of the graph have suitable labels and units.	1
	Accurately plotted data points and, where appropriate, a line of best fit.	1
Analysis	Valid comparison of the experimental data with data from the internet/literature source.	1
Conclusion	A conclusion that relates to the aim and is supported by all the data in the report.	1
Evaluation	An evaluation of the experimental procedure.	2
Structure	A clear and concise report	1
		20

The report is submitted to SQA for external marking.

All marking is quality assured by SQA.

Assessment conditions

Controlled assessment is designed to:

- ensure that all candidates spend approximately the same amount of time on their assignments
- prevent third parties from providing inappropriate levels of guidance and input
- mitigate concerns about plagiarism and improve the reliability and validity of SQA awards
- allow centres a reasonable degree of freedom and control
- allow candidates to produce an original piece of work

Detailed conditions for assessment are given in the assignment assessment task.

Time

It is recommended that no more than 8 hours is spent on the **whole** assignment. A maximum of 1 hour and 30 minutes is allowed for the report stage.

Supervision, control and authentication

There are two levels of control.

Under a high degree of supervision and control	Under some supervision and control
♦ the use of resources is tightly prescribed ♦ all candidates are within direct sight of the supervisor throughout the session(s) ♦ display materials that might provide assistance are removed or covered ♦ there is no access to e-mail, the internet or mobile phones ♦ candidates complete their work independently ♦ interaction with other candidates does not occur ♦ no assistance of any description is provided	♦ candidates do not need to be directly supervised at all times ♦ the use of resources, including the internet, is not tightly prescribed ♦ the work an individual candidate submits for assessment is their own ♦ teachers and lecturers can provide reasonable assistance

The assignment has two stages.

Stage	Level of control
♦ research	conducted under some supervision and control
♦ report	conducted under a high degree of supervision and control

Resources

Please refer to the instructions for teachers within the assignment assessment task.

In the research stage:

- teachers/lecturers must agree the choice of topic with the candidate
- teachers/lecturers must provide advice on the suitability of the candidate's aim
- teachers/lecturers can supply instructions for the experimental procedure
- candidates must undertake research using only websites, journals and/or books, to find secondary data/information
- a wide list of URLs and/or a wide range of books and journals may be provided

Teachers/lecturers **must not**:

- provide an aim
- provide candidates with a set of experimental data for the candidate's experiment
- provide candidates with a set of experimental data to compare with the candidate's own data
- provide a blank or pre-populated table for experimental results
- provide feedback to candidates on their research

The only materials that **can** be used in the report stage are:

- the instructions for candidates, which must not have been altered
- the candidate's raw experimental data
- comparative data/information
- a record of the source of the comparative data/information
- extract(s) from internet/literature source(s) to support the underlying chemistry
- the experimental method, if appropriate

Candidates **must not** have access to a previously prepared:

- draft of a report
- draft of a description of the underlying chemistry
- specimen calculation or set of calculations for mean or derived values
- graph
- comparison of data
- conclusion
- evaluation of an experimental procedure

In addition, candidates **must not** have access to the assignment marking instructions during the report stage.

Candidates **must not** have access to the internet during the report stage.

Reasonable assistance

Candidates must undertake the assessment independently. However, reasonable assistance may be provided prior to the formal assessment process taking place. The term ‘reasonable assistance’ is used to try to balance the need for support with the need to avoid giving too much assistance. If any candidates require more than what is deemed to be ‘reasonable assistance’, they may not be ready for assessment or it may be that they have been entered for the wrong level of qualification.

The assignment assessment task provides guidance on reasonable assistance.

Evidence to be gathered

The following candidate evidence is required for this assessment:

- a report

The report is submitted to SQA, within a given time frame, for marking.

The same report cannot be submitted for more than one subject.

Volume

There is no word count.

Grading

A candidate’s overall grade is determined by their performance across the course assessment. The course assessment is graded A–D on the basis of the total mark for all course assessment components.

Grade description for C

For the award of grade C, candidates will typically have demonstrated successful performance in relation to the skills, knowledge and understanding for the course.

Grade description for A

For the award of grade A, candidates will typically have demonstrated a consistently high level of performance in relation to the skills, knowledge and understanding for the course.

Equality and inclusion

This course is designed to be as fair and as accessible as possible with no unnecessary barriers to learning or assessment.

For guidance on assessment arrangements for disabled candidates and/or those with additional support needs, please follow the link to the assessment arrangements web page: www.sqa.org.uk/assessmentarrangements.

Further information

The following reference documents provide useful information and background.

- National 5 Chemistry subject page
- Assessment arrangements web page
- Building the Curriculum 3–5
- Design Principles for National Courses
- Guide to Assessment
- SCQF Framework and SCQF level descriptors
- SCQF Handbook
- SQA Skills Framework: Skills for Learning, Skills for Life and Skills for Work
- Coursework Authenticity: A Guide for Teachers and Lecturers
- Educational Research Reports
- SQA Guidelines on e-assessment for Schools
- SQA e-assessment web page

Appendix: course support notes

Introduction

These support notes are not mandatory. They provide advice and guidance to teachers and lecturers on approaches to delivering the course. They should be read in conjunction with this course specification, the specimen question paper and the assignment assessment task.

Developing skills, knowledge and understanding

This section provides further advice and guidance about skills, knowledge and understanding that could be included in the course. Teachers and lecturers should refer to this course specification for the skills, knowledge and understanding for the course assessment. Course planners have considerable flexibility to select coherent contexts which will stimulate and challenge their candidates, offering both breadth and depth.

When developing your chemistry course there should be opportunities for candidates to take responsibility for their learning. Learning and teaching should build on candidates' prior knowledge, skills and experiences.

Flexibility and differentiation of tasks should be built into the course to allow candidates of differing abilities to demonstrate achievement.

An investigative approach is encouraged in chemistry, with candidates actively involved in developing their skills, knowledge and understanding. A holistic approach should be adopted to encourage the simultaneous development of candidates' conceptual understanding and skills.

Where appropriate, investigative work/experiments in chemistry should allow candidates the opportunity to select activities and/or carry out extended study. Investigative and experimental work is part of the scientific method of working and can fulfil a number of educational purposes.

Learning and teaching should offer opportunities for candidates to work collaboratively. Practical activities and investigative work can offer opportunities for group work, which should be encouraged.

Group work approaches can be used to simulate real-life situations, share tasks and promote team working skills.

Laboratory work should include the use of technology and equipment to reflect current practices in chemistry. Appropriate risk assessment must be undertaken.

In addition to programmed learning time, candidates would be expected to contribute their own time.

Effective partnership working can enhance the learning experience. Where appropriate, locally-relevant contexts should be studied, with visits if possible. Guest speakers from industry, further and higher education could be invited to share their knowledge of particular aspects of chemistry.

Information and Communications Technology (ICT) makes a significant contribution to the chemistry course. In addition to the use of computers as a learning tool, computer animations and simulations can be used to develop the understanding of reactions and other processes. Computer interfacing equipment can detect changes in variables, allowing experimental results to be recorded and processed. This allows experimental results to be recorded over periods of time which are either too short or too long to be easily recorded by hand. Results can also be displayed in real-time which helps to improve understanding.

Assessment should be integral to, and improve, learning and teaching. The approach should involve candidates and provide supportive feedback. Self- and peer-assessment techniques should be encouraged wherever appropriate. Assessment information can be used to set learning targets and next steps.

Approaches to learning and teaching

Examples of possible learning and teaching activities can be found in the table below.
The content of the first column is identical to the ‘Skills, knowledge and understanding for the course assessment’ section in this course specification.

The second column offers suggestions for activities that could be used to enhance teaching and learning. All resources named were correct at the time of publication and may be subject to change.

1 Chemical changes and structure **Mandatory knowledge**	**Suggested activities**
(a) Rates of reaction	
To follow the progress of chemical reactions, changes in mass, volume and other quantities can be measured. Graphs can then be drawn and be interpreted in terms of: ♦ end-point of a reaction ♦ quantity of product ♦ quantity of reactant used ♦ effect of changing conditions	RSC LearnChemistry offers a range of experimental procedures that can be used to produce reaction progress graphs including: The rate of reaction of magnesium with hydrochloric acid, in which magnesium reacts with dilute hydrochloric acid in a conical flask which is connected to an inverted measuring cylinder in a trough of water. The volume of hydrogen gas produced is measured over a few minutes and the results are used to plot a graph. RSC LearnChemistry’s Rate of Reaction Graphs offers an assessment for learning activity in which candidates match pre-drawn graphs to different reaction conditions for the reaction between calcium carbonate and hydrochloric acid.

1 Chemical changes and structure (continued) **Mandatory knowledge**	**Suggested activities**
Rates of reaction can be increased: ♦ by increasing the temperature ♦ by increasing the concentration of a reactant ♦ by increasing surface area/decreasing particle size ♦ through the use of a catalyst	RSC LearnChemistry website offers a wide range of practical experiments to show the effect of changing reaction conditions. For example: In The effect of concentration and temperature on reaction rate, when two colourless solutions are mixed, a dark blue colour forms. Changing the concentration or temperature of the solutions changes the time required for the blue colour to develop. Rates and Rhubarb uses rhubarb sticks to decolourise potassium permanganate. The experiment can be used to show how the rate of reaction is affected by surface area or concentration. The Burning milk powder activity shows how a pile of dried milk powder will not ignite even using a roaring Bunsen burner. However, if the powder is sprinkled onto a flame, a spectacular fireball is produced (a video of the experiment is also available). In August 2000 one of the world's most advanced submarines, the Kursk, sank to the bottom of the sea with no survivors. It is believed that rusty ironwork acted as a catalyst for the decomposition of hydrogen peroxide. In LearnChemistry's What sank the Kursk?, instructions are provided for experiments to record reaction progress graphs using different transition metals as catalysts.

1 Chemical changes and structure (continued) **Mandatory knowledge**	**Suggested activities**
	In the simpler Hydrogen peroxide decomposition using different catalysts activity, measuring cylinders are set up containing a washing-up liquid, a catalyst and some hydrogen peroxide. The rate at which foam forms depends on the effectiveness of the catalyst (a video of the experiment is also available). Candidates can see the effect of a catalyst using experiments such as Catalysis of the reaction between zinc and sulfuric acid or in the demonstration experiment Catalysis of the reaction between sodium thiosulfate and hydrogen peroxide.
Catalysts are substances that speed up chemical reactions but can be recovered chemically unchanged at the end of the reaction.	The RSC LearnChemistry's Involvement of catalysts in reactions experiment provides visible evidence that, although a catalyst does actively participate in a reaction, it is regenerated at the end. In this reaction, a pink cobalt catalyst solution is used which changes to dark green while the catalyst is active and is seen to change back to pink once the reaction is over.
The average rate of a chemical reaction can be calculated, with appropriate units, using the equation: $rate = \frac{\Delta quantity}{\Delta t}$ The rate of a reaction can be shown to decrease over time by calculating the average rate at different stages of the reaction.	

<table>
<tr><th>1 Chemical changes and structure (continued)
Mandatory knowledge</th><th>Suggested activities</th></tr>
<tr><td colspan="2">(b) Atomic structure and bonding related to properties of materials</td></tr>
<tr><td><i>(i) Periodic Table and atoms</i>
Elements in the Periodic Table are arranged in order of increasing atomic number.
The Periodic Table can be used to determine whether an element is a metal or non-metal.
Groups are columns in the Periodic Table containing elements with the same number of outer electrons, indicated by the group number.
Elements within a group share the same valency and have similar chemical properties because they have the same number of electrons in their outer energy levels.
The electron arrangement of the first 20 elements can be written.</td><td>The RSC’s online Periodic Table is fully interactive. Filters can be used to update the table in a way that highlights:
♦ metallic or non-metallic elements
♦ individual groups
♦ individual periods
♦ the state of the elements at any temperature
Clicking on the video tab gives access to a bank of videos providing profiles of all 118 elements.
The RSC Periodic Table is also available as a free-of-charge app for both Android and iOS devices.
RSC LearnChemistry’s ‘Secondary Support Pack’ has been produced to support the use of Elements Top Trumps cards to help candidates become familiar with the arrangement of elements within the Periodic Table. These activities can help develop the skill of making predictions and generalisations.
RSC LearnChemistry’s Interactive Periodic Table game allows candidates to test their knowledge of the Periodic Table by exploring trends and patterns in elements and their position in the Table.</td></tr>
</table>

1 Chemical changes and structure (continued) **Mandatory knowledge**	**Suggested activities**
An atom has a nucleus, containing protons and neutrons, and electrons that orbit the nucleus. Protons have a charge of one-positive, neutrons are neutral and electrons have a charge of one-negative. Protons and neutrons have an approximate mass of one atomic mass unit and electrons, in comparison, have virtually no mass. The number of protons in an atom is given by the atomic number. In a neutral atom the number of electrons is equal to the number of protons. The mass number of an atom is equal to the number of protons added to the number of neutrons.	The LearnChemistry Build an atom simulation activity allows candidates to build an atom from scratch, using protons, neutrons, and electrons. Nuclide notation can be explored using the 'symbol' option. This allows candidates to explore the effect of changing the numbers of protons, neutrons and electrons. The 'game' option can be used to provide a revision activity. LearnChemistry offers a selection of short video clips covering a wide range of topics. In Royal Institution Christmas Lectures® 2012: Atomic Structure, Dr Peter Wothers explores the structure of an atom and reveals that it is the number of protons that defines an element.
Isotopes are defined as atoms with the same atomic number but different mass numbers, or as atoms with the same number of protons but different numbers of neutrons. Nuclide notation is used to show the atomic number, mass number (and charge) of atoms (ions) from which the number of protons, electrons and neutrons can be determined. Most elements have two or more isotopes. The average atomic mass has been calculated for each element using the mass and proportion of each isotope present. These values are known as relative atomic masses.	

1 Chemical changes and structure (continued) **Mandatory knowledge**	**Suggested activities**
(ii) Covalent bonding Covalent bonds form between non-metal atoms. A covalent bond forms when two positive nuclei are held together by their common attraction for a shared pair of electrons. Diagrams can be drawn to show how outer electrons are shared to form the covalent bond(s) in a molecule. 7 elements exist as diatomic molecules through the formation of covalent bonds: H_2, N_2, O_2, F_2, Cl_2, Br_2, I_2.	The formation of a covalent compound can be shown using activities from the RSC LearnChemistry website: Exploding bubbles of hydrogen and oxygen is a particularly fun way to show two non-metal elements reacting together (a video is also available). Chemistry exciting elements has an online video showing the reaction of hydrogen gas with fluorine, chlorine and bromine. The explosive reaction of hydrogen and chlorine is also shown in Fire and Flame: Part 4 (clips 43 and 44) and The Chemistry of Light: Part 3 (clip 26). Instructions on how to carry out the reaction between hydrogen and chlorine gases safely in a school or college lab is provided by SSERC (SSERC Bulletin 223, page 10, 2007).
The shape of simple covalent molecules depends on the number of bonds and the orientation of these bonds around the central atom. These molecules can be described as linear, angular, trigonal pyramidal or tetrahedral.	PhET at the University of Colorado have created Build a molecule, a simulation that lets candidates assemble molecules on screen and view their structures in 3D.
More than one bond can be formed between atoms leading to double and triple covalent bonds.	NBC Learn: Chemistry Now, available through RSC LearnChemistry, introduces the formation of double bonds, as a way of atoms acquiring a stable octet in the video Carbon, Captured: Carbon dioxide — The Chemistry of CO2: Carbon dioxide.
Covalent substances can form either discrete molecular or giant network structures.	

1 Chemical changes and structure (continued) **Mandatory knowledge**	**Suggested activities**
Covalent molecular substances: ♦ have strong covalent bonds within the molecules and only weak attractions between the molecules ♦ have low melting and boiling points as only weak forces of attraction between the molecules are broken when a substance changes state ♦ do not conduct electricity because they do not have charged particles which are free to move. Covalent molecular substances which are insoluble in water may dissolve in other solvents.	LearnChemistry's Which substances conduct electricity? experiment enables candidates to distinguish between electrolytes and non-electrolytes and to verify that covalent substances never conduct electricity even when liquefied, whereas ionic compounds conduct in the molten state.
Covalent network structures: ♦ have a network of strong covalent bonds within one giant structure ♦ have very high melting and boiling points because the network of strong covalent bonds is not easily broken ♦ do not dissolve	The Exhibition Chemistry: Red hot carbon resource from LearnChemistry has been created to show that graphite has an exceptionally high melting point, and is a good conductor of heat in an experiment that results in the dramatic destruction of a pencil (a video is also available).
In general, covalent network substances do not conduct electricity. This is because they do not have charged particles which are free to move.	The Royal Institution Christmas Lectures 2012®: Allotropes of Carbon video, available on LearnChemistry, discusses the properties of diamond and graphite and, by burning samples of both in liquid oxygen, provides proof that they are both forms of carbon.

1 Chemical changes and structure (continued) Mandatory knowledge	Suggested activities
(iii) Ionic compounds Ions are formed when atoms lose or gain electrons to obtain the stable electron arrangement of a noble gas. In general, metal atoms lose electrons forming positive ions and non-metal atoms gain electrons forming negative ions. Ion-electron equations can be written to show the formation of ions through loss or gain of electrons. Ionic bonds are the electrostatic attraction between positive and negative ions. Ionic compounds form lattice structures of oppositely charged ions with each positive ion surrounded by negative ions and each negative ion surrounded by positive ions. Ionic compounds have high melting and boiling points because strong ionic bonds must be broken in order to break up the lattice.	The formation of an ionic compound can be shown using experiments from the RSC LearnChemistry website that include: Reaction between aluminium and iodine, Reaction of zinc with iodine, Exhibition Chemistry: The reaction between aluminium and bromine, Reactions of chlorine, bromine and iodine with aluminium, Iron and sulfur reaction (a video is also available), Reacting elements with chlorine, Heating Group 1 metals in air and in chlorine (a video is also available), The combustion of iron wool and Halogen reactions with iron wool (a video is also available).
Many ionic compounds are soluble in water. As they dissolve the lattice structure breaks up allowing water molecules to surround the separated ions.	The PhET team at the University of Colorado have created Sugar and Salt Solutions, a simulation that lets candidates add sugar or salt to water and watch what happens at an atomic scale. They can also use a virtual conductivity tester to test the conductivity of the solutions.

1 Chemical changes and structure (continued) **Mandatory knowledge**	**Suggested activities**
Ionic compounds conduct electricity only when molten or in solution as the lattice structure breaks up allowing the ions to be free to move.	The LearnChemistry experiments Electrolysing molten lead(II) bromide and Electrolysis of molten zinc chloride (a video is also available) demonstrate that conduction is possible when ionic compounds are molten, and show the products of electrolysis. LearnChemistry's Microscale Chemistry — Using a microscale conductivity meter gives details of how to make a cheap and simple conductivity meter that can be used to test the conductivity of solids (eg metals) or solutions.
Conduction in ionic compounds can be explained by the movement of ions towards oppositely charged electrodes.	LearnChemistry offers descriptions of experiments that allow candidates to observe the movement of coloured ions. In The migration of ions: evidence for the ionic model a glass microscope slide is used to support a wet strip of filter paper on which a crystal of potassium manganate(VII) is placed. Applying a DC voltage across the filter paper causes a purple plume to move towards the positive terminal. It is relatively rare to be able to see the motion of both the positive and negative ions in the same experiment, but an example is given in Exhibition Chemistry: Migration of coloured ions by electrolysis.
(c) Formulae and reacting quantities	
(i) Chemical formulae Compound names are derived from the names of the elements from which they are formed. Most compounds with a name ending in '-ide' contain the two elements indicated. The ending '-ite' or '-ate' indicates that oxygen is also present.	

1 Chemical changes and structure (continued) **Mandatory knowledge**	**Suggested activities**
Chemical formulae can be written for two element compounds using valency rules and a Periodic Table. Roman numerals can be used, in the name of a compound, to indicate the valency of an element. The chemical formula can also be determined from names with prefixes. The chemical formula of a covalent molecular substance gives the number of each type of atom present in a molecule. The formula of a covalent network gives the simplest ratio of each type of atom in the substance. Ions containing more than one type of atom are often referred to as group ions. Chemical formulae can be written for compounds containing group ions using valency rules and the data booklet.	
Ionic formulae give the simplest ratio of each type of ion in the substance and can show the charges on each ion, if required. In formulae, charges must be superscript and numbers of atoms/ions must be subscript.	In LearnChemistry's Writing formulae for ionic compounds, ion formulae cards are used to help candidates check, consolidate and demonstrate their ability to write correct formulae for ionic compounds.

1 Chemical changes and structure (continued) **Mandatory knowledge**	**Suggested activities**
(ii) Calculations involving the mole and balanced equations Chemical equations, using formulae and state symbols, can be written and balanced.	LearnChemistry’s Eggsplosive Chemistry provides instructions and videos to carry out spectacular demonstrations to show that getting your reactants in the right proportions can be the difference between a bang and a fizzle. The PhET team at the University of Colorado have created Balancing Chemical Equations, a simulation that lets candidates learn how to tell if a chemical equation is balanced. It also allows them explore how to balance equations with an interactive game.
The mass of a mole of any substance, in grams (g), is equal to the gram formula mass and can be calculated using relative atomic masses.	
Calculations can be performed using the relationship between the mass and the number of moles of a substance.	
A solution is formed when a solute is dissolved in a solvent.	
For solutions, the mass of solute (grams or g), the number of moles of solute (moles or mol), the volume of solution (litres or l) or the concentration of the solution (moles per litre or mol l^{-1}) can be calculated from data provided.	The Molarity Simulation from PhET is an ideal way to introduce the idea of the measurement of concentrations, allowing you to vary the volume of solvent and the amount of solute used to form solutions. The Concentration Simulation available on RSC LearnChemistry allows even more variables to be explored.

1 Chemical changes and structure (continued) **Mandatory knowledge**	**Suggested activities**
Given a balanced equation, the mass or number of moles of a substance can be calculated given the mass or number of moles of another substance in the reaction. ***(iii) Percentage composition*** The percentage composition of an element in any compound can be calculated from the formula of the compound.	Using the balanced equation, candidates can calculate the mass of magnesium oxide formed when a known mass of magnesium burns. The change in mass when magnesium burns provides a method to allow candidates to carry out an experiment to confirm their calculated value. This resource extends the procedure into the calculation of an empirical formula. National 5 candidates do not need to be able to calculate empirical formula.
(d) Acids and bases	
(i) pH The pH scale is an indication of the hydrogen ion concentration and runs from below 0 to above 14.	LearnChemistry’s pH scale basics simulation can be used to explore the basics of pH. Candidates can add a variety of common solutions, modify the concentration and see the effects on pH.
A neutral solution has equal concentrations of $H^+(aq)$ and $OH^-(aq)$ ions. Water is neutral as it dissociates according to the equation $H_2O(\ell) \rightleftharpoons H^+(aq) + OH^-(aq)$ producing equal concentrations of hydrogen and hydroxide ions. At any time, only a few water molecules are dissociated into free ions. The $\rightleftharpoons$ symbol indicates that a reaction is reversible and occurs in both directions.	The pH scale advanced simulation, available from RSC LearnChemistry, provides a more sophisticated pH simulator to visualise and compare the numbers of H^+ and OH^- ions present in different solutions. Candidates can investigate the comparative conductivity of saline solution, tap water and distilled water. These measurements can be linked to ion concentration to develop an understanding of the dissociation of water molecules.

1 Chemical changes and structure (continued) Mandatory knowledge	Suggested activities
Acidic solutions have a higher concentration of $H^+(aq)$ ions than $OH^-(aq)$ and have a pH below 7. Alkaline solutions have a higher concentration of $OH^-(aq)$ ions than $H^+(aq)$ ions and have a pH above 7.	
Dilution of an acidic solution with water will decrease the concentration of $H^+(aq)$ and the pH will increase towards 7. Dilution of an alkaline solution with water will decrease the concentration of $OH^-(aq)$ and the pH will decrease towards 7.	The effect of dilution on the pH of acidic and alkaline solutions can be explored using the LearnChemistry activity The pH scale. It shows how a solution with a given pH number differs in concentration from the one with the next pH number by a factor of 10.
Soluble non-metal oxides dissolve in water forming acidic solutions.	Testing the pH of oxides from LearnChemistry offers an experiment which helps to establish the idea that the soluble oxides of metals are alkaline and the oxides of non-metals are acidic. If a supply of dry ice is available, the LearnChemistry activity Indicators and dry ice demonstration is very dramatic. Dry ice is added to pH indicator solutions. Bubbles and 'fog' are produced along with a gradual colour change. The experiment highlights that carbon dioxide dissolves to form an acidic solution.
Soluble metal oxides dissolve in water to form alkaline solutions: metal oxide + water → metal hydroxide	The video clip Free Range Chemistry: Part 3 (clip 27, 'Exploding Rock') available through LearnChemistry shows the violent reaction that occurs when water is added to calcium oxide. This is one of a series of clips produced by Peter Wothers of Cambridge University.

1 Chemical changes and structure (continued) **Mandatory knowledge**	**Suggested activities**
Metal oxides, metal hydroxides, metal carbonates and ammonia neutralise acids and are called bases. Those bases that dissolve in water form alkaline solutions.	
(ii) Neutralisation reactions A neutralisation reaction is one in which a base reacts with an acid to form water. A salt is also formed in this reaction.	In LearnChemistry's An effervescent Universal indicator rainbow experiment, sodium carbonate solution is added to a burette containing a little hydrochloric acid and Universal Indicator. The two solutions react, with effervescence, and the liquid in the burette shows a 'rainbow' of colours. A striking alternative that candidates can carry out for themselves is Neutralisation circles. Drops of dilute acid and alkali are placed a few centimetres apart on a sheet of filter paper and allowed to spread out until they meet. A few drops of Universal Indicator are then placed over the moist area of the filter paper and a band of colours showing the range of colours of the Universal Indicator is seen on the paper.
Equations can be written for the following neutralisation reactions: a metal oxide + an acid → a salt + water	In Reacting copper(II) oxide with sulfuric acid black, insoluble copper(II) oxide is reacted with sulfuric acid and the product solution evaporated to form blue copper(II) sulfate crystals.
a metal hydroxide + an acid → a salt + water a metal carbonate + an acid → a salt + water + carbon dioxide	A very simple example of the reaction of an acid and a carbonate not often carried out in chemistry classrooms is described in LearnChemistry's Outreach: bendy bones. Vinegar reacts with the calcium carbonate in chicken bones to release bubbles of carbon dioxide.

1 Chemical changes and structure (continued) **Mandatory knowledge**	**Suggested activities**
The name of the salt produced depends on the acid and base used. Hydrochloric acid produces chlorides, sulfuric acid produces sulfates and nitric acid produces nitrates. Spectator ions are ions that remain unchanged by the reaction. Reaction equations can be used to identify spectator ions. For neutralisation reactions, equations can be written omitting spectator ions: $2H^+(aq) + O^{2-}(s) \rightarrow H_2O(\ell)$ for metal oxides $H^+(aq) + OH^-(aq) \rightarrow H_2O(\ell)$ for metal hydroxides $2H^+(aq) + CO_3^{2-}(aq) \rightarrow H_2O(\ell) + CO_2(g)$ for aqueous metal carbonates $2H^+(aq) + CO_3^{2-}(s) \rightarrow H_2O(\ell) + CO_2(g)$ for insoluble metal carbonates	
In an acid-base titration, the concentration of the acid or base is determined by accurately measuring the volumes used in the neutralisation reaction. An indicator can be added to show the end-point of the reaction.	The interactive lab primer — titration from LearnChemistry is a suite of videos, simulations and animations created to show candidates how to use pipettes and burettes to carry out a titration. The titration animation provides, in a very clear and simple way, an overview of how a titration allows the concentration of a solution to be measured.

1 Chemical changes and structure (continued) **Mandatory knowledge**	**Suggested activities**
Given a balanced equation for the reaction occurring in any titration: ♦ the concentration of one reactant can be calculated given the concentration of the other reactant and the volumes of both solutions ♦ the volume of one reactant can be calculated given the volume of the other reactant and the concentrations of both solutions	LearnChemistry's Titration screen experiment is an interactive virtual lab resource. The activity has four levels. The first level is suitable as a resource to revise and consolidate understanding of the Acids and Bases topic at National 5 level. As this resource was created for world wide use, concentration is expressed in mol dm^{-3}. Before using this resource, it would be advisable to inform candidates that 1 dm^{3} is equivalent to 1 litre.
(iii) Neutralisation reactions can be used to prepare soluble salts Titration can be used to produce a soluble salt. Once the volumes of acid and alkali have been noted, the reaction can be repeated without the indicator to produce an uncontaminated salt solution. The solution can then be evaporated to dryness. Insoluble metal carbonates and insoluble metal oxides can be used to produce soluble salts. Excess base is added to the appropriate acid, the mixture is filtered and the filtrate evaporated to dryness.	In the Titrating sodium hydroxide with hydrochloric acid experiment from LearnChemistry, sodium hydroxide is titrated with hydrochloric acid and the product solution evaporated to produce sodium chloride crystals. LearnChemistry's Preparing salts by neutralisation of oxides and carbonates provides well-tried class experiments, which should take no more than thirty minutes to reach the point at which the product solution has been filtered.

2 Nature's chemistry **Mandatory knowledge**	**Suggested activities**
(a) Homologous series	
(i) Systematic carbon chemistry A homologous series is a family of compounds with the same general formula and similar chemical properties.	
Patterns are often seen in the physical properties of the members of a homologous series. The subsequent members of a homologous series show a general increase in their melting and boiling points. This pattern is attributed to increasing strength of the intermolecular forces as the molecular size increases. The type of intermolecular force does not need to be identified.	The SQA National 5 Databooklet lists the melting and boiling points of the smaller alkanes, alkenes and cycloalkanes. Whilst the boiling points of these compounds rise steadily, there are minor anomalies in the melting points of the smaller alkanes and alkenes. Candidates are not expected to comment on these anomalies and are only expected to appreciate the overall trend of increasing melting point with increasing molecular size.
Hydrocarbons are compounds containing only hydrogen and carbon atoms. Compounds containing only single carbon–carbon bonds are described as saturated. Compounds containing at least one carbon–carbon double bond are described as unsaturated. It is possible to distinguish an unsaturated compound from a saturated compound using bromine solution. Unsaturated compounds decolourise bromine solution quickly. The structure of any molecule can be drawn as a full or a shortened structural formula.	
Isomers: ♦ are compounds with the same molecular formula but different structural formulae ♦ may belong to different homologous series ♦ usually have different physical properties	The poster 'Types Of Isomerism In Organic Chemistry', available as part of the Organic chemistry infographics resource on RSC LearnChemistry, illustrates different types of structural isomers covered in the National 5 course using examples drawn from the alkane, alkene, and cycloalkane families.

2 Nature's chemistry (continued) **Mandatory knowledge**	**Suggested activities**
Given a structural formula for a compound, an isomer can be drawn. Isomers can be drawn for a given molecular formula. ***(ii) Alkanes*** Alkanes: ♦ are a homologous series of saturated hydrocarbons ♦ are commonly used as fuels ♦ are insoluble in water ♦ can be represented by the general formula C_nH_{2n+2} Straight-chain and branched alkanes can be systematically named from structural formulae, containing no more than 8 carbons in the longest chain. Molecular formulae can be written and structural formulae can be drawn, from the systematic names of straight-chain and branched alkanes, containing no more than 8 carbons in the longest chain. ***(iii) Cycloalkanes*** Cycloalkanes: ♦ are a homologous series of saturated, cyclic hydrocarbons ♦ are used as fuels and solvents ♦ are insoluble in water ♦ can be represented by the general formula C_nH_{2n} Cycloalkanes (C_3–C_8) can be systematically named from structural formulae. Branched cycloalkanes are not required. Molecular formulae can be written and structural formulae can be drawn, from the systematic names of un-branched cycloalkanes.	Twig — Oil Products: Hydrocarbons factpack, available through RSC LearnChemistry, provides a brief two-minute video with accompanying worksheets introducing alkanes and alkenes and their general formulae.

2 Nature's chemistry (continued) **Mandatory knowledge**	**Suggested activities**
(iv) Alkenes Alkenes: ♦ are a homologous series of unsaturated hydrocarbons ♦ are used to make polymers and alcohols ♦ are insoluble in water ♦ contain the C=C double bond functional group ♦ can be represented by the general formula C_nH_{2n} Straight-chain and branched alkenes can be systematically named indicating the position of the double bond from structural formulae containing no more than 8 carbon atoms in the longest chain. Molecular formulae can be written and structural formulae can be drawn, from the systematic names of straight-chain and branched alkenes, containing no more than 8 carbons in the longest chain. Chemical equations can be written for the addition reactions of alkenes, using molecular or structural formulae. Alkenes undergo addition reactions: ♦ with hydrogen forming alkanes, known as hydrogenation ♦ with halogens forming dihaloalkanes ♦ with water forming alcohols, known as hydration	In LearnChemistry's The hydration of alkenes activity, hex-1-ene is hydrated to produce hexan-2-ol.

2 Nature’s chemistry (continued) **Mandatory knowledge**	**Suggested activities**
(b) Everyday consumer products	
(i) Alcohols Alcohols are used as fuels as they are highly flammable and burn with very clean flames. Alcohols are often used as solvents.	The flammability of methylated spirits in camping stoves can be demonstrated whilst methanol can be discussed as a fuel in drag racing and speedway. LearnChemistry offer a range of spectacular experiments. In the classic whoosh bottle demonstration, a mixture of alcohol and air in a large polycarbonate bottle is ignited. The resulting rapid combustion reaction, often accompanied by a dramatic ‘whoosh’ sound and flames, demonstrates the large amount of chemical energy released in the combustion of alcohols. The ethanol rocket is a more recent variation on this theme and comes with instructional video. The flammability of alcohols is also demonstrated in The alcohol gun experiment or the Money to burn trick (a video is also available).
Methanol, ethanol and propanol are miscible with water, thereafter the solubility decreases as size increases.	
As alcohols increase in size, their melting and boiling points increase due to the increasing strength of the intermolecular forces. The type of intermolecular force does not need to be identified.	At this level candidates are only required to have an appreciation of the general trend that as molecular size increases the strength of the intermolecular forces tends to increase. The straight-chain alcohols show increasing boiling points with increasing chain length.

2 Nature's chemistry (continued) **Mandatory knowledge**	**Suggested activities**
	The melting points of methanol and ethanol are anomalously high but National 5 candidates are not expected to be aware of these anomalies.

Alcohol	*Melting point* (^{0}C)	*Boiling point* (^{0}C)
methanol	-97.5	65
ethanol	-114	78
propan-1-ol	-124	97
butan-1-ol	-88	118
pentan-1-ol	-78	138
hexan-1-ol	-47	158
heptan-1-ol	-33	176
octan-1-ol	-15	195
nonan-1-ol	-5	213
decan-1-ol	7	231
undecan-1-ol	16	245
dodecan-1-ol	24	260
tridecan-1-ol	32	274
tetradecan-1-ol	38	287
pentadecan-1-ol	44	300
hexadecan-1-ol	49	312
heptadecan-1-ol	54	324
octadecan-1-ol	58	335
nadecan-1-ol	62	345
1-eicosanol	65	356

Please note: candidates are only required to be able to name straight-chain alcohols containing no more than 8 carbon atoms.

2 Nature's chemistry (continued) **Mandatory knowledge**	**Suggested activities**
An alcohol is a molecule containing a hydroxyl functional group, ─OH group. Saturated, straight-chain alcohols can be represented by the general formula $C_nH_{2n+1}OH$. Straight-chain alcohols can be systematically named indicating the position of the hydroxyl group from structural formulae containing no more than 8 carbon atoms. Molecular formulae can be written and structural formulae can be drawn, from the systematic names of straight-chain alcohols, containing no more than 8 carbons.	
(ii) Carboxylic acids Carboxylic acids are used in the preparation of preservatives, soaps and medicines. Vinegar is a solution of ethanoic acid, with molecular formula CH_3COOH. Vinegar is used in household cleaning products as it is a non-toxic acid so can be used safely in household situations.	Vinegar offers candidates an introduction to carboxylic acids using a familiar example. To obtain a rough indication of the concentration of ethanoic acid in different vinegars, marble chips are attached to the inside of the lids of a number of 35 mm film cans. Vinegar is poured into the film cans until they are one-third full. The lids are placed onto the cans and the cans are inverted. The order in which the vinegar 'rockets' take off gives a rough indication of the concentration of ethanoic acid. The concentration of ethanoic acid in vinegars can be compared by measuring the volume of carbon dioxide liberated when excess solid carbonate is added to equal volumes of different vinegars.

2 Nature's chemistry (continued) Mandatory knowledge	Suggested activities
	To demonstrate both the acidic nature of ethanoic acid and its use as a food preservative, pickled eggs can be produced by placing boiled eggs (still in their shells) into jars containing vinegar. The acid will remove the shell to leave a pickled egg in vinegar. Pickles (food preserved in vinegar) can be stored for a long time because the low pH prevents the growth of harmful bacteria and fungi. The Neutralisation — 'curing acidity' experiment from LearnChemistry allows candidates to follow the pH and temperature changes when an acidic solution (vinegar) is gradually neutralised by the addition of slaked lime (calcium hydroxide) and limestone (calcium carbonate).
Methanoic, ethanoic, propanoic and butanoic acid are miscible in water, thereafter the solubility decreases as size increases.	
As carboxylic acids increase in size their melting and boiling points increase due to the increasing strength of the intermolecular forces. The type of intermolecular force does not need to be identified.	At this level candidates are only required to have an appreciation of the general trend that as molecular size increases, the strength of the intermolecular forces tends to increase. The straight-chain carboxylic acids show increasing boiling points with increasing chain length. Whilst there is a general trend to increasing melting point with increasing chain length, individual acids can lie above or below the trend line.

<table>
<tr><th>2 Nature’s chemistry (continued)
Mandatory knowledge</th><th>Suggested activities</th></tr>
<tr><td></td><td>Plotting a graph of the number of carbons against the boiling point allows development of graph drawing skills.
<table>
<tr><th><i>Acid</i></th><th><i>Melting point</i> (^{0}C)</th><th><i>Boiling point</i> (^{0}C)</th></tr>
<tr><td>methanoic</td><td>8</td><td>101</td></tr>
<tr><td>ethanoic</td><td>17</td><td>119</td></tr>
<tr><td>propanoic</td><td>-21</td><td>141</td></tr>
<tr><td>butanoic</td><td>-5</td><td>164</td></tr>
<tr><td>pentanoic</td><td>-34</td><td>186</td></tr>
<tr><td>hexanoic</td><td>-3</td><td>205</td></tr>
<tr><td>heptanoic</td><td>-7</td><td>222</td></tr>
<tr><td>octanoic</td><td>16</td><td>239</td></tr>
<tr><td>nonanoic</td><td>13</td><td>254</td></tr>
<tr><td>decanoic</td><td>31</td><td>269</td></tr>
<tr><td>undecanoic</td><td>29</td><td>280</td></tr>
<tr><td>dodecanoic</td><td>44</td><td>330</td></tr>
<tr><td>tridecanoic acid</td><td>45</td><td></td></tr>
<tr><td>tetradecanoic acid</td><td>54</td><td>326</td></tr>
<tr><td>pentadecanoic acid</td><td>52</td><td>356</td></tr>
<tr><td>hexadecanoic acid</td><td>62</td><td>390</td></tr>
<tr><td>heptadecanic acid</td><td>61</td><td>321</td></tr>
<tr><td>octadecanoic acid</td><td>69</td><td>dec. 350</td></tr>
<tr><td>nonadecanoic acid</td><td>69</td><td></td></tr>
<tr><td>eicosanoic acid</td><td>76</td><td>dec. 328</td></tr>
</table>
Please note: candidates are only required to be able to name straight-chain carboxylic acids containing no more than eight carbon atoms.</td></tr>
</table>

2 Nature's chemistry (continued) Mandatory knowledge	Suggested activities
Carboxylic acids can be identified by the carboxyl functional group, –COOH. Carboxylic acids can be represented by the general formula $C_nH_{2n+1}COOH$. Straight-chain carboxylic acids can be systematically named from structural formulae, containing no more than 8 carbons. Molecular formulae can be written and structural formulae drawn, from the systematic names of straight-chain carboxylic acids, containing no more than 8 carbons.	
Solutions of carboxylic acids have a pH less than 7 and like other acids, can react with metals, metal oxides, hydroxides and carbonates forming salts. Salts formed from straight-chain carboxylic acids, containing no more than 8 carbons, can be named.	The LearnChemistry activity The acidic reactions of ethanoic acid provides instructions for simple experiments to show that carboxylic acids take part in the same reactions as hydrochloric acid. Although this resource mentions strong and weak acids, no knowledge or understanding of the concept of strong/weak acids is required at National 5.
(c) Energy from fuels	
A reaction or process that releases heat energy is described as exothermic. A reaction or process that takes in heat energy is described as endothermic.	Exothermic or endothermic? from LearnChemistry is a useful class practical to introduce energy changes in chemical reactions. Candidates measure the temperature changes in four reactions, and classify the reactions as exothermic or endothermic. The experiments can also be used to revise different types of chemical reaction and, with some classes, chemical formulae and equations.

2 Nature's chemistry (continued) **Mandatory knowledge**	**Suggested activities**
In combustion, a substance reacts with oxygen releasing energy.	Royal Institution Christmas Lectures® 2012: The Composition of Air, available from RSC LearnChemistry, presents a couple of short videos on the composition of air. The video 'Altering the Composition of the Air' shows the effect of reducing the proportion of oxygen in the air on combustion. LearnChemistry's It's a Gas: Part 1 is a series of video experiments showing the role of oxygen in supporting combustion. Clip 11, 'Oxygen and Food' shows that energy is released from food when it combines with oxygen.
Hydrocarbons and alcohols burn in a plentiful supply of oxygen to produce carbon dioxide and water. Equations can be written for the complete combustion of hydrocarbons and alcohols.	Identifying the products of combustion, from LearnChemistry, describes a procedure to collect and test the products of combustion for a solid hydrocarbon. A simpler version, that does not require the use of a pump, is given in Classic Chemistry Experiments — Combustion.
Fuels burn releasing different quantities of energy.	LearnChemistry offer several experiments to measure the release of heat. Heat energy from alcohols is an experiment comparing the amounts of heat energy produced by burning various alcohols. In Search of Solutions: Which fuel is better? is set in a camping expedition scenario and compares several types of solid fuels.

2 Nature's chemistry (continued) **Mandatory knowledge**	**Suggested activities**
The quantity of heat energy released can be determined experimentally and calculated using, $E_h = cm\Delta T$. The quantities E_h, c, m or ΔT can be calculated, in the correct units, given relevant data. Calculations can involve heating substances other than water. It is not necessary to calculate the enthalpy per mole of substance burned.	LearnChemistry offers Heat of combustion of alcohols simulation, a virtual experiment in which candidates can investigate the factors that determine the heat produced when alcohols burn. Variables that can be adjusted include: type of alcohol, mass of water and time of heating.

3 Chemistry in society **Mandatory knowledge**	**Suggested activities**
(a) Metals	
(i) Metallic bonding Metallic bonding is the electrostatic force of attraction between positively charged ions and delocalised electrons. Metallic elements are conductors of electricity because they contain delocalised electrons. ***(ii) Reactions of metals*** Equations, involving formulae, can be written to show the reaction of metals with oxygen, water, and dilute acids: metal + oxygen → metal oxide	The combustion of iron wool from LearnChemistry is a simple but dramatic experiment showing the increase in mass occurring when metals burn. Iron wool is ignited on a simple 'see-saw' balance in a demonstration that takes no more than five minutes. An ideal accompaniment to this activity is video clip 19 'Iron Wool and Oxygen' from Free Range Chemistry: Part 2. Using the balanced equation, candidates can calculate the mass of magnesium oxide formed when a known mass of magnesium burns. The LearnChemistry resource The change in mass when magnesium burns provides a method to allow candidates to carry out an experiment to confirm their calculated value. This resource extends the procedure into the calculation of an empirical formula. National 5 candidates do not need to be able to calculate empirical formula.

3 Chemistry in society (continued) Mandatory knowledge	Suggested activities
metal + water → metal hydroxide + hydrogen	For teachers and lecturers who may not have recently carried out experiments showing the reactivity of alkali metals, LearnChemisty's Alkali metals is a combined video and text CPD resource showing how to demonstrate safely the reactions of Group 1 elements with water.
metal + dilute acid → salt + hydrogen	LearnChemistry's Metals and acids experiment offers detailed instructions for two well-tried class experiments. The first shows that hydrogen is given off as metals react with an acid. In the second, the salt formed is recovered by crystallisation. A worksheet is provided. Magnesium and Hydrochloric Acid, available from the University of Oregon, shows that hydrogen is produced when magnesium reacts with hydrochloric acid.
Metals can be arranged in order of reactivity by comparing the rates at which they react.	The activity Exothermic metal-acid reactions from LearnChemistry offers a less familiar method of establishing the reactivity series. Candidates add powdered or finely-divided metals to hydrochloric acid and measure the temperature changes. The experiment reinforces ideas about energy changes during reactions, the reactivity series of the metals, and the chemical behaviour of acids. Because of the stability of its surface coating of aluminium oxide, aluminium can appear an unreactive metal. Exhibition Chemistry: Dancing flames from LearnChemistry describes an experiment to show the true reactivity of aluminium. In this demonstration eerie green flames are seen to dance over the reaction mixture (a video is also available).

3 Chemistry in society (continued) **Mandatory knowledge**	**Suggested activities**
Metals can be used to produce soluble salts. Excess metal is added to the appropriate acid, the mixture is filtered and the filtrate evaporated to dryness. ***(iii) Redox*** Reduction is a gain of electrons by a reactant in any reaction. Oxidation is a loss of electrons by a reactant in any reaction. In a redox reaction, reduction and oxidation take place at the same time.	
Ion-electron equations can be written for reduction and oxidation reactions. Ion-electron equations can be combined to produce redox equations. ***(iv) Extraction of metals*** During the extraction of metals, metal ions are reduced forming metal atoms. The method used to extract a metal from its ore depends on the position of the metal in the reactivity series. Equations can be written to show the extraction of metals.	Candidates should be familiar with page 10 of the SQA Databooklet showing the electrochemical series and can practise using this resource to identify oxidation and reduction reactions.
Methods used are: ♦ heat alone (for extraction of Ag, Au and Hg)	In Decomposition of Silver Oxide, available from the University of Oregon, black silver oxide is heated in a test tube to give metallic silver and oxygen gas. The gas is captured in a balloon.

3 Chemistry in society (continued) Mandatory knowledge	Suggested activities
♦ heating with carbon or carbon monoxide (for extraction of Cu, Pb, Sn, Fe and Zn)	LearnChemistry offer a wide range of activities demonstrating the extraction of a metal from its ore using carbon or carbon monoxide. Exhibition Chemistry: The extraction of iron describes a very simple experiment where iron is extracted from its ores using the charcoal formed on the tip of a used match. A variation of this experiment is given in Extraction of iron on a match head in which candidates first dip the head of an unused match in sodium carbonate powder and iron(III) oxide. When the head of the match burns it flares, resulting in the formation of iron. National 5 candidates are not required to know the details of the industrial production of iron. However, should you wish, a video showing a blast furnace in action is available as part of the resource Alchemy: Iron and Steel. Extracting metals with charcoal provides detailed instructions for the reduction of lead and copper oxides in the laboratory. Video clip 10, ‘Copper from Malachite’ from Free Range Chemistry: Part 1, shows Peter Wothers demonstrating the extraction of copper from its ore malachite by heating with carbon.
♦ electrolysis (for extraction of more reactive metals including aluminium)	The industrial production of aluminium is shown in a video included in LearnChemistry’s resource pack Alchemy: Aluminium extraction.

3 Chemistry in society (continued) **Mandatory knowledge**	**Suggested activities**
Electrolysis is the decomposition of an ionic compound into its elements using electricity. A d.c. supply must be used if the products of electrolysis are to be identified. Positive ions gain electrons at the negative electrode and negative ions lose electrons at the positive electrode.	LearnChemistry offer a number of activities to allow candidates to explore electrolysis. Electrolysing molten lead(II) bromide demonstrates that conduction is only possible where lead(II) bromide is molten, and that metallic lead and bromine are the products of electrolysis. Electrolysis of molten zinc chloride offers a safer alternative to lead bromide for demonstrating the electrolysis of molten salts (a video is also available)
(v) Electrochemical cells Electrically conducting solutions containing ions are known as electrolytes. A simple cell can be made by placing two metals in an electrolyte.	Instructions for assembling a very simple cell in which two metals are placed into salt solution are given in LearnChemistry's Electricity from chemicals. An unusual experiment in The Solar Spark: Hand Battery demonstrates that the sweat present on human skin can be used as the electrolyte in a simple cell. When candidates place one hand on an aluminium plate and the other on a copper plate, a multimeter connected between the plates shows a voltage being created.
Another type of cell can be made using two half-cells (metals in solutions of their own ions). An 'ion bridge' (salt bridge) can be used to link the half-cells. Ions can move across the bridge to complete an electrical circuit.	The University of Oregon provides instructions for the activity, Standard Zinc/Copper Cell. A zinc strip in $1{\cdot}0$ mol l^{-1} $ZnSO_4$ solution and a copper strip in $1{\cdot}0$ mol l^{-1} $CuSO_4$ solution are connected using a salt bridge.

3 Chemistry in society (continued) **Mandatory knowledge**	**Suggested activities**
Electricity can be produced in cells where at least one of the half-cells does not involve metal atoms/ions. A graphite rod can be used as the electrode in such half-cells. Different pairs of metals produce different voltages. These voltages can be used to arrange the elements into an electrochemical series. The further apart elements are in the electrochemical series, the greater the voltage produced when they are used to make an electrochemical cell. Electrons flow in the external circuit from the species higher in the electrochemical series to the one lower in the electrochemical series. For an electrochemical cell, including those involving non-metals, ion-electron equations can be written for: ♦ the oxidation reaction ♦ the reduction reaction ♦ the overall redox reactions The direction of electron flow can be deduced for electrochemical cells including those involving non-metal electrodes.	
(b) Plastics	
(i) Addition polymerisation Plastics are examples of materials known as polymers.	LearnChemistry's Twig — Oil Products: Plastics and polymers provides a short introductory video on polymers/plastics.

3 Chemistry in society (continued) **Mandatory knowledge**	**Suggested activities**
Polymers are long chain molecules formed by joining together a large number of small molecules called monomers. Addition polymerisation is the name given to a chemical reaction in which unsaturated monomers are joined, forming a polymer. The names of addition polymers are derived from the name of the monomer used. Note: brackets can be used in polymer names to aid identification of the monomer unit. ***(ii) Representation of the structure of monomers and polymers*** A repeating unit is the shortest section of polymer chain which, if repeated, would yield the complete polymer chain (except for the end-groups). The structure of a polymer can be drawn given either the structure of the monomer or the repeating unit. From the structure of a polymer, the monomer or repeating unit can be drawn.	Twig — Oil Products: Plastics and polymers offers a handout sheet showing the addition polymerisation of ethene. Twig — Oil Products: Plastics and polymers also provides an information sheet showing common polymers and their monomers.
(c) Fertilisers	
(i) Commercial production of fertilisers Growing plants require nutrients, including compounds containing nitrogen, phosphorous or potassium.	The activity ‘Effect of nutrient solutions on plant growth (soil culture)’, part of LearnChemistry’s Plant science practicals — Challenging Plants uses quick growing seeds to demonstrate the effect of nutrient deficiencies on plants.

3 Chemistry in society (continued) **Mandatory knowledge**	**Suggested activities**
Fertilisers are substances which restore elements, essential for healthy plant growth, to the soil.	Challenging Plants: Fertilisers available from LearnChemistry, provides information sheets on ‘Nutrients and fertilisers’ and ‘Fertilisers providing primary and secondary nutrients’.
Ammonia and nitric acid are important compounds used to produce soluble, nitrogen-containing salts that can be used as fertilisers.	
Ammonia is a pungent, clear, colourless gas which dissolves in water to produce an alkaline solution.	LearnChemistry provides details on experiments to introduce the properties of ammonia. In Making and testing ammonia candidates make ammonia, investigate its solubility in water and its alkaline nature. The experiment provides a useful precursor to the ammonia fountain experiment. The classic Ammonia fountain experiment illustrates the very high solubility of ammonia in water (a video is also available).
Ammonia solutions react with acids to form soluble salts. ammonia solution + an acid → an ammonium salt + water ***(ii) Haber and Ostwald processes*** The Haber process is used to produce the ammonia required for fertiliser production. $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$	Preparing a soluble salt by neutralisation from LearnChemistry, gives practical details for the production of ammonium sulfate crystals from ammonia solution and sulfuric acid.

3 Chemistry in society (continued) **Mandatory knowledge**	**Suggested activities**
At low temperatures the forward reaction is too slow to be economical. If the temperature is increased, the rate of reaction increases but, as the temperature increases, the backward reaction becomes more dominant. An iron catalyst is used to increase reaction rate. Ammonia is the starting material for the commercial production of nitric acid. The Ostwald process uses ammonia, oxygen and water to produce nitric acid. A platinum catalyst is used in this process.	
(d) Nuclear chemistry	
(i) Radiation Radioactive decay involves changes in the nuclei of atoms. Unstable nuclei (radioisotopes) can become more stable nuclei by giving out alpha, beta or gamma radiation.	LearnChemistry's The Royal Institution Christmas Lectures®: Radioactivity video clip, 'Radioactivity video' offers a simple introduction to radioactivity.
Alpha particles (α) consist of two protons and two neutrons and carry a double positive charge. They have a range of only a few centimetres in air and are stopped by a piece of paper. Alpha particles will be attracted towards a negatively charged plate.	PhET at the University of Colorado have created Alpha Decay which explores half-life through the decay of polonium.
Beta particles (β) are electrons ejected from the nucleus of an atom. They are able to travel over a metre in air but can be stopped by a thin sheet of aluminium. Beta particles will be attracted towards a positively charged plate.	Beta Decay, also from PhET at the University of Colorado, shows beta decay occurring for a collection of nuclei or for an individual nucleus.
Gamma rays (γ) are electromagnetic waves emitted from within the nucleus of an atom. They are able to travel great distances in air. They can be stopped by barriers made of materials such as lead or concrete. Gamma rays are not deflected by an electric field.	

3 Chemistry in society (continued) **Mandatory knowledge**	**Suggested activities**
(ii) Nuclear equations Balanced nuclear equations can be written using nuclide notation. In nuclear equations: ♦ an alpha particle can be represented as $^{4}_{2}\mathrm{He}$ ♦ a beta particle can be represented as $^{0}_{-1}\mathrm{e}$ ♦ a proton can be represented as $^{1}_{1}\mathrm{p}$ ♦ a neutron can be represented as $^{1}_{0}\mathrm{n}$ In the course of any nuclear reaction: ♦ The sum of the atomic numbers on the left of the reaction arrow is equal to the sum of the atomic numbers on the right of the reaction arrow. ♦ The sum of the mass numbers on the left of the reaction arrow is equal to the sum of the mass numbers on the right of the reaction arrow. Candidates do not need to show electrical charges when writing balanced equations representing nuclear reactions.	
(iii) Half-life Half-life is the time for half of the nuclei of a particular isotope to decay.	

3 Chemistry in society (continued) Mandatory knowledge	Suggested activities
The half-life of an isotope is a constant, unaffected by chemical or physical conditions. Radioactive isotopes can be used to date materials. The half-life of an isotope can be determined from a graph showing a decay curve. Calculations can be performed using the link between the number of half-lives, time and the proportion of a radioisotope remaining. ***(iv) Use of radioactive isotopes*** Radioisotopes have a range of uses in medicine and in industry. Candidates do not need to be able to name the isotope used in a particular application. Given information on the type of radiation emitted and/or half-lives, the suitability of an isotope for a particular application can be evaluated.	The Radioactive Dating Game from PhET at the University of Colorado matches the percentage of the dating element that remains to the age of an object.

3 Chemistry in society (continued) **Mandatory knowledge**	**Suggested activities**
(e) Chemical analysis	
(i) Common chemical apparatus Candidates must be familiar with the use(s) of the following types of apparatus: ♦ conical flask ♦ beaker ♦ measuring cylinder ♦ delivery tube ♦ dropper ♦ test tubes/boiling tubes ♦ funnel ♦ filter paper ♦ evaporating basin ♦ pipette with safety filler ♦ burette ♦ thermometer	

3 Chemistry in society (continued) **Mandatory knowledge**	**Suggested activities**
(ii) General practical techniques Candidates must be familiar with the following practical techniques:	
♦ simple filtration using filter paper and a funnel to separate the residue from the filtrate	It is often necessary to obtain pure solid chemicals from impure samples. LearnChemistry's Purifying an impure solid involves the purification of alum. This experiment allows large crystals of alum to be formed.
♦ use of a balance	The interactive lab primer — weighing compounds using a balance, available through LearnChemistry, is a collection of videos and online simulation that allows candidates to become familiar with the correct use of chemical balances.
♦ methods for the collection of gases including: — collection over water (for relatively insoluble gases) — downward displacement of air (for soluble gases that are less dense than air) — upward displacement of air (for soluble gases that are more dense than air)	LearnChemistry's Generating, collecting and testing gases demonstrates the collection of gases by the three named methods.

3 Chemistry in society (continued) Mandatory knowledge	Suggested activities
♦ methods of heating using Bunsen burners and electric hotplates	The interactive lab primer — heating, from LearnChemistry, provides animations showing key points in the correct operation of Bunsen burners and hotplates. The safe heating of a solution can be practised using LearnChemistry's Recovering water from copper(II) sulfate solution. A copper(II) sulfate solution is evaporated and the water condensed using simple apparatus.
♦ preparation of soluble salts by the reaction of acids with metals, metal oxides, metal hydroxides and metal carbonates	LearnChemistry offers a number of experiments in which soluble salts are prepared. Reacting copper(II) oxide with sulfuric acid describes the preparation of copper(II) sulfate crystals from copper(II) carbonate and sulfuric acid. Preparing salts by neutralisation of oxides and carbonates describes the preparation of copper(II) sulfate crystals from copper(II) oxide and the preparation of magnesium sulfate crystals from magnesium carbonate.

3 Chemistry in society (continued) **Mandatory knowledge**	**Suggested activities**
♦ preparation of insoluble salts by precipitation	LearnChemistry offers a number of experiments in which insoluble salts are prepared. Making magnesium carbonate: the formation of an insoluble salt in water describes the precipitation of magnesium carbonate from magnesium sulfate and sodium carbonate. In Silver and lead halides, insoluble silver and lead halides form as precipitates when solutions of silver or lead salts are added to solutions containing halide ions. The University of Oregon's Precipitation of Lead Iodide describes an unusual way of demonstrating precipitation reactions. When a few crystals of lead nitrate and potassium iodide are added to opposite sides of a dish containing water, a line of bright yellow lead iodide forms down the middle of the dish.
♦ testing the electrical conductivity of solids and solutions	LearnChemistry offers a number of experiments to test the electrical conductivity of solids and solutions. The experiment Which substances conduct electricity? enables candidates to distinguish between non-conducting covalent substances and ionic compounds that conduct when molten or in solution (a worksheet is also provided). Electrolysis of molten zinc chloride: this demonstration shows that an ionic substance will conduct electricity when molten but not when solid (a video is also available).

3 Chemistry in society (continued) **Mandatory knowledge**	**Suggested activities**
♦ setting up an electrochemical cell using a salt bridge and either metal or carbon electrodes	
♦ electrolysis of solutions using a d.c. supply	LearnChemistry offer a number of activities exploring electrolysis. Electrolysing molten lead(II) bromide demonstrates that conduction is only possible where lead(II) bromide is molten, and that metallic lead and bromine are the products of electrolysis. Electrolysis of molten zinc chloride offers a safer alternative to lead bromide for demonstrating the electrolysis of molten salts (a video is also available). Electrolysis of copper(II) sulfate solution uses graphite rods to carry out the electrolysis of dilute copper(II) sulfate solution.
♦ determination of E_h	LearnChemistry's Heat energy from alcohols is an experiment comparing the amounts of heat energy produced by burning various alcohols.

3 Chemistry in society (continued) Mandatory knowledge	Suggested activities
(iii) Analytical methods Titration is used to determine, accurately, the volumes of solution required to reach the end-point of a chemical reaction. An indicator is normally used to show when the end-point is reached. Titre volumes within 0·2 cm^3 are considered concordant.	LearnChemistry offer a number of titration activities. The interactive lab primer — titration is a suite of videos, simulations and animations that show candidates how to use pipettes and burettes to carry out a titration. The titration animation provides a clear overview of how a titration allows the concentration of a solution to be measured. Titrations quizzes: new users guide to our practical skills quizzes is a collection of videos including another titration experiment. The 'Colours of pH indicators' infographic from Colourful chemistry infographics illustrates the range of indicators available. The Titration screen experiment is an interactive virtual lab resource. The activity has four levels. The first level is suitable as a resource to revise and consolidate understanding of the 'Acids and Bases' topic (see section 1 (d)(ii) in this table). As this resource was created for world wide use, concentration is expressed in mol dm^{-3}. Before using this resource, it would be advisable to inform candidates that 1 dm^3 is equivalent to 1 litre.
Solutions of accurately known concentration are known as standard solutions.	The Molarity Simulation from PhET is an ideal way to introduce the idea of the measurement of concentrations allowing you to vary the volume of solvent and the amount of solute used to form solutions.

3 Chemistry in society (continued) **Mandatory knowledge**	**Suggested activities**
Flame tests can identify metals present in a sample.	LearnChemistry offer a number of activities related to flame testing. Assessment for Learning Chemistry: What's in a firework? uses party poppers and sparklers to set the scene for flame testing of the metallic compounds that give fireworks their colour. Flame colours — a demonstration gives straightforward instructions for a teacher demonstration of flame colours. Flame tests (the wooden splint method) gives instructions for a simple method for candidates to use. Royal Institution Christmas Lectures® 2012: group 1 flame tests is a library of short videos showing the flame colours for different ions.
Simple tests can be used to identify oxygen, hydrogen and carbon dioxide gases.	
Precipitation is the reaction of two solutions to form an insoluble salt called a precipitate. Information on the solubility of compounds can be used to predict when a precipitate will form. The formation of a precipitate can be used to identify the presence of a particular ion.	Assessment for Learning Chemistry: what happens when substances dissolve? What happens when a precipitate forms? This is a simple experimental comparison and discussion to consider the key questions ‘what happens when a substance dissolves?’ and ‘what happens when a precipitate forms?’ In Making magnesium carbonate: the formation of an insoluble salt in water a sample of magnesium carbonate is made by mixing solutions of magnesium sulfate and sodium carbonate.

3 Chemistry in society (continued) **Mandatory knowledge**	**Suggested activities**
(iv) Reporting experimental work Labelled, sectional diagrams can be drawn for common chemical apparatus. Data can be presented in tabular form with appropriate headings and units of measurement. Data can be presented as a bar, line or scatter graph with suitable scale(s) and labels. A line of best fit (straight or curved) can be used to represent the trend observed in experimental data. Average (mean) values can be calculated from data. Given a description of an experimental procedure and/or experimental results, an improvement to the experimental method can be suggested and justified.	

Preparing for course assessment

Each course has additional time which may be used at the discretion of teachers and lecturers to enable candidates to prepare for course assessment. This time may be used at various points throughout the course for consolidation and support. It may also be used towards the end of the course, for further integration, revision and preparation.

The question paper assesses a selection of knowledge and skills acquired in the course. It also provides opportunities to apply skills in a range of contexts, some of which may be unfamiliar.

During delivery of the course, opportunities should be found:

- for identification of particular aspects of work requiring reinforcement and support
- to develop skills of scientific inquiry in preparation for the assignment
- to practise responding to multiple-choice, short-answer, extended-answer, and open-ended questions
- to improve exam technique

Developing skills for learning, skills for life and skills for work

Course planners should identify opportunities throughout the course for candidates to develop skills for learning, skills for life and skills for work.

Candidates should be aware of the skills they are developing and teachers and lecturers can provide advice on opportunities to practise and improve them.

SQA does not formally assess skills for learning, skills for life and skills for work.

There may also be opportunities to develop additional skills depending on approaches being used to deliver the course in each centre. This is for individual teachers and lecturers to manage.

Candidates are expected to develop broad, generic skills as an integral part of their learning experience. This course specification lists the skills for learning, skills for life and skills for work that candidates should develop through this course. These are based on SQA's Skills Framework: Skills for Learning, Skills for Life and Skills for work and must be built into the course where there are appropriate opportunities. The level of these skills will be appropriate to the level of the course.

For this course, it is expected that the following skills for learning, skills for life and skills for work will be developed.

Numeracy
This is the ability to use numbers in order to solve problems by counting, doing calculations, measuring, and understanding graphs and charts. This is also the ability to understand the

results. Candidates will have opportunities to extract, process and interpret information presented in various formats including tabular and graphical. Experimental work will provide opportunities to develop time and measurement skills.

2.1 Number processes

Number processes means solving problems arising in everyday life through carrying out calculations, when dealing with data and results from experiments and everyday class work, making informed decisions based on the results of these calculations and understanding these results.

2.2 Money, time and measurement

This means using and understanding time and measurement to solve problems and handle data in a variety of chemistry contexts, including experiments.

2.3 Information handling

Information handling means being able to interpret chemical data in tables, charts and other graphical displays to draw sensible conclusions throughout the course. It involves interpreting the data and considering its reliability in making reasoned deductions and informed decisions. It also involves an awareness and understanding of the chance of events happening.

Thinking skills

This is the ability to develop the cognitive skills of remembering and identifying, understanding and applying. The course will allow candidates to develop skills of applying, analysing and evaluating. Candidates can analyse and evaluate experiments and data by reviewing the process, identifying issues and forming valid conclusions. They can demonstrate understanding and application of concepts and explain and interpret information and data.

5.3 Applying

Applying is the ability to use existing information to solve problems in different chemistry contexts, and to plan, organise and complete a task such as an investigation.

5.4 Analysing and evaluating

Analysis is the ability to solve problems in chemistry and make decisions that are based on available information. It may involve the review and evaluation of relevant information and/or prior knowledge to provide an explanation.

In addition, candidates will have opportunities to develop literacy skills, working with others, creating and citizenship.

Literacy

Candidates will develop the skills to communicate key chemical concepts effectively. They will have opportunities to communicate knowledge and understanding as well as develop listening and reading skills when gathering and processing information.

Working with others

Throughout the course, learning activities provide many opportunities for candidates to work with others. Practical activities and investigations offer opportunities for group work, which is an important aspect of chemistry and should be encouraged.

Creating

Through learning in chemistry, candidates can demonstrate their creativity. In particular, candidates have the opportunity to be innovative when planning and designing experiments.

Citizenship

Candidates will develop citizenship skills when considering the application of chemistry on our lives. Citizenship includes having concern for the environment and for the safety of others. This course has an extensive range of suggested practical activities which provide opportunities for candidates to work safely with others. Awareness of health and safety issues and safe working practices are key considerations. Candidates will develop an awareness of their rights and responsibilities, and learn to act responsibly.

Administrative information

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History of changes to course specification

Version	Description of change	Date
1.1	Formula corrected in chemistry in society table, Haber and Ostwald processes section.	April 2017
2.0	Course support notes added as appendix	September 2017
3.0	'Course assessment structure: assignment' section: minor amendments to pages 21–26 to clarify the research and report stages.	October 2018

Note: you are advised to check SQA's website to ensure you are using the most up-to-date version of the course specification.