OCR
RECOGNISING ACHIEVEMENT

GCSE

Chemistry B

Gateway Science Suite

OCR GCSE in Chemistry B J264

Second Draft Version August 2010

Revised Specification Content

This document comprises the 2nd Draft of the content section (section 3) of GCSE Chemistry B Specification J264. This document is still subject to accreditation by Ofqual, and may change as a result of final proof reading.

The 2nd Draft is provided to assist teachers who are intending to start teaching the new specification from September 2010, before the accreditation process is complete. Changes from the 1st Draft (April 2010) are highlighted in yellow.

The full specification and specimen assessment materials will be published after accreditation.

3 Content of GCSE Chemistry B

3.1 Summary of content

The specification content is presented as six modules which are listed below. Within each module the content is shown as eight items (eg C1a, C1b, C1c, C1d, C1e, C1f, C1g, C1h). Thus, the specification content contains a total of 48 teaching items. Each item requires approximately 2½ hours teaching time.

Module C1: Carbon Chemistry	Module C2: Chemical Resources	Module C3: Chemical Economics
a Making crude oil useful	a The structure of the Earth	a Rate of Reaction (1)
b Using carbon fuels	b Construction materials	b Rate of Reaction (2)
c Clean air	c Metals and Alloys	c Rate of Reaction (3)
d Making polymers	d Making cars	d Reacting Masses
e Designer polymers	e Chemicals from the Air – making ammonia	e Percentage yield and atom economy
f Cooking and food additives	f Acids and Bases	f Energy
g Smells	g Fertilisers and crop yield	g Batch or continuous?
h Paints and pigments	h Chemicals from the Sea: The Chemistry of Sodium Chloride	h Allotropes of carbon and Nanochemistry
Module C4: The Periodic Table	**Module C5: How Much (Quantitative Analysis)**	**Module C6: Chemistry Out There**
a Atomic structure	a Moles and Molar mass	a Electrolysis
b Ionic bonding	b Percentage composition and empirical formula	b Energy Transfer – Fuel cells
c The Periodic Table and covalent bonding	c Quantitative analysis	c Redox reactions
d The Group 1 Elements	d Titrations	d Alocohols
e The Group 7 elements	e Gas Volumes	e Depletion of the ozone layer
f Transition Elements	f Equilibria	f Hardness of water
g Metal structure and properties	g Strong and Weak Acids	g Natural fats and oils
h Purifying and tesitng water	h Ionic Equations and Precipitation	h Detergents

3.2 Layout of teaching items

The detailed specification content is displayed in tabular format, designed to provide a 'teacher-friendly' approach to the content. This allows teachers to see, at a glance, links between the development of skills and understanding of how science works, and the knowledge and understanding of different science ideas and contexts. The layout of each module follows the outline given below.

Module code and title (eg Understanding ourselves)	
Item code and title: eg B1a: Fitness and Health **Summary:** A short overview of the item, including the skills, knowledge and understanding of how science works that may be covered within this item.	
Suggested activities and experiences to select from	**Assessable learning outcomes Foundation Tier only: low demand**
Ideas for teaching activities related to the item, which will integrate the skills, knowledge and understanding of how science works into a teaching scheme. Teachers may choose from these suggestions or develop other comparable activities.	Learning outcomes that will only be assessed in the Foundation Tier paper. The use of bullet points provides guidance on: • depth • context • exemplification

Module code and title	
Links to other modules: opportunities for linking ideas across modules within the Gateway suite of sciences.	
Assessable learning outcomes both tiers: standard demand	**Assessable learning outcomes Higher Tier only: high demand**
Learning outcomes that can be assessed on either the Foundation Tier or Higher Tier question papers. The use of bullet points provides guidance on: • depth • context • exemplification	Learning outcomes that will only be assessed in the Higher Tier paper. The use of bullet points provides guidance on: • depth • context • exemplification

3.3 Fundamental Scientific Processes

FUNDAMENTAL SCIENTIFIC PROCESSES

Item Sa: How Science Works

Summary: In addition to knowledge of the scientific explanations that are detailed in sections 3.4 – 3.9 below, candidates require an understanding of the fundamental scientific processes that underpin these explanations.

Aspects of Fundamental Scientific Processes and opportunities to develop them in the specification	Assessable learning outcomes Foundation Tier only: low demand
Developing Scientific Explanations	
C1e, C3b, C3c, C3h,C4b, C4c, C4d, C4e, C5g, C5h, C6a, C6c, C6h	Describe a simple scientific idea using a simple model.
C2g, C2a, C4a	Identify two different scientific views or explanations of scientific data.
C1c, C1e, C2a, C4a, C6e	Recall that scientific explanations (hypotheses) are • used to explain observations • tested by collecting data / evidence.
C2a, C4a	Describe examples of how a famous scientist used a scientific idea to explain experimental observations or results.
C2a, C4a	Recognise that science explanations are provisional because they only explain the current evidence and that some evidence/observations cannot yet be explained.
Science in Society	
C1a, C1b, C1e, C1g, C2a, C2g, C3g, C4a, C6b, C6d, C6h	Identify different views that might be held regarding a given scientific or technological development.
C1a, C1c, C1g, C2c, C2d, C2e, C2g, C4g, C5c, C6b, C6e	Identify how a scientific or technological development could affect different groups of people or the environment.
C1b, C1c, C1c, C1e	Describe risks from new scientific or technological advances.
Institutions and social practices	
C2d	Identify information and data from different sources, without consideration of issues of misrepresentation.
C2a, C4a	Recognise the importance of the peer review process in which scientists check each other's work.
Methods of Science	
C2e, C3a, C3a, C3b, C3c, C3d, C3e, C3f, C5a, C5b, C5d, C5e, C5f, C6a, C6h	Present data as tables, pie charts or line graphs and identify trends in the data and process data using simple statistical methods such as calculating a mean.
C2a, C4a	Explain how a conclusion is based on the scientific evidence which has been collected.

FUNDAMENTAL SCIENTIFIC PROCESSES

Summary (cont.): Studying these processes will provide candidates with some understanding of

- how scientific explanations have been developed,
- something of their limitations, and
- how they may impact on individuals and society as a whole.

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain a scientific process, using ideas or models.	Explain a complex scientific process, using abstract ideas or models.
Describe (without comparing) the scientific evidence which supports or refutes opposing scientific explanations.	Evaluate and critically compare opposing views, justifying why one scientific explanation is preferred to another.
Explain how a scientific idea has changed as new evidence has been found.	Identify the stages in the development of a scientific theory in terms of the way the evidence base has developed over time alongside the development of new ways of interpreting this evidence.
Describe examples of how a famous scientist planned a series of investigations / made a series of observations in order to develop new scientific explanations.	Understand that unexpected observations or results can lead to new developments in the understanding of science.
Recognise that science explanations are provisional but more convincing if predictions can be made and subsequently confirmed.	Recognise that confidence increases in provisional scientific explanations if observations match predictions, but this does not prove the explanation is correct.
Explain how the application of science and technology depends on economic, social and cultural factors. Identify some arguments for and against a scientific or technological development, in terms of its impact on different groups of people or the environment. Suggest ways of limiting risks and recognise the benefits of activities that have a known risk.	Describe the ways in which the values of society have influenced the development of science and technology. Evaluate the application of science and technology, recognising the need to consider what society considers right or wrong, and the ideal that the best decision will have the best outcome for the majority of the people involved. Analyse personal and social choices in terms of a balance of risk and benefit.
Distinguish between claims/opinions and scientific evidence in sources. Explain how publishing results through scientific conferences and publications enables results to be checked and further evidence to be collected.	Evaluate critically the quality of scientific information or a range of views, from a variety of different sources, in terms of shortcomings in the explanation, misrepresentation or lack of balance. Explain the importance of using teams of scientists to enable different interpretations of data to be considered and further work to be undertaken, so that an agreed explanation can be reached.
Choose the most appropriate format for presenting data, and process data using mathematical techniques such as statistical methods or calculating the gradients of graphs.	Identify complex relationships between variables, including inverse relationships, using several mathematical steps.
Determine the level of confidence for a conclusion based on the identification of a qualitative relationship between variables and describe how further predictions can lead to more evidence being obtained.	Identify and critically analyse conflicting evidence, or weaknesses in the data, which lead to different interpretations, and explain what further data would help to make the conclusion more secure.

Module C1: Carbon Chemistry

Item C1: Fundamental Chemical Concepts

Summary: Throughout the study of chemistry in GCSE science there are a number of ideas and concepts that are fundamental. These ideas and concepts have not been put into a particular item but should permeate through all the GCSE chemistry modules C1 to C6.

Suggested practical and research activities to select from	**Assessable learning outcomes Foundation Tier only: low demand**
These learning outcomes are intended to be taught throughout this specification.	Describe that in a chemical reaction reactants are changed into products. Recognise the reactants and products in a word equation. Construct word equations given the reactants and products.
These learning outcomes are intended to be taught throughout this specification.	Recognise the reactants and the products in a symbol equation.
These learning outcomes are intended to be taught throughout this specification.	Deduce the number of elements in a compound given its formula. Deduce the number of atoms in a formula with no brackets. Deduce the number of each different type of atom in a formula with no brackets.
These learning outcomes are intended to be taught throughout this specification.	Recognise whether a substance is an element or a compound from its formula. Deduce the names of the different elements in a compound given its formula.
These learning outcomes are intended to be taught throughout this specification.	Understand that a molecule is made up of more than one atom joined together. Explain that a molecular formula shows the numbers and types of atom in a molecule. Deduce the number of atoms in a displayed formula. Deduce the names of the different elements in a compound given its displayed formula. Deduce the number of each different type of atom in a displayed formula.
These learning outcomes are intended to be taught throughout this specification.	Recognise whether a particle is an atom, molecule or ion given its formula. Understand that atoms contain smaller particles one of which is a negative electron.
These learning outcomes are intended to be taught throughout this specification.	Describe that atoms in a compound are held together by chemical bonds

Module C1: Carbon Chemistry

Item C1: Fundamental Chemical Concepts
Links to other modules: C1 to C6

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Construct balanced symbol equations given the formulae (no brackets) of the reactants and products. Explain that a symbol equation is balanced when the number of each type of atom is the same on both sides of an equation.	Construct balanced symbol equations given the formulae (some or all with brackets) of the reactants and products. Construct balanced symbol equations given the names of the reactants and products (limited to the learning outcomes in C1).
Deduce the number of atoms in a formula with brackets. Deduce the number of each type of different atom in a formula with brackets. Recall the formula of the following substances • carbon dioxide and carbon monoxide • oxygen and water	Recall the formula of the following substances: • sulfuric acid • sulfur dioxide • sodium hydrogencarbonate and sodium carbonate
Explain that a displayed formula shows both the atoms and the bonds in a molecule. Write the molecular formula of a compound given its displayed formula.	Construct balanced equations using displayed formulae.
Understand that positive ions are formed when electrons are lost atoms Understand that negative ions are formed when electrons are gained by atoms	
Recall that two types of chemical bond holding atoms are • ionic bonds • covalent bonds	Describe that an ionic bond is the attraction between a positive ion and a negative ion Describe that a covalent bond is a shared pair of electrons

Module C1: Carbon Chemistry

Item C1a: Making Crude Oil Useful

Summary: Articles on television and in newspapers show the unacceptable side of oil exploitation in terms of oil pollution at sea or on beaches. This item develops ideas about oil exploitation and how crude oil is changed into useful products such as fuels. It also demonstrates the importance of timescale with reference to non-renewable fuels.

This item provides the opportunity to illustrate the use of ICT in science and technology when researching oil exploitation and the industrial production of products from crude oil. The discussion about exploitation of oil raises ethical issues and allows consideration of some questions that science cannot currently answer.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Research different fossil fuels with groups of candidates preparing a presentation on each fuel.	Understand that crude oil, coal and gas are fossil fuels. Describe non-renewable fuels as ones which take a very long time to make and are used up faster than they are formed.
Demonstrate the fractional distillation of crude oil using synthetic crude oil mixture. Research the different products that can be made from crude oil.	Recognise that fractional distillation separates crude oil into useful products called fractions. Recognise that fractional distillation works because of differences in boiling points. Recognise that LPG, petrol, diesel, paraffin, heating oil, fuel oils and bitumen are fractions obtained from crude oil. Recall that LPG contains propane and butane gases.
Research the problems of oil exploitation and possible solutions.	Understand that crude oil is found in the Earth's crust and may have to be pumped to the surface. Describe some of the environmental problems involved in the exploitation of crude oil: • oil slicks as a result of accidents • damage to wildlife and beaches.
Demonstrate the cracking of liquid paraffin.	Label the laboratory apparatus used for cracking liquid paraffin. Describe cracking as a process that: • needs a catalyst and a high temperature • converts large hydrocarbon molecules into smaller ones that are more useful • makes more petrol.

Module C1: Carbon Chemistry

Item C1a: Making Crude Oil Useful
Links to other modules:

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain why fossil fuels are finite resources and are non-renewable: • finite resources are no longer being made or being made extremely slowly • non-renewable resources are used up faster than they are formed. Describe crude oil as a mixture of many hydrocarbons.	Discuss the problems associated with the finite nature of crude oil: • all the readily extractable resources will be used up in the future • finding replacements • conflict between making petrochemicals and fuels.
Label a diagram of a crude oil fractional distillation column to show the main fractions and the temperature gradient. Describe the fractional distillation of crude oil into fractions: • crude oil is heated • use of a fractionating column which has a temperature gradient (cold at the top and hot at the bottom) • fractions containing mixtures of hydrocarbons are obtained • fractions contain many substances with similar boiling points • fractions with a low boiling points 'exit' from the top of the fractionating column • fractions with high boiling points 'exit' at the bottom of the fractionating column.	Explain why crude oil can be separated by fractional distillation: • covalent bonds between carbon and hydrogen atoms within a hydrocarbon molecule are stronger than the intermolecular forces between hydrocarbon molecules • during boiling intermolecular forces are broken • intermolecular forces between large hydrocarbon molecules are stronger than those between smaller hydrocarbon molecules • hydrocarbons with large molecules have a higher boiling point than those with smaller molecules.
Explain some of the potential environmental problems involved in the transportation of crude oil: • damage to birds' feathers causing death • use of detergents to clean up oil slicks and consequent damage to wildlife.	Explain in simple terms the political problems associated with the exploitation of crude oil: • UK dependent on oil and gas from politically unstable countries • future supply issues.
Describe cracking as a process that: • converts large alkane molecules into smaller alkane and alkene molecules • makes useful alkene molecules because they can be used to make polymers • interpret data about the supply and demand of crude oil fractions (no recall expected).	Explain how cracking helps an oil refinery match its supply of useful products such as petrol with the demand for them.

Module C1: Carbon Chemistry

Item C1b: Using carbon fuels

Summary: This item develops ideas about fuels and the factors that need to be considered when choosing a fuel that is fit for purpose. It also considers the process of combustion and how and why decisions about science and technology are made.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Discuss fuels for a purpose (eg choosing the right fuel for heating / lighting a remote house in Scotland, powering a car, use in an electricity generating station, etc).	Interpret data about fuels in order to choose the best fuel for a particular purpose (no recall expected).
Carry out an experiment to show that combustion of a hydrocarbon in a plentiful supply of air produces carbon dioxide and water.	Describe that the combustion or burning of a fuel requires oxygen. Recall that the combustion of a fuel releases useful heat energy. Understand that complete combustion needs a plentiful supply of oxygen (air). Recall that complete combustion of a hydrocarbon fuel makes only carbon dioxide and water. Construct word equations to show the complete combustion of a hydrocarbon fuel given the reactants and products.
Design a poster warning about the dangers of carbon monoxide poisoning eg using appropriate ICT software. Investigate the products of complete and incomplete combustion by experiment.	Understand that incomplete combustion takes place when there is a shortage of oxygen (air). Describe that a blue Bunsen flame transfers more energy than a yellow flame. Identify that a yellow flame produces lots of soot. Recall that incomplete combustion of a hydrocarbon fuel makes carbon monoxide, carbon (soot)and water. Understand that carbon monoxide is a poisonous gas. Construct word equations to show the incomplete combustion of a hydrocarbon fuel given the reactants and products.

Module C1: Carbon Chemistry

Item C1b: Using carbon fuels
Links to other modules:

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe the factors that need to be considered for a given use of a fossil fuel: • energy value • availability • storage • cost • toxicity • pollution eg acid rain, greenhouse effect • ease of use. Interpret data about fuels in order to choose the best fuel for a particular purpose (no recall expected).	Evaluate the use (no recall expected) of different fossil fuels: • energy value • availability • storage • cost • toxicity • pollution eg acid rain, greenhouse effect • ease of use. Explain why the amount of fossil fuels being burnt is increasing: • increasing world population • growth of use in developing countries eg India and China
Describe a fuel as a substance that reacts with oxygen to release useful energy. Describe an experiment to show that combustion of a hydrocarbon in a plentiful supply of air produces carbon dioxide and water. Construct word equations to show the complete combustion of a hydrocarbon fuel (not all reactants and products given).	Construct the balanced symbol equation for the complete combustion of a simple hydrocarbon fuel given its molecular formula.
Explain that a blue flame releases more energy than a yellow flame because it involves complete combustion rather than incomplete combustion. Describe the advantages of complete combustion over incomplete combustion of hydrocarbon fuels: • less soot made • more heat released • poisonous carbon monoxide not produced. Explain the importance of regularly servicing gas appliances. Construct word equations to show the incomplete combustion of a hydrocarbon fuel (not all reactants and products given).	Construct the balanced symbol equation for the incomplete combustion of a simple hydrocarbon fuel given its molecular formula and the product (carbon or carbon monoxide)

Module C1: Carbon Chemistry

Item C1c: Clean Air

Summary: The increase in respiratory illnesses such as asthma in young people may be caused by an increase in air pollution. This item develops ideas about air pollution and how it can be prevented. The use of catalytic converters to reduce atmospheric pollution is also considered. The evolution of the atmosphere including the timescales involved and the ethical issues around human influences on the atmosphere are also introduced.

Suggested practical and research activities to select from	**Assessable learning outcomes Foundation Tier only: low demand**
Experimental determination of the composition of clean air. Produce some research or a poster to show the main processes in the carbon cycle Produce a time line showing the sequence of events in the evolution of the atmosphere.	Recall that air contains oxygen, nitrogen, water vapour and carbon dioxide. Describe that oxygen, nitrogen and carbon dioxide levels in the present day atmosphere are approximately constant. Describe that photosynthesis decreases the level of carbon dioxide and increases the level of oxygen in the air. Describe that respiration and combustion increase the level of carbon dioxide and decrease the level of oxygen in the air.
Research the increase in occurrences of asthma in the UK and possible links with air pollution eg from the internet. Write a leaflet describing the main forms of atmospheric pollution, their effects and origins.	Relate the common pollutants found in air to the environmental problem the pollutant causes: • carbon monoxide – a poisonous gas • oxides of nitrogen – photochemical smog and acid rain • sulfur dioxide – acid rain that will kill plants, kill aquatic life, erode stonework and corrode metals.
Research the methods of preventing atmospheric pollution.	Understand that a catalytic converter removes carbon monoxide from the exhaust gases of a car.

Module C1: Carbon Chemistry

Item C1c: Clean Air
Links to other modules:

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Recall the percentage composition by volume of clean air: • 21% oxygen • 78% nitrogen • 0.035% carbon dioxide. Describe a simple carbon cycle involving photosynthesis, respiration and combustion. Describe how the present day atmosphere evolved: • original atmosphere came from gases escaping from the interior of the Earth • photosynthesis by plants increased the percentage of oxygen until it reached today's level.	Evaluate the effects of human influences on the composition of air: • deforestation • increased energy consumption (burning of fossil fuels) • population. Describe one possible theory for how the present day atmosphere evolved over millions of years (based on the composition of gases vented by present day volcanic activity): • degassing of early volcanoes producing an atmosphere rich in water and carbon dioxide • condensing of water vapour to form oceans • dissolving of carbon dioxide in ocean waters • relative increase of nitrogen due to its lack of reactivity • development of photosynthetic organisms • increase in oxygen levels due to photosynthesis.
Describe the origin of the following atmospheric pollutants: • carbon monoxide – incomplete combustion of petrol or diesel in car engines • oxides of nitrogen – formed in the internal combustion engine • sulfur dioxide – formed when sulfur impurities in fossil fuels burn • Interpret data about the effects of atmospheric pollutants.	Explain that the high temperature inside an internal combustion engine allows nitrogen from the air to react with oxygen to make oxides of nitrogen.
Explain why it is important that atmospheric pollution is controlled. Understand that a catalytic converter changes carbon monoxide into carbon dioxide.	Describe the use of a catalytic converter in removing carbon monoxide from exhaust fumes by converting it to carbon dioxide: $2CO + 2NO \rightarrow N_2 + 2CO_2$

Module C1: Carbon Chemistry

Item C1d: Making polymers

Summary: Candidates will be familiar with the idea that virtually all materials are made through chemical reactions. They will also be able to represent compounds by formulae and chemical reactions by word equations. This item applies these ideas to the formation of a group of substances vital for life in the 21st century.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Use of molecular models. Use of ICT to show shapes of molecules.	Recall the two elements chemically combined in a hydrocarbon: • carbon • hydrogen. Recognise a hydrocarbon from its molecular or displayed formula.
Use of molecular models. Use of ICT to show shapes of molecules.	Recognise that alkanes are hydrocarbons. Recognise alkanes from their names: • methane • ethane • propane • butane.
Test for unsaturation using bromine water.	Recognise that alkenes are hydrocarbons. Recognise alkenes from their names: • ethene • propene • butene.
Card game: matching monomers and polymers. Use of molecular models. Making 'polypaperclips'.	Deduce the name of an addition polymer given the name of the monomer and vice versa.
Demonstration of preparation of nylon as an example of how monomers can form chains (but understanding that this is not an example of addition polymerisation). Demonstration making poly(phenylethene) details from RSC web site www.practicalchemistry.org PVA polymer slime details from RSC web-site www.practicalchemistry.org	Recall that polymers are very large molecules. Recall that molecules in plastics are called polymer molecules. Describe that polymers are made when many small molecules called monomers join together. Describe that the reaction that makes polymers from monomers is called polymerisation.

Module C1: Carbon Chemistry

Item C1d: Making polymers
Links to other modules:

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe a hydrocarbon as a compound formed between carbon atoms and hydrogen atoms only. Explain why a compound is a hydrocarbon given its molecular or displayed formula.	Describe a saturated compound as one which contains only single covalent bonds between carbon atoms. Describe an unsaturated compound as one which contains at least one double covalent bond between carbon atoms.
Describe alkanes as hydrocarbons which contain single covalent bonds only. Interpret information on displayed formulae of alkanes.	Interpret information from the displayed formula of a saturated hydrocarbon.
Describe alkenes as hydrocarbons which contain a double covalent bond(s) between carbon atoms. Interpret information on displayed formulae of alkenes. Describe how the reaction with bromine can be used to test for an alkene: • bromine water is orange • bromine water is decolourised.	Interpret information from the displayed formula of an unsaturated hydrocarbon. Explain the reaction between bromine and alkenes: • addition reaction • test for unsaturation • formation of a colourless dibromo compound.
Recognise the displayed formula for a polymer.	Construct the displayed formula of an addition polymer given the displayed formula of its monomer. Construct the displayed formula of a monomer given the displayed formula of its addition polymer.
Describe addition polymerisation as a process in which many monomer molecules react together to give a polymer which requires high pressure and a catalyst.	Explain that addition polymerisation involves the reaction of many unsaturated monomer molecules (alkenes) to form a saturated polymer.

Module C1: Carbon Chemistry

Item C1e: Designer polymers

Summary: Candidates may be familiar with the idea that everyday items such as supermarket bags are made from polymers. This item explores why technology moves forward with the development of materials focusing on the very wide range of uses that polymers have, including health care, in the 21st century. Issues of disposal of polymers are also considered.

Suggested practical and research activities to select from	**Assessable learning outcomes Foundation Tier only: low demand**
Activity interpreting information and researching personal interests in the context of why technology moves forward with the development of materials precisely matched to need (using a variety of contexts to capture different interests (CDs, sports equipment, health contexts etc).	Interpret simple information about properties of polymers (plastics) and their uses given appropriate information (no recall expected).
Data-search about waterproof clothing eg using appropriate ICT. Identification of polymers (plastics).	Describe how polymers (plastics) are used in packaging and clothing: • polythene or poly(ethene) is used for plastic bags • polystyrene is used for damage protection in packaging and for insulation • nylon and polyester are used in clothing. Describe one advantage of waterproof clothing. Describe one advantage of breathable clothing.
Research how local councils dispose of public waste.	Describe many polymers as non-biodegradable, so they will not decay or decompose by bacterial action. Describe some of the problems of using non-biodegradable polymers: • litter and difficult to dispose of. Describe some of the ways that waste polymers can be disposed of: • use of land fill sites • burning of waste polymers • recycling.

Module C1: Carbon Chemistry

Item C1e: Designer polymers
Links to other modules:

<table>
<tr><th>Assessable learning outcomes
both tiers: standard demand</th><th>Assessable learning outcomes
Higher Tier only: high demand</th></tr>
<tr><td>Suggest the properties a polymer (plastic) should have in order to be used for a particular purpose.
Explain why a polymer (plastic) is suitable for a particular use given the properties of the polymer.</td><td>Describe that the atoms in plastics are held together by strong covalent bonds.
Relate the properties of plastics to simple models of their structure:
plastics that have weak intermolecular forces between polymer molecules have low melting points and can be stretched easily as the polymer molecules can slide over one another
plastics that have strong forces between the polymer molecules (covalent bonds or cross-linking bridges) have high melting points, cannot be stretched and are rigid.</td></tr>
<tr><td>Compare the properties of nylon and Gore-Tex®:
nylon is tough, lightweight, keeps water out, keeps UV light out but does not let water vapour through it which means that sweat condenses
Gore-Tex® has all of the properties of nylon but is also breathable.
Explain why the discovery of Gore-Tex® type materials has been of great help to active outdoor people to cope with perspiration wetness.</td><td>Describe the construction of Gore-Tex® type materials explaining why they make clothing waterproof and yet breathable:
nylon laminated with PTFE / polyurethane membrane
holes in PTFE are too small for water to pass through but are big enough for water vapour to pass through
PTFE laminate is too fragile on its own and so is combined with nylon.</td></tr>
<tr><td>Explain why chemists are developing polymers that are biodegradable:
easily disposed of by dissolving eg for dishwasher detergents.
Explain some of the environmental and economic issues related to the use of polymers:
landfill sites get filled quickly wasting valuable land
burning waste plastics makes toxic gases
disposal by burning or land-fill sites wastes a valuable resource
difficult to sort out different polymers so recycling is difficult.</td><td></td></tr>
</table>

Module C1: Carbon Chemistry

Item C1f: Cooking and food additives

Summary: Cooking involves chemical reactions in food to develop a different texture and taste. This item considers the chemical changes that happen to some foods when they are cooked. Much of the food eaten today contains food additives to colour food, enhance the flavour, add vitamins, stabilise the food, or to stop it from decaying. This item considers different types of food additive and some of the issues concerned with their use. This item provides the opportunity to collect and analyse secondary data using ICT tools when researching food additives and provides opportunities for interpreting and applying science ideas.

Suggested practical and research activities to select from	**Assessable learning outcomes** **Foundation Tier only: low demand**
Investigate the effect of heating on proteins such as those in eggs or meat. Investigate the effect of heat on potatoes. RSC material at www.practicalchemistry.org/experiments/structure-and-bonding/	Recognise that a chemical change takes place if: • there is a new substance made • the process is irreversible • an energy change takes place. Understand that the process of cooking food is an example of a chemical change. Describe the changes that occur when an egg or meat is cooked: • change in appearance • change in texture. Describe how the texture and taste of a potato changes when it is heated
Data search into the types of food additive eg using suitable web sites. Look at food labels for additives. Discuss the advantages and disadvantages of using food additives. Investigate emulsifiers by mixing oil and water. Test a range of common substances to see which act as emulsifiers.	Recall the main types of food additives: • antioxidants • food colours • flavour enhancers • emulsifiers. Recognise that oil and water do not mix. Describe that emulsifiers help oil and water to mix and not separate. Recall examples of foods that contain emulsifiers eg mayonnaise.
Investigate the action of heat on baking powder.	Recall that baking powder gives off carbon dioxide gas when it is heated. Explain that the carbon dioxide made when baking powder is heated helps make cakes rise. Describe that the chemical test for carbon dioxide is that it turns lime water cloudy. Construct the word equation for the decomposition of sodium hydrogencarbonate given the reactants and products. sodium hydrogencarbonate → sodium carbonate + carbon dioxide + water

Module C1: Carbon Chemistry

Item C1f: Cooking and food additives
Links to other modules:

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain that cooking food is a chemical change because a new substance is formed and the process cannot be reversed. Recall that eggs or meat are good sources of proteins. Understand that protein molecules in eggs and meat change shape when eggs and meat are cooked. Recall that potatoes are a good of source of carbohydrates.	Explain the changes that occur to an egg or meat when it is cooked: • shape of protein molecules change • the process is irreversible • the process is called denaturing. Explain the changes that happen to a potato when it is cooked: • cell walls rupture resulting in loss of rigid structure and a softer texture • starch grains swell up and spread • potato is easier to digest.
Describe the function of the main types of food additive: • antioxidants stop foods from reacting with oxygen • food colours give food an improved colour • flavour enhancers improve the flavour of a food. Describe emulsifiers as molecules that have a water loving part (hydrophilic) and an oil or fat loving (hydrophobic) part.	Describe how an emulsifier helps to keep oil and water from separating: • hydrophilic end bonds to water molecules • hydrophobic end bonds with oil molecules.
Recall that baking powder contains sodium hydrogencarbonate. Describe that sodium hydrogencarbonate breaks down when heated (decomposes) to make sodium carbonate, carbon dioxide and water. Recall the word equation for the decomposition of sodium hydrogencarbonate (not all products given). sodium hydrogencarbonate → sodium carbonate + carbon dioxide + water Construct the balanced symbol equation for the decomposition of sodium hydrogencarbonate (some or all formulae given) $2NaHCO_3 \longrightarrow Na_2CO_3 + H_2O + CO_2$	Construct the balanced symbol equation for the decomposition of sodium hydrogencarbonate (formulae not given) • $2NaHCO_3 \longrightarrow Na_2CO_3 + H_2O + CO_2$

Module C1: Carbon Chemistry

Item C1g: Smells

Summary: Cosmetics play an important part in the life of teenagers. This item considers some cosmetic products; perfumes and nail varnish remover. The properties of these products and the need for testing new cosmetic products are considered. This item provides the opportunity to explore how and why decisions about science and technology are made, including ethical issues on the testing of cosmetics on animals. The investigation on nail varnish removal provides the opportunity to collect and analyse primary scientific data, working accurately and safely.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Preparation of an ester eg butyl ethanoate. Microscale preparation of a range of esters and identifying the smells. Research the uses of esters.	Understand that some cosmetics can be made from natural sources. Describe two examples of perfumes obtained from natural sources. Understand that some cosmetics are synthetic and others are obtained from natural sources. Describe that esters are perfumes that can be made synthetically.
Research and display the properties of perfumes.	Recall that perfumes have a pleasant smell. Describe the necessary physical properties of perfumes: • evaporates easily • non-toxic • does not react with water • does not irritate the skin • insoluble in water.
Investigate the removal of coloured nail varnish with different solvents.	Describe that nail-varnish remover dissolves nail varnish colours. Understand that substances that dissolve in a liquid are soluble and those that do not are insoluble. Understand that a solute is the substance dissolved in a solution. Understand that a solvent is the liquid that does the dissolving. Interpret information on the effectiveness of solvents given relevant data.
Debate: "Is testing on animals ever justified?"	Recall that testing of cosmetics on animals is banned in the UK. Describe that cosmetics must be tested to ensure that they are safe to use.

Module C1: Carbon Chemistry

Item C1g: Smells
Links to other modules:

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe that alcohols react with acids to make an ester and water. Describe how to carry out a simple experiment to make an ester.	
Explain why a perfume needs certain properties: • easily evaporates so that the perfume particles can easily reach the nose • non-toxic so it does not poison you • does not react with water because otherwise the perfume would react with perspiration • does not irritate the skin otherwise the perfume could not be put directly on the skin • insoluble in water so it cannot be washed off easily.	Explain the volatility (ease of evaporation) of perfumes in terms of kinetic theory: • in order to evaporate particles need sufficient energy to overcome the attraction to other molecules in the liquid • only weak attraction exists between particles in the liquid perfume so easy to overcome this attraction.
Recall that esters can be used as solvents. Describe a solution as a mixture of solvent and solute that does not separate out. Interpret information on the effectiveness of solvents (no recall expected).	Explain why water will not dissolve nail varnish colours: • attraction between water molecules is stronger than attraction between water molecules and particles in nail varnish • attraction between particles in nail varnish is stronger than attraction between water molecules and particles in nail varnish.
Explain why new cosmetic products need to be thoroughly tested before they are permitted to be used. Describe one advantage and one disadvantage of testing on animals.	Explain why people have different opinions about the testing of cosmetic products

Module C1: Carbon Chemistry

Item C1h: Paints and Pigments

Summary: Pigments and paints play an important part in our modern day lives. Our clothes, houses and our local environment are all made much more interesting and pleasing to the eye by the use of colour.

Suggested practical and research activities to select from	**Assessable learning outcomes Foundation Tier only: low demand**
Making coloured substances by mixing together solutions Data-search via internet about paints and the ingredients in paints. Make a simple paint	Recall the main ingredients of paint: • solvent, binding medium and pigment. Describe the functions of the solvent, binding medium and pigment in a paint: • solvent thins the paint and makes it easier to spread • binding medium sticks the pigment in the paint to the surface • pigment is the substance that gives the paint its colour. Recognise that paint is a type of mixture called a colloid. Describe that oil paints: • have the pigment dispersed in an oil • and often a solvent that dissolves oil.
Survey some advertisement leaflets about different types of paints.	Describe that paints are used to decorate or protect surfaces.
Investigating thermochromic pigments using materials eg material from Middlesex University Teaching Resources. Demonstrate some objects that contain thermochromic pigments	Describe that thermochromic pigments change colour when heated or cooled.
Investigating phosphorescent pigments using material eg material from Middlesex University Teaching Resources.	Describe that phosphorescent pigments can glow in the dark.

Module C1: Carbon Chemistry

Item C1h: Paints and Pigments
Links to other modules:

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe paint as a colloid where the particles are mixed and dispersed with particles of a liquid but are not dissolved.	Explain that the components of a colloid will not separate because the particles are scattered or dispersed throughout the mixture and are sufficiently small so as not to settle at the bottom.
Describe that many paints are applied as a thin layer which dries when the solvent evaporates. Describe emulsion paints as water based paints that dry when the solvent evaporates.	Explain that oil paints dry because the solvent evaporates and then the oil is oxidised by atmospheric oxygen.
Describe some uses of thermochromic pigments: • warning of a hot cup • use in electric kettles • mood rings • babies' spoons and bath toys.	Describe that thermochromic pigments can be added to acrylic paints to give even more colour changes.
Describe that phosphorescent pigments absorb and store energy and release it as light over a period of time.	Explain that phosphorescent pigments are much safer than the alternative radioactive substances eg in use of 'glow in the dark' watches.

Module C2: Chemical Resources

Item C2: Fundamental Chemical Concepts

Summary: Summary: Throughout the study of chemistry in GCSE science there are a number of ideas and concepts that are fundamental. These ideas and concepts have not been put into a particular item but should permeate through all the GCSE chemistry modules C1 to C6.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
These learning outcomes are intended to be taught throughout this specification.	Describe that in a chemical reaction reactants are changed into products. Recognise the reactants and products in a word equation. Construct word equations given the reactants and products.
These learning outcomes are intended to be taught throughout this specification.	Recognise the reactants and the products in a symbol equation.
These learning outcomes are intended to be taught throughout this specification.	Deduce the number of elements in a compound given its formula. Deduce the number of atoms in a formula with no brackets. Deduce the number of each different type of atom in a formula with no brackets.
These learning outcomes are intended to be taught throughout this specification.	Recognise whether a substance is an element or a compound from its formula. Deduce the names of the different elements in a compound given its formula
These learning outcomes are intended to be taught throughout this specification.	Understand that a molecule is made up of more than one atom joined together. Explain that a molecular formula shows the numbers and types of atom in a molecule. Deduce the number of atoms in a displayed formula. Deduce the names of the different elements in a compound given its displayed formula. Deduce the number of each different type of atom in a displayed formula.
These learning outcomes are intended to be taught throughout this specification.	Recognise whether a particle is an atom, molecule or ion given its formula Understand that atoms contain smaller particles one of which is a negative electron
These learning outcomes are intended to be taught throughout this specification.	Describe that atoms in a compound are held together by chemical bonds

Module C2: Chemical Resources

Item C2: Fundamental Chemical Concepts
Links to other modules: C1 to C6

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Construct balanced symbol equations given the formulae (no brackets) of the reactants and products. Explain that a symbol equation is balanced when the number of each type of atom is the same on both sides of an equation.	Construct balanced symbol equations given the formulae (some or all with brackets) of the reactants and products. Construct balanced symbol equations given the names of the reactants and products (limited to the learning outcomes in C2).
Deduce the number of atoms in a formula with brackets. Deduce the number of each type of different atom in a formula with brackets. Recall the formula of the following substances: • calcium carbonate and calcium oxide • carbon dioxide, hydrogen and water. • sodium chloride and potassium chloride • ammonia and nitrogen. • hydrochloric acid	Recall the formula of the following substances: • nitric acid and sulfuric acid • copper oxide, sodium hydroxide, potassium hydroxide and sodium carbonate • potassium sulfate, sodium sulfate and ammonium sulfate • calcium chloride, magnesium chloride magnesium sulfate and copper(II) sulfate
Explain that a displayed formula shows both the atoms and the bonds in a molecule. Write the molecular formula of a compound given its displayed formula.	Construct balanced equations using displayed formulae.
Understand that positive ions are formed when electrons are lost atoms Understand that negative ions are formed when electrons are gained by atoms	
Recall that two types of chemical bond holding atoms are • ionic bonds • covalent bonds	Describe that an ionic bond is the attraction between a positive ion and a negative ion Describe that a covalent bond is a shared pair of electrons

Module C2: Chemical Resources

Item C2a: The Structure of the Earth

Summary: We often read or hear news items on earthquakes and volcanoes. This item builds on the interest young people show towards these events. Models are used to help explain volcanic eruptions. The development of the theory of plate tectonics illustrates science as an evidence based discipline, the collaborative nature of science and how scientific theories develop and are validated. It also covers how the Earth's surface has changed over time.

Suggested practical and research activities to select from	**Assessable learning outcomes Foundation Tier only: low demand**
Create a scale model of the Earth's structure. Use ICT and/or other material to construct a map of where volcanoes and earthquakes occur on the Earth's surface. 'Wegener and continental drift' example taken from Collins Ideas and Evidence CD.	Describe the structure of the Earth as a sphere with a thin rocky crust, mantle and core. Recall that the Earth's core contains iron. Understand that the movement of tectonic plates • results in volcanic activity and earthquakes. • is very slow (about 2.5cm per year) • movement of continents took millions of years Recognise that: • many theories have been put forward to explain the nature of the Earth's surface • most scientists accept the theory of plate tectonics.
Model a volcano using the candle wax experiment.	Describe how molten rock can find its way to the surface through weaknesses in the crust.
Look for clues contained in volcanic rocks that show how they formed. Video clips of volcano types. Treacle investigation.	Describe that igneous rock is made when molten rock cools down. Describe magma as molten rock beneath the surface of the Earth. Describe lava as molten rock at the Earth's surface • lava erupts from a volcano. Describe that some of the rock on the Earth's surface has been formed by volcanic activity. Describe that some volcanoes erupt runny lava, while some erupt thick lava violently and catastrophically.
Research examples of people who live near volcanoes and the reasons why	Explain that some people choose to live near volcanoes because volcanic soil is very fertile.

Module C2: Chemical Resources

Item C2a: The Structure of the Earth
Links to other modules:

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe the outer layer of the Earth (lithosphere) as made of tectonic plates. Describe the lithosphere as the (relatively) cold rigid outer part of the Earth that includes the crust and part of the mantle. Explain that tectonic plates are less dense than the mantle below. Explain the problems associated with studying the structure of the Earth: • crust is too thick to drill through the need to use seismic waves produced by earthquakes or man-made explosions. Explain that plate tectonics as a theory is now widely accepted because • it explains a wide range of evidence • it has been discussed and tested by a wide range of scientists	Describe the mantle as the zone between the lithosphere and the core which is: • cold and rigid just below the crust • hot and non-rigid at greater depths and therefore able to move. Describe the theory of plate tectonics: • energy transfer involving convection currents in the semi-rigid mantle causing the plates to move slowly • oceanic floor more dense than continents • collision between oceanic floor and continents leads to subduction and partial re-melting • plates cooler at ocean margins so sink and pull plates down. Describe in simple terms the development of the theory of plate tectonics: • Wegener's continental drift theory (1914) • continental drift theory not accepted by scientists at the time • new evidence in 1960s – sea floor spreading • theory of plate tectonics slowly accepted.by the scientific community as all subsequent research has supported the theory
Explain that magma from the mantle must have a density less than that of the crust in order to rise through it.	
Explain how the size of crystals in an igneous rock is related to the rate of cooling of molten rock: • slow cooling gives large crystals • fast cooling gives small crystals.	Explain that magma can have different compositions and that this affects the rock that forms and the type of eruption, limited to: • iron-rich basalt (runny and fairly 'safe') • explosive silica-rich rhyolite (producing pumice and volcanic ash and bombs).
Explain that geologists study volcanoes to be able to forecast future eruptions and to reveal information about the structure of the Earth.	Explain that geologists are now able to better forecast volcanic eruptions but not with 100% certainty.

Module C2: Chemical Resources

Item C2b: Construction materials

Summary: Most landscapes include buildings such as houses, factories, flats or skyscrapers. Many of these buildings are made from raw materials found in or on the Earth's surface. The removal of the raw materials and their use has an enormous impact on the environment.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Data-search about construction materials and their sources.	Identify the names of some construction materials: • aluminium and iron • brick, cement, concrete and glass • granite, limestone and marble.
Look at samples of marble, limestone and granite. Video clips of mining and quarrying.	Recall that some rocks are used in construction of buildings and roads: • granite, limestone, marble and aggregates. Describe the environmental problems that may be caused by removing rocks from the ground: • landscape destroyed and has to be reconstructed when the mining or quarrying has finished • increased noise, traffic and dust.
Experimental investigation of the decomposition of calcium carbonate.	Understand that limestone and marble are both forms of calcium carbonate. Describe that limestone thermally decomposes to make calcium oxide and carbon dioxide.
Making a sample of concrete.	Describe that concrete is made when cement, sand, aggregate and water are mixed together and allowed to set.
Investigating the strength of concrete beams.	Describe that concrete can be reinforced, which is made by allowing the concrete to set around a steel support.

Module C2: Chemical Resources

Item C2b: Construction materials
Links to other modules:

Assessable learning outcomes both tiers: standard demand	**Assessable learning outcomes Higher Tier only: high demand**
Recall that some construction materials are manufactured from substances found in the Earth's crust: • aluminium and iron from ores • brick from clay • glass from sand.	
Describe that marble is much harder than limestone. Describe that granite is harder than marble.	Explain why granite, marble and limestone have different hardness: • limestone is a sedimentary rock • marble is a metamorphic rock made by the action of high pressures and temperatures on limestone • granite is an igneous rock.
Construct the word equation for the decomposition of limestone (products not given) calcium carbonate→calcium oxide +carbon dioxide Construct the balanced symbol equation for the decomposition of limestone (given some formulae) $CaCO_3 \rightarrow CaO + CO_2$ Describe thermal decomposition as a reaction in which, when heated, one substance is chemically changed into at least two new substances.	Construct the balanced symbol equation for the decomposition of limestone (formulae not given) $CaCO_3 \rightarrow CaO + CO_2$
Describe that cement is made when limestone and clay are heated together.	
Describe reinforced concrete as a composite material containing concrete and a solid steel support.	Explain why reinforced concrete is a better construction material that non-reinforced concrete in terms of: • hardness of the concrete • flexibility and strength of the steel.

Module C2: Chemical Resources

Item C2c: Metals and Alloys

Summary: Metallic elements and alloys have many uses in our society. This item examines how metals are extracted from their ores. It also describes some of the uses of some important alloys including smart alloys.□Suggested practical and research activities to select from

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Extraction of copper by heating malachite and carbon. Experimental purification of copper by electrolysis.	Understand that copper can be extracted by heating its ore with carbon. Recall that copper can be purified by electrolysis. Explain why recycling copper is cheaper than extracting copper from its ore: • saves resources • uses less energy.
Research about alloys – their uses and composition. Data search or experimental investigation into the properties of alloys. Modelling alloys with plasticine see RSC web-site www.practicalchemistry.org Making solder and comparing its properties with lead and tin see RSC web-site www.practicalchemistry.org	Recall that alloys are mixtures containing one or more metal elements. Recognise that brass, bronze, solder, steel, and amalgam are alloys. Describe one important large scale use for each of the following alloys: • amalgam used in tooth fillings • brass used in musical instruments, coins and door decorations eg door knockers • solder used to join electrical wires.
Internet research about smart alloys and their uses. Investigate nitinol (Middlesex University Teaching Resources).	Recognise that the properties of an alloy are different from the properties of the metals from which it is made. Interpret data about the properties of metals, including alloys eg hardness, density, boiling point and strength.

Module C2: Chemical Resources

Item C2c: Metals and Alloys
Links to other modules:

Assessable learning outcomes both tiers: standard demand	**Assessable learning outcomes Higher Tier only: high demand**
Recall that reduction is the removal of oxygen. Label the apparatus needed to purify copper by electrolysis. Describe some of the advantages and disadvantages of recycling copper • cheaper than extracting from its ore • problems of sorting waste metals • problems persuading the public to recycle.	Describe the use of electrolysis in the purification of copper: • impure copper as anode • pure copper as cathode • copper(II) sulfate solution as electrolyte • cathode gains mass because copper is deposited • $Cu^{2+} + 2e^- \rightarrow Cu$ as an example of reduction • anode loses mass as copper dissolves • $Cu - 2e^- \rightarrow Cu^{2+}$ as an example of oxidation.
Recall the main metals in each of the following alloys: • amalgam – mercury • brass – copper and zinc • solder – lead and tin.	
Describe that alloys often have properties that are different from the metals they are made from and that these properties may make the alloy more useful than the pure metal. Suggest properties needed by a metal or alloy for a particular given use.	Explain why metals, including alloys are suited to a given use given appropriate data (no recall expected). Explain how the use of 'smart alloys' such as those with a shape memory property have increased the number of applications of alloys • nitinol (nickel and titanium) used to make spectacle frames as the frames will return to their original shape after bending.

Module C2: Chemical Resources

Item C2d: Making Cars

Summary: Young people take the use of cars for granted. This item develops ideas about the problem of disposing of cars and the recycling of metals. Rusting and corrosion are also considered.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Investigate the corrosion of aluminium and iron using different conditions (eg salt water, acid rain, moist air). Comparing rate of corrosion of cars in the UK with that of Mediterranean countries.	Understand that rusting needs iron, water and oxygen. Recall that aluminium does not corrode in moist conditions. Interpret data about the rate of corrosion of different metals in different conditions (no recall is expected).
Compare the physical properties of iron and aluminium and their alloys both by data search and by experiment (density, magnetic property, electrical conductivity, flexibility, hardness and strength). Write a promotional leaflet for a car made from aluminium illustrating the advantages of such a car over one made from iron or steel.	Describe similarities and differences between the properties of iron and aluminium: • iron is more dense than aluminium • iron is magnetic and aluminium is not • iron corrodes (rusts) easily and aluminium does not • iron and aluminium are both malleable • iron and aluminium are both good electrical conductors. Recall that alloys are mixtures containing one or more metal elements.
Research all the materials that are used to manufacture cars (eg plastics, fibres, glass, copper, iron, aluminium).	Recall the major materials needed to build a car: • steel, copper and aluminium • glass, plastics and fibres.
Discuss the problems of disposing of cars. Visit a car scrap yard.	Describe the advantages of recycling materials: • saves natural resources • reduces disposal problems.

Module C2: Chemical Resources

Item C2d: Making Cars
Links to other modules:

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Understand that salt water and acid rain accelerate rusting. Understand that oxidation is the addition of oxygen. Explain that aluminium does not corrode in moist conditions because it has a protective layer of aluminium oxide which does not flake off the surface. Interpret data about the rate of corrosion of different metals in different conditions (no recall is expected).	Describe rusting as an oxidation reaction where iron reacts with water and oxygen to form hydrated iron(III) oxide. Construct the word equation for rusting: iron + oxygen + water → hydrated iron(III) oxide.
Describe that alloys often have properties that are different from the metals they are made from and that these properties may make the alloy more useful than the pure metal: • steel is harder and stronger than iron • steel is less likely to corrode than iron. Describe advantages and disadvantages of building car bodies from aluminium or from steel: • car body of the same car will be lighter with aluminium • car body with aluminium will corrode less • car body of the same car will be more expensive made from aluminium.	Explain advantages and disadvantages of building car bodies from aluminium or from steel: • car body of the same car will be lighter with aluminium so get better fuel economy • car body with aluminium will corrode less and so may have a longer lifetime • iron is cheaper than aluminium leading to a lower purchase price.
Suggest properties needed by a material for a particular use in a car. Explain why a material used in a car is suited to a particular use given appropriate data (no recall expected).	
Explain the advantages and disadvantages of recycling the materials used to make cars. Explain that new laws specify that a minimum percentage of all materials used to manufacture cars must be recyclable.	Evaluate information on materials used to manufacture cars (no recall expected).

Module C2: Chemical Resources

Item C2e: Chemicals from the Air - Making ammonia

Summary: : This item underlines the importance of the air as a source of useful materials. This item has as its central focus the industrial preparation of ammonia and its link with the fertiliser industry. The concept of reversible reactions is introduced with reference being made to the production of ammonia. In reversible reactions the fact that a balance that has to be struck between rate and percentage conversion is explored. Industrial case studies provide the opportunity to examine how scientific knowledge and ideas change over time. The factors affecting the cost of making a new substance provide opportunities to present information using technical, scientific and mathematical language.

Suggested practical and research activities to select from	**Assessable learning outcomes Foundation Tier only: low demand**
Examine historical, social, moral or economic reasons leading to the need to produce ammonia as a starting point for fertiliser production. Produce a poster on ammonia manufacture. Computer animation to illustrate how temperature and pressure affect yield in the Haber process eg Multimedia Science School 11-16 or Boardworks. Industrial case study. Watch video of Haber process with pre-prepared questions	Recall that ammonia is made from nitrogen and hydrogen. Understand that the nitrogen needed for the manufacture of ammonia is obtained from air. Understand that the hydrogen needed for the Haber process often comes from the cracking of oil fractions or from natural gas.
Research manufacturing costs (via internet) and class discussion.	Describe that the cost of making a new substance depends on: • price of energy (gas and electricity) • cost of starting materials • wages (labour costs) • equipment (plant) • how quickly the new substance can be made (cost of catalyst).
Industrial case studies.	Recognise that $\rightleftharpoons$ is used to represent a reversible reaction. Understand that a reversible reaction can proceed in both directions.
Survey of household chemicals containing ammonia and their uses.	Describe some of the uses of ammonia: • manufacture of fertilisers • manufacture of nitric acid • in cleaning fluids.

Module C2: Chemical Resources

Item C2e: Chemicals from the Air - Making ammonia
Links to other modules:

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe how ammonia is made in the Haber process: • nitrogen + hydrogen ⇌ ammonia • iron catalyst • high pressure • temperature in the region of 450°C • unreacted nitrogen and hydrogen are recycled. Construct the balanced symbol equation for the manufacture of ammonia in the Haber process (given some or all of the formulae) $N_2 + 3H_2 \rightleftharpoons 2NH_3$	Explain the conditions used in the Haber process: • high pressure increases the percentage yield of ammonia • high temperature decreases the percentage yield of ammonia • high temperature gives a high rate of reaction • 450°C is an optimum temperature to give a fast reaction with a sufficiently high percentage yield • catalyst increases the rate of reaction but does not change the percentage yield. Construct the balanced symbol equation for the manufacture of ammonia in the Haber process (formulae not given) $N_2 + 3H_2 \rightleftharpoons 2NH_3$
Describe how different factors affect the cost of making a new substance: • the higher the pressure the higher the plant cost • the higher temperature the higher the energy cost • catalysts reduce costs by increasing the rate of reaction • when unreacted starting materials are recycled costs are reduced • automation reduces the wages bill.	Explain that economic considerations determine the conditions used in the manufacture of chemicals: • rate must be high enough to give a sufficient daily yield of product • percentage yield must be high enough to give a sufficient daily yield of product • a low percentage yield can be accepted if the reaction can be repeated many times with recycled started materials • optimum conditions used that give the lowest cost rather than the fastest reaction or highest percentage yield.
Interpret data in tabular and graphical form relating to percentage yield in reversible reactions and changes in conditions. (No recall required).	Interpret data about rate, percentage yield and costs for alternative industrial processes (No recall required).
Recognise the importance of ammonia in relation to world food production.	

Module C2: Chemical Resources

Item C2f: Acids and Bases

Summary: Young people are familiar with acids and alkalis. They are excited by the opportunity to use these 'dangerous' chemicals. This item revises previous knowledge and understanding and gives them the opportunity to practice word and symbolic equations in relation to neutralisation reactions. The testing of pH provides the opportunity to use ICT as part of teaching and learning.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Carry out an experiment to test a variety of solutions to find pH: • reactions between acids and alkalis • reactions between acids and bases. (Opportunity to use datalogger.) Test everyday household substances	Recognise that solutions with a pH of less than 7 are acids. Recognise that solutions with a pH of more than 7 are alkalis. Recognise that solutions with a pH of 7 are neutral.
Simple investigation into the change in pH during neutralisation (not pH titration curves).	Describe the change in pH when an acid is neutralised by an alkali or vice versa: • pH increases when alkali added • pH decreases when acid is added.
Investigate the reactions of acids with bases and carbonates eg hydrochloric acid with metal oxides, hydroxides and carbonates.	Understand that an acid can be neutralised by a base or alkali, or vice versa.

Module C2: Chemical Resources

Item C2f: Acids and Bases
Links to other modules:

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe how universal indicator can be used to estimate the pH of a solution.	
Describe an alkali as a soluble base. Recall that in neutralisation: acid + base → salt + water. Explain the change in pH when an acid is neutralised by an alkali, or vice versa.	Recall that acids in solution contain hydrogen ions. Recall that alkalis in solution contain hydroxide ions. Describe neutralisation using the ionic equation. $H^+ + OH^- \rightarrow H_2O$
Describe that metal oxides and metal hydroxides neutralise acids because they are bases. Describe that carbonates neutralise acids to give water, a salt and carbon dioxide. Construct word equations to show the neutralisation of acids by bases and carbonates (names of the products not given). Predict the name of the salt produced when a named base or carbonate is neutralised by a laboratory acid limited to: • sulfuric acid • nitric acid • hydrochloric acid • phosphoric acid	Construct balanced symbol equations for the neutralisation of acids by bases and carbonates limited to: • sulfuric acid, nitric acid, and hydrochloric acid • ammonia, potassium hydroxide, sodium hydroxide and copper oxide • sodium carbonate and calcium carbonate.

Module C2: Chemical Resources

Item C2g: Fertilisers and crop yields

Summary: News items regularly feature stories of famine in various parts of the world. In this item we explore the role of fertilisers in increasing plant growth and crop yield. This item looks at the use of contemporary scientific and technological developments and their benefits, risks and drawbacks.

Suggested practical and research activities to select from

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Survey of fertilisers available at garden centres and commercially (via Internet searches). Research the main processes involved in eutrophication. Eutrophication animation or case study.	Understand that fertilisers make crops grow faster and bigger. Recall that plants absorb minerals through their roots. Describe fertilisers as chemicals that provide plants with essential chemical elements. Recall that nitrogen, phosphorus and potassium are three essential elements needed for plant growth. Recognise the essential elements given the formula of a fertiliser. Understand that the use of fertilisers can be beneficial (increasing food supply)and also cause problems e.g. death of aquatic organisms (eutrophication).
Preparation of a fertiliser by the neutralisation of an acid by an alkali using a burette (eg potassium nitrate or ammonium sulfate).	Label the apparatus needed to prepare a fertiliser by the neutralisation of an acid with an alkali: • burette and measuring cylinder • filter funnel. Recall the names of two nitrogenous fertilisers manufactured from ammonia eg: • ammonium nitrate • ammonium phosphate • ammonium sulfate • urea.

Module C2: Chemical Resources

Item C2g: Fertilisers and crop yields
Links to other modules:

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain that fertilisers must first dissolve in water before they can be absorbed by plants. Recall that fertilisers increase crop yield. Identify arguments for and against the use of fertilisers • world population is rising so need to produce more food • eutrophication and pollution of water supplies can result from excessive use of fertilisers	Explain how the use of fertilisers increases crop yield: • replaces essential elements used by a previous crop or provides extra essential elements • more nitrogen gets incorporated into plant protein so increased growth. Explain the process of eutrophication: • run-off of fertiliser • increase of nitrate or phosphate in river water • algal bloom • blocks off sunlight to other plants which die • aerobic bacteria use up oxygen • most living organisms die.
Predict the name of the acid and the alkali needed to make each of the following fertilisers: • ammonium nitrate • ammonium phosphate • ammonium sulfate • potassium nitrate.	Describe the preparation of a named synthetic fertiliser by the reaction of an acid and an alkali: • names of reactants • experimental method • how a neutral solution is obtained • how solid fertiliser is obtained.

Module C2: Chemical Resources

Item C2h: Chemicals from the Sea: The Chemistry of Sodium Chloride

Summary: The sea is a major source of salt. Producing chemicals from salt on a large scale in the UK has been carried out for hundreds of years. Salt is still an important raw material in the production of bulk chemicals today.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Research salt mining.	Describe that sodium chloride (salt) is an important raw material in the chemical industry which can be obtained from the sea or from salt deposits.
Carry out an experiment to electrolyse sodium chloride solution, test the products hydrogen and chlorine and show, using Universal Indicator, that the solution becomes alkaline.	Recall that the electrolysis of concentrated sodium chloride gives chlorine and hydrogen. Describe that the chemical test for chlorine is that it bleaches moist litmus paper.
Survey the range of products formed from salt.	Understand that sodium chloride is used: • as a preservative • as a flavouring. Understand that sodium chloride is an important source of chlorine and sodium hydroxide. Recall that household bleach, pvc and solvents are made from substances derived from salt. Recall that chlorine is used to sterilise water and to make solvents, household bleach and plastics. Recall that hydrogen is used in the manufacture of margarine. Recall that sodium hydroxide is used to make soap.

Module C2: Chemical Resources

Item C2h: Chemicals from the Sea: The Chemistry of Sodium Chloride

Links to other modules: C2d Metals and Alloys, C2e Cars for Scrap, C3f Electrolysis, C4h How Pure is Our Water?, C5b Electrolysis

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe how salt can also be mined as rock salt and by solution mining in Cheshire. Explain that mining for salt can lead to subsidence.	
Describe the key features of the electrolysis of concentrated sodium chloride solution (brine): • hydrogen made at the cathode • chlorine made at the anode • sodium hydroxide is also made • use of inert electrodes.	Explain how the electrolysis of sodium chloride solution (brine) produces sodium hydroxide, hydrogen and chlorine: • cathode $2H^+ + 2e^- \rightarrow H_2$ • reduction is the gain of electrons • anode $2Cl^- - 2e^- \rightarrow Cl_2$ • oxidation is the loss of electrons • ions not discharged make sodium hydroxide.
Describe that household bleach is made by reacting sodium hydroxide and chlorine.	

Module C3: Chemical Economics

Item C3: Fundamental Chemical Concepts

Summary: Throughout the study of chemistry in GCSE science there are a number of ideas and concepts that are fundamental. These ideas and concepts have not been put into a particular item but should permeate through all the GCSE chemistry modules C1 to C6.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
These learning outcomes are intended to be taught throughout this specification.	Describe that in a chemical reaction reactants are changed into products. Recognise the reactants and products in a word equation. Construct word equations given the reactants and products.
These learning outcomes are intended to be taught throughout this specification.	Recognise the reactants and the products in a symbol equation.
These learning outcomes are intended to be taught throughout this specification.	Deduce the number of elements in a compound given its formula. Deduce the number of atoms in a formula with no brackets. Deduce the number of each different type of atom in a formula with no brackets.
These learning outcomes are intended to be taught throughout this specification.	Recognise whether a substance is an element or a compound from its formula. Deduce the names of the different elements in a compound given its formula
These learning outcomes are intended to be taught throughout this specification.	Understand that a molecule is made up of more than one atom joined together. Explain that a molecular formula shows the numbers and types of atom in a molecule. Deduce the number of atoms in a displayed formula. Deduce the names of the different elements in a compound given its displayed formula. Deduce the number of each different type of atom in a displayed formula.
These learning outcomes are intended to be taught throughout this specification.	Recognise whether a particle is an atom, molecule or ion given its formula Understand that atoms contain smaller particles one of which is a negative electron
These learning outcomes are intended to be taught throughout this specification.	Describe that atoms in a compound are held together by chemical bonds

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Module C3: Chemical Economics

Item C3: Fundamental Chemical Concepts
Links to other modules: C1 to C6

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Construct balanced symbol equations given the formulae (no brackets) of the reactants and products. Explain that a symbol equation is balanced when the number of each type of atom is the same on both sides of an equation.	Construct balanced symbol equations given the formulae (some or all with brackets) of the reactants and products. Construct balanced symbol equations given the names of the reactants and products (limited to the learning outcomes in C3).
Deduce the number of atoms in a formula with brackets. Deduce the number of each type of different atom in a formula with brackets. Recall the formula of the following substances: • calcium carbonate • carbon dioxide, hydrogen and water. • hydrochloric acid	Recall the formula of the following substances: • sulfuric acid • calcium chloride, magnesium chloride and magnesium sulfate
Explain that a displayed formula shows both the atoms and the bonds in a molecule. Write the molecular formula of a compound given its displayed formula.	Construct balanced equations using displayed formulae.
Understand that positive ions are formed when electrons are lost atoms Understand that negative ions are formed when electrons are gained by atoms	
Recall that two types of chemical bond holding atoms are • ionic bonds • covalent bonds	Describe that an ionic bond is the attraction between a positive ion and a negative ion Describe that a covalent bond is a shared pair of electrons

Module C3: Chemical Economics

Item C3a: Rate of Reaction (1)

Summary: Explosions are impressive examples of very fast reactions. This item develops the ideas about how the rate of a reaction can be determined by means of practical work.

Suggested activities and practical activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Video clips of fires, rusting and explosions to illustrate different rates of reaction.	Recognise that some reactions can be fast and others very slow: • rusting is a slow reaction • burning and explosions are very fast reaction.
Investigate the rate of reaction of magnesium ribbon and dilute hydrochloric acid by measuring reaction time. Investigate the rate of the reaction of sodium thiosulfate and dilute hydrochloric acid by measuring reaction time.	Recognise that the fastest reaction has the shortest reaction time (or vice versa). Plot experimental results involving reaction times on a graph with the labelled axes provided.
Investigate the rate of reaction of magnesium ribbon or calcium carbonate and dilute hydrochloric acid using gas syringe to collect gas. Investigate the rate of reaction of calcium carbonate and dilute hydrochloric acid using mass loss	Label the laboratory apparatus needed to measure the rate of reaction producing a gas: • gas syringe • flask. Interpret data in table, graphical and written form involving the rate of reaction for example: • reading off values from a graph • recognising the fastest reaction by comparing gradients of graphs • recognising the shortest reaction time and hence the fastest reaction. Plot experimental results involving gas volumes or mass loss on a graph with the labelled axes provided
	Explain that a reaction stops when one of the reactants is all used up.

Module C3: Chemical Economics

Item C3a: Rates of Reaction (1)

Links to other modules: C3b Faster or Slower (2), C3c Faster or Slower (3), Cxx Making Ammonia – Haber Process and Costs, Cxx Gas Volumes, Cxx Equilibria

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe that the rate of a reaction measures how much product is formed in a fixed time period	Use the following units for the rate of reaction: • g/s or g/min • cm^3/s or cm^3/min.
Interpret data in table, graphical and written form involving reaction times.	
Interpret data in table, graphical and written form involving rate of reaction for example: • deciding when a reaction has finished • comparing the rate of reaction during a reaction • deciding when the rate of reaction is the greatest.	Interpret data from table, graphical and written form involving rate of reaction for example: • calculating the rate of reaction from the slope of an appropriate graph • extrapolation • interpolation.
Describe that the amount of product formed depends on the amount of reactant used: • amount of product is directly proportional to the amount of reactant. Explain that the limiting reactant is the reactant not in excess that is all used up at the end of the reaction	Explain that the amount of product formed depends on the amount of limiting reactant used: • more reactant means more reactant particles and so more of these particles react making more product particles.

Module C3: Chemical Economics

Item C3b: Rate of Reaction (2)

Summary: This item develops the ideas of rate of reaction including the collision theory model. The effect of changing temperature, concentration and pressure on the rate of reaction are considered by means of practical work.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
ICT simulations involving collisions between particles.	Recognise that a chemical reaction takes place when particles collide.
Investigate the rate of reaction using magnesium ribbon or calcium carbonate and different temperatures of dilute hydrochloric acid.	Describe the effect of changing temperature on the rate of a chemical reaction: • rate increases as temperature increases • rate decreases as temperature decreases.
Investigate the rate of reaction using magnesium ribbon or calcium carbonate and with different concentrations of hydrochloric acid. Investigate the rate of reaction of sodium thiosulfate with dilute hydrochloric acid (disappearing cross experiment)	Describe the effect of changing the concentration on the rate of a chemical reaction: • rate increases as concentration increases • rate decreases as concentration decreases.
Look at the application of rate of reaction in everyday life (eg speed of cooking with pressure cooker, slowing rusting, rate of dissolving tablets for medicinal use).	Describe the effect of changing the pressure on the rate of a chemical reaction of gases: • rate increases as pressure increases • rate decreases as pressure decreases.
Investigate the rate of reaction using magnesium ribbon or calcium carbonate and dilute hydrochloric acid using gas syringe to collect gas.	Interpret data in table, graphical and written form involving the effect of temperature, concentration and pressure on the rate of reaction for example: • reading off values from a graph • recognising the fastest reaction by comparing gradients of graphs • recognising the shortest reaction time and hence the fastest reaction.

Module C3: Chemical Economics

Item C3b: Rate of Reaction (2)

Links to other modules: C3a Faster or Slower (1), C3c Faster or Slower (3), Cxx Making Ammonia – Haber Process and Costs, Cxx Gas Volumes, Cxx Equilibria

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain that the more collisions between particles the faster the reaction.	Explain that the rate of reaction depends on the: • collision frequency of reacting particles • energy transferred during the collision(whether the collision is successful or effective).
Explain that an increase in temperature makes particles move faster so they have more energy, and that this gives an increased rate of reaction (and vice versa).	Explain that an increase in temperature results in more effective, successful or energetic collisions per second (and vice versa).
Explain that increasing the concentration increases the rate of a reaction because there are more particles in the same volume (more crowded) and so there are more collisions (and vice-versa).	Explain that increasing the concentration increases the rate of a reaction by increasing the frequency of collisions between particles (and vice versa).
Explain that increasing the pressure of a reaction between gases increases the rate of a reaction because there are more particles in the same volume (more crowded) and so there are more collisions (and vice-versa).	Explain that increasing the pressure of a reaction between gases increases the rate of a reaction involving gases by increasing the frequency of collisions between particles (and vice versa).
Interpret data in table, graphical and written form involving the effect of concentration and temperature on the rate of reaction for example: • deciding when a reaction has finished • comparing the rate of reaction during a reaction • deciding when the rate of reaction is the greatest. Draw sketch graphs to show the effect of changing temperature, concentration or pressure on: • rate of reaction • amount of product formed in a reaction.	Interpret data from table, graphical and written form involving the effect of temperature and concentration on the rate of reaction for example: • calculating the rate of reaction from the slope of an appropriate graph • extrapolation • interpolation.

Module C3: Chemical Economics

Item C3c: Rate of Reaction (3)

Summary: Explosions are impressive examples of very fast reactions. This item develops the ideas of rate of reaction including collision frequency. The effect of changing surface area and catalysts on the rate of reaction are considered by means of practical work.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Class practical to investigate catalysis using hydrogen peroxide and metal oxide catalysts or zinc and dilute hydrochloric acid with a variety of possible catalysts including copper and copper compounds.	Describe that the rate of a reaction can be increased by the addition of a catalyst.
Investigate surface area using magnesium powder and ribbon with acid or marble chips or powder with acid.	Describe that the rate of a reaction can be increased by using powdered reactant rather than a lump (or vice versa).
Watch a video on flour/lycopodium explosions. Video clips of other explosions eg knocking down a building, explosion in a quarry. Demonstrate explosive reactions (cornflour or custard powder)	Recall examples of explosions: • burning hydrogen • custard powder explosion • TNT or dynamite explosion.
Look at the application of rate of reaction in everyday life (eg resin and hardener in a car body filler, catalytic converters)	Interpret data in table, graphical and written form involving the effect of surface area and the addition of a catalyst on the rate of reaction for example: • reading off values from a graph • recognising the fastest reaction by comparing gradients of graphs • recognising the shortest reaction time and hence the fastest reaction.

Module C3: Chemical Economics

Item C3c: Rate of Reaction (3)

Links to other modules: C3a Faster or Slower (1), C3b Faster or Slower (2), Cxx Making Ammonia – Haber Process and Costs, Cxx Gas Volumes, Cxx Equilibria

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe a catalyst as a substance which changes the rate of reaction and is unchanged at the end of the reaction. Explain that only a small amount of a catalyst is needed to catalyse large amounts of reactants.	Recognise that a catalyst is specific to a particular reaction.
Explain that a powder has a larger surface area than a lump and so reacts faster because there are more collisions.	Explain that an increase in surface area increases the frequency of collisions.
Describe an explosion as a very fast reaction which releases a large volume of gaseous products.	Explain the dangers of fine combustible powders in factories (eg custard powder, flour or sulfur).
Interpret data in table, graphical and written form involving the effect of surface area and the addition of a catalyst on the rate of reaction: • deciding when a reaction has finished • comparing the rate of reaction during a reaction • deciding when the rate of reaction is the greatest. Draw sketch graphs to show the effect of changing surface area and the addition of a catalyst on the: • rate of reaction • amount of product formed in a reaction.	Interpret data from table, graphical and written form involving surface area and the addition of a catalyst on the rate of reaction: • calculating the rate of reaction from the slope of an appropriate graph • extrapolation • interpolation.

Module C3: Chemical Economics

Item C3d: Reacting Masses

Summary: Quantitative aspects of chemistry involving relative atomic mass are introduced. Relative atomic masses are used to calculate relative formula masses. Balanced symbol equations are used quantitatively to calculate reacting masses and to predict the mass of product that should be formed in a reaction.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Looking at the periodic table to find relative atomic masses. Relative formula mass (Mr) calculations.	Look up relative atomic masses using the periodic table. Calculate the relative formula mass of a substance from its formula (no brackets) given the appropriate relative atomic masses.
Class experiment to confirm the principle of conservation of mass using precipitation reactions such as sodium hydroxide solution with copper(II) sulfate solution.	Understand that the total mass of reactants at the start of a reaction is equal to the total mass of products made and that this is called the principle of conservation of mass.
Class experiment to find out the relationship between mass of malachite and mass of copper oxide that can be obtained from it – opportunity to use spreadsheets for analysis of results.	Use the principle of conservation of mass to calculate mass of reactant or product for example: • mass of gaseous product formed during decomposition • mass of oxygen that reacts with a known mass of magnesium to make magnesium oxide. Recognise and describe the connection between the mass of reactant and the mass of product formed: • more reactant gives more product • less reactant gives less product

Module C3: Chemical Economics

Item C3d: Reacting Masses

Links to other modules: C3e Percentage yield and atom economy, C5x and C5x

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Calculate the relative formula mass of a substance from its formula (with brackets) given appropriate relative atomic masses.	
Use provided relative formula masses and a symbol equation (1:1 molar ratio) to show that mass is conserved during a reaction.	Use relative formula masses and a provided symbol equation to show that mass is conserved during a reaction. Explain that mass is conserved in chemical reactions because: • there are the same number and type of atom on each side of the equation • atoms are not created or destroyed during a chemical reaction.
Recognise and describe that the mass of reactant is directly proportional to the mass of product formed. Use simple ratios to calculate reacting masses and product masses given the mass of a reactant and a product.	Interpret chemical equations quantitatively. Calculate masses of products or reactants from balanced symbol equations using relative formula masses.

Module C3: Chemical Economics

Item C3e: Percentage yield and atom economy

Summary: Percentage yield and atom, economy are two important concepts that help the chemical industry make their processes more sustainable and green. This item shows how to calculate these two quantities and shows their importance to the chemical industry.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Preparation of ammonium sulfate or other salts	Describe percentage yield as a way of comparing amount of product made (actual yield) to amount expected (predicted yield): • 100% yield means that no product has been lost • 0% yield means that no product has been made.
Class practical preparation of magnesium sulfate from a variety of starting materials (magnesium, magnesium oxide, magnesium hydroxide or magnesium carbonate) – comparison of percentage yield and atom economy	Describe atom economy as a way of measuring the amount of atoms that are wasted when manufacturing a chemical: • 100% atom economy means that all atoms in the reactant have been converted to the desired product • the higher the atom economy the ‘greener’ the process
	Interpretation of percentage yield and atom economy data

Module C3: Chemical Economics

Item C3e: Percentage yield and atom economy
Links to other modules: C3d Reacting Masses, C5x and C5x

Assessable learning outcomes both tiers: standard demand	**Assessable learning outcomes Higher Tier only: high demand**
Recall and use the formula: • percentage yield = $\frac{\text{actual yield}}{\text{predicted yield}} \times 100$ Calculate percentage yield given ‘actual yield’ and ’predicted yield’. Recognise possible reasons (given experimental details) why the percentage yield of a product is less than 100% for example: • loss in filtration • loss in evaporation • loss in transferring liquids • loss in heating.	Explain that an industrial process wants as high a percentage yield as possible to reduce wasting reactants and reduce cost.
Recall and use the formula: • atom economy = $\frac{\text{Mr of desired products}}{\text{sum of Mr of all products}} \times 100$ Calculate atom economy given balanced symbol equation (1:1 molar ratio) and appropriate relative formula masses.	Calculate atom economy given balanced symbol equation and appropriate relative formula masses. Explain that an industrial process wants as high an atom economy as possible to reduce the formation of unwanted products and make the process more sustainable.
Interpretation of percentage yield and atom economy data	Interpretation of percentage yield and atom economy data Explain using the balanced symbol equation why a process has: • a 100% atom economy • less than 100% atom economy.

Module C3: Chemical Economics

Item C3f: Energy

Summary: This item develops ideas about how the amount of energy released during a chemical reactions such as combustion can be measured. Ideas about bond forming and bond breaking are used to explain why reactions are exothermic or endothermic

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Carry out experiments to find out about exothermic and endothermic reactions (with the option of using data loggers).	Recognise that chemical reactions can be used to heat things, to make light, sound and electricity. Recognise that energy can be given out or taken in during a chemical reaction. Recognise that an energy change has taken place by using temperature changes.
Compare the energy output from a blue and from a yellow Bunsen flame. Measure the energy released per gram during the combustion of butane and the combustion of some liquid fuels – possible use of spreadsheets to analyse results.	Recall that energy is measured in joules or kilojoules and temperature in °C. Label the apparatus needed to compare the energy output of liquid or gaseous fuels. Interpret and use data from simple calorimetric experiments related to the combustion of fuels: • calculating temperature changes • comparing which fuel releases the most energy (mass of water used constant).

Module C3: Chemical Economics

Item C3f: Energy

Links to other modules: C1x Using Carbon Fuels, C6b Energy Transfers – Fuel Cells, P1x Heating Houses, P1x Keeping Homes Warm

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe an exothermic reaction as one in which energy is transferred into the surroundings (releases energy). Describe an endothermic reaction as one in which energy is taken from the surroundings (absorbs energy). Recognise exothermic and endothermic reactions using temperature changes.	Describe bond making as an exothermic process. Describe bond breaking as an endothermic process. Explain why a reaction is exothermic or endothermic using the energy changes that occur during bond breaking and bond making.
Describe, using a diagram, a simple calorimetric method for comparing the energy transferred in combustion reactions: • use of spirit burner or a bottled gas burner • heating water in a copper calorimeter • measuring the temperature change • fair tests. Interpret and use data from simple calorimetric experiments related to the combustion of fuel to compare which fuel releases the most energy.	Describe a simple calorimetric method for comparing the energy transferred per gram of fuel combusted: • use of spirit burner or a bottled gas burner • heating water in a copper calorimeter • measuring mass of fuel burnt • measuring temperature change • fair and reliable tests. Calculate the energy transferred by using the formula (no recall needed): • energy transferred (in J) = m x c x ΔT • where m = mass of water heated • c = specific heat capacity (4.2) • ΔT = temperature change. Calculate the energy output of a fuel in J/g by recalling and using the formula: energy per gram = $\frac{\text{energy released (in J)}}{\text{mass of fuel burnt (in g)}}$

Module C3: Chemical Economics

Item C3g: Batch or Continuous?

Summary: Speciality chemicals such as pharmaceutical drugs are widely used in our society. This item looks at how speciality chemicals are developed, tested and marketed. It also describes the differences between batch manufacture used for speciality chemicals and continuous manufacture used for making substances such as ammonia.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Industrial case studies. See www.atworkwithsicence.com	Describe that chemicals are made all the time in a continuous process. Understand that ammonia and sulfuric acid are manufactured in continuous processes. Describe that chemicals in a batch process are made on demand and not all the time. Understand that speciality chemicals such as pharmaceuticals are made in batch processes
Industrial case studies.	Describe the factors that affect the cost of making and developing a pharmaceutical drug: • research and testing • labour costs • energy costs • raw materials • time taken for development • marketing.
Practical extraction of a natural oil from a plant. Research plants and animals used as source of drugs.	Understand that the raw materials for speciality chemicals such as pharmaceuticals can be either made synthetically or extracted from plants.

Module C3: Chemical Economics

Item C3g: Batch or Continuous?

Links to other modules: C2x Making Ammonia – Haber Process and Costs, C5x Equilibria and C6d Alcohols

<table>
<tr><th>Assessable learning outcomes
both tiers: standard demand</th><th>Assessable learning outcomes
Higher Tier only: high demand</th></tr>
<tr><td>Describe the differences between a batch and a continuous process
Explain why batch processes are often used for the relatively small scale production of pharmaceutical drugs but continuous processes are used to produce chemicals needed in large amounts</td><td>Evaluate the advantages and disadvantages of batch and continuous manufacturing processes given relevant data and information.</td></tr>
<tr><td>Describe the factors contributing to the high costs involved in making and developing a new pharmaceutical drug:
often more labour intensive
less automation possible
research and testing may take many years
raw materials could be rare and/or expensive
legislative demands.</td><td>Explain how economic considerations determine the development of new drugs in relation to:
research and development time and associated labour costs
time required to meet legal requirements including timescale for testing and human trials
anticipated demand for new product
length of pay back time for initial investment before patent expiry.</td></tr>
<tr><td>Describe how chemicals are extracted from plant sources:
crushing
boiling and dissolving in suitable solvent
chromatography.</td><td></td></tr>
</table>

Module C3: Chemical Economics

Item C3h: Allotropes of carbon and Nanochemistry

Summary: Electronic devices are becoming smaller each year due to the introduction of nanotechnology. Nanotubes can be made from Fullerenes which are allotropes of carbon. This item describes the structure, properties and uses of three allotropes of carbon and some of the new applications of nanotubes.

Suggested practical and research activities to select from	**Assessable learning outcomes Foundation Tier only: low demand**
Examine and compare the structures of diamond, graphite and Buckminster fullerene. Research the discovery of Buckminster fullerene.	Recall that three forms of carbon are: • diamond • graphite • Buckminster fullerene (bucky balls).
	Describe the physical properties of diamond: • lustrous, colourless and clear (transparent) • hard and has a high melting point • insoluble in water • does not conduct electricity. Describe that diamond is used in cutting tools and jewellery.
Examine samples of graphite.	Describe the physical properties of graphite: • black, lustrous and opaque • slippery • insoluble in water • conducts electricity. Describe that graphite is used as an electrode, in pencil leads and in lubricants.
Build models of fullerenes and nanotubes. (RSC – Contemporary chemistry for schools and colleges has useful worksheets etc). Survey of uses of fullerenes (via Internet).	Describe that fullerenes can be joined together to make nanotubes. Recall that nanotubes: • are very strong • conduct electricity.

Module C3: Chemical Economics

Item C3h: Allotropes of carbon and Nanochemistry
Links to other modules:

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Recognise the structures of diamond, graphite and Buckminster fullerene. Recognise that allotropes are different forms of the same element in the same physical state	Explain why diamond, graphite and fullerenes are allotropes of carbon.
Explain that diamond is used in cutting tools because it is very hard and has a high melting point. Explain that diamond is used in jewellery because it is lustrous and colourless.	Explain the properties of diamond in terms of its structure: • does not conduct electricity since it has no free electrons • hard and has a high melting point because of the presence of many strong covalent bonds that need lots of energy to break.
Explain that graphite is used in pencil leads because it is slippery and black. Explain that graphite is used in lubricants because it is slippery. Explain that graphite is used as an electrode in electrolysis because it conducts electricity and has a high melting point.	Explain the properties of graphite in terms of its structure: • conducts electricity because it has delocalised electrons that can move • slippery because the layers of carbon atoms are weakly held together and can slide easily over each other • high melting point because there are many strong covalent bonds that need lots of energy to break.
Recall that Buckminster fullerene has the formula C_{60}. Describe some uses of nanotubes: • semiconductors in electrical circuits • industrial catalysts • reinforce graphite in tennis rackets.	Describe the use of fullerenes to 'cage' other molecules. Describe the use of 'caged molecules' in new drug delivery systems. Explain the use of nanotubes as catalysts: • catalyst can be attached to surface of nanotube • large surface area available.

Module C4: The Periodic Table

Item C4: Fundamental Chemical Concepts

Summary: Throughout the study of chemistry in GCSE science there are a number of ideas and concepts that are fundamental. These ideas and concepts have not been put into a particular item but should permeate through all the GCSE chemistry modules C1 to C6.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
These learning outcomes are intended to be taught throughout this specification.	Describe that in a chemical reaction reactants are changed into products. Recognise the reactants and products in a word equation. Construct word equations given the reactants and products.
These learning outcomes are intended to be taught throughout this specification.	Recognise the reactants and the products in a symbol equation.
These learning outcomes are intended to be taught throughout this specification.	Deduce the number of elements in a compound given its formula. Deduce the number of atoms in a formula with no brackets. Deduce the number of each different type of atom in a formula with no brackets.
These learning outcomes are intended to be taught throughout this specification.	Recognise whether a substance is an element or a compound from its formula. Deduce the names of the different elements in a compound given its formula.
These learning outcomes are intended to be taught throughout this specification.	Understand that a molecule is made up of more than one atom joined together. Explain that a molecular formula shows the numbers and types of atom in a molecule. Deduce the number of atoms in a displayed formula. Deduce the names of the different elements in a compound given its displayed formula. Deduce the number of each different type of atom in a displayed formula.
These learning outcomes are intended to be taught throughout this specification.	Recognise whether a particle is an atom, molecule or ion given its formula Understand that atoms contain smaller particles one of which is a negative electron
These learning outcomes are intended to be taught throughout this specification.	Describe that atoms in a compound are held together by chemical bonds

Module C4: The Periodic Table

Item C4: Fundamental Chemical Concepts
Links to other modules: C1 to C6

Assessable learning outcomes both tiers: standard demand	**Assessable learning outcomes Higher Tier only: high demand**
Construct word equations (not all reactants and products given)	
Construct balanced symbol equations given the formulae (no brackets) of the reactants and products. Explain that a symbol equation is balanced when the number of each type of atom is the same on both sides of an equation.	Construct balanced symbol equations given the formulae (some or all with brackets) of the reactants and products. Construct balanced symbol equations given the names of the reactants and products (limited to the learning outcomes in C4).
Deduce the number of atoms in a formula with brackets. Deduce the number of each type of different atom in a formula with brackets. Recall the formula of the following substances: • Sodium chloride and potassium chloride • chlorine, bromine and iodine • water, carbon dioxide and hydrogen	Recall the formula of the following substances: • the oxides of sodium, magnesium, zinc, copper, iron(II) and manganese • magnesium chloride and barium chloride • the carbonates of copper(II), iron(II), zinc and manganese • the hydroxides of sodium, potassium, lithium, copper(II), iron(II) and iron(III) • silver nitrate
Explain that a displayed formula shows both the atoms and the bonds in a molecule. Write the molecular formula of a compound given its displayed formula.	Construct balanced equations using displayed formulae.
Understand that positive ions are formed when electrons are lost atoms Understand that negative ions are formed when electrons are gained by atoms	
Recall that two types of chemical bond holding atoms are • ionic bonds • covalent bonds	Describe that an ionic bond is the attraction between a positive ion and a negative ion Describe that a covalent bond is a shared pair of electrons

Module C4: The Periodic Table

Item C4a: Atomic Structure

Summary: Atomic structure is fundamental to the study of chemistry. This item considers the sub-atomic particles and electronic structures. This item provides the opportunity to develop and use scientific theories, models and ideas. The item also includes how a scientific theory has developed.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Research the models developed for the structure of an atom.	Describe an atom as a nucleus surrounded by electrons. Recall that a nucleus is positively charged, an electron is negatively charged and an atom is neutral. Understand that atoms have a very small mass and a very small size.
Deduce the numbers of protons, electrons and neutrons from atomic numbers and mass numbers.	Identify the atomic number of an element by using a periodic table. Identify the name or symbol of an element given its atomic number using a periodic table.
Identify elements and numbers of atoms of each element from formulae.	Recall that there are just over 100 elements. Describe an element as a substance which: • cannot be broken down chemically • contains the same type of atom. Identify the elements in a compound from its formula, using a periodic table. Describe a compound as a substance that contains at least two elements chemically combined.
Draw electronic structures given atomic numbers.	Describe that electrons occupy the space around the nucleus.
Research or produce a poster of the work of Dalton, J.J. Thomson, Rutherford and/or Bohr. Produce a timeline of events for the development of the theory of atomic structure.	Describe the main stages in the development of atomic structure illustrating the provisional nature of evidence • Dalton's atomic theory (detail not required) • J.J. Thomson (discovery of the electron) • Rutherford (nuclear atom) • Bohr (electron orbits)

Module C4: The Periodic Table

Item C4a: Atomic Structure

Links to other modules:

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Recall that the nucleus is made up of protons and neutrons. Recall the relative charge and relative mass of an electron, a proton and a neutron: • electron charge -1 and mass 0.0005 (zero) • proton charge +1 and mass 1 • neutron charge 0 and mass 1.	Explain that an atom is neutral because it has the same number of electrons as protons. Understand that atoms have a radius of about 10^{-10}m and a mass of about 10^{-23}g
Describe atomic number as the number of protons in an atom. Describe mass number as the total number of protons and neutrons in an atom. Describe isotopes as varieties of an element that have the same atomic number but different mass numbers.	Deduce the number of protons, electrons and neutrons in a particle given its atomic number, mass number and the charge on the particle. • using data in a table • using the conventional symbolism eg carbon-12 or $^{12}_{6}$C. Identify isotopes from data about the number of electrons, protons and neutrons in particles.
Describe that the elements in the periodic table are arranged in ascending atomic number.	
Recall that electrons occupy shells.	Deduce the electronic structure of the first 20 elements in the periodic table eg calcium is 2.8.8.2.
Describe Dalton's atomic theory and how the work of J.J.Thomson, Rutherford and Bohr contributed to the development of the theory of atomic structure. • the theory changed as new evidence was found • science explanations are provisional but more convincing when predictions are later confirmed	Explain the significance of the work of Dalton, J.J. Thomson, Rutherford and Bohr in the development of the theory of atomic structure. • unexpected results (e.g. Geiger and Marsden's experiment) led to the theory of a nuclear atom

Module C4: The Periodic Table

Item C4b: Ionic Bonding

Summary: This item extends the ideas about atomic structure into ionic bonding and the properties of ionic compounds. The experimental investigation of solubility and electrical conductivity allows the opportunity to collect primary data safely and accurately, and to analyse it using quantitative and qualitative methods.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Draw dot and cross diagrams to model ionic bonding.	Understand that an ion is a charged atom or group of atoms. Recognise an ion, an atom and a molecule from given formulae.
Research melting points and boiling points of sodium chloride and magnesium oxide. Experimental investigation of solubility and electrical conductivity of solids and solutions.	Describe that sodium chloride: • has a high melting point • dissolves in water • when solid does not conduct electricity. Describe that magnesium oxide: • has a very high melting point • when solid does not conduct electricity.

Module C4: The Periodic Table

Item C4b: Ionic Bonding
Links to other modules:

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe the formation of positive ions by the loss of electrons from atoms eg: • 2+ ions form by the loss of 2 electrons. Describe the formation of negative ions by the gain of electrons by atoms: • 2- ion formed by the gain of 2 electrons. Explain that, in ionic bonding, a metal and non-metal combine by transferring electrons to form positive ions and negative ions which then attract one another.	Describe, using the "dot and cross" model, the ionic bonding in the following: • sodium chloride • magnesium oxide • sodium oxide • magnesium chloride. Explain that atoms gain or lose electrons to get a complete outer shell (a stable octet). Deduce the formula of an ionic compound from the formula of the positive and negative ions.
Recall that sodium chloride solution conducts electricity. Recall that magnesium oxide and sodium chloride conduct electricity when molten.	Describe the structure of sodium chloride or magnesium oxide as a giant ionic lattice in which positive ions are strongly attracted to negative ions. Explain some of the physical properties of sodium chloride and magnesium oxide: • high melting points because the strong attraction between positive and negative ions has to be overcome • solid will not conduct electricity because ions cannot move in solid • aqueous solution and molten liquid conducts electricity because ions can move in solution or in a molten liquid

Module C4: The Periodic Table

Item C4c: The Periodic Table and Covalent bonding

Summary: This item introduces covalent bonding. It also provides an introduction to the periodic table. This item provides the opportunity to develop and use scientific theories, models and ideas.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Draw electronic structures of covalent molecules. Construct molecular models of covalent compounds.	Describe a molecule as two or more atoms bonded together. Deduce the number of atoms in a molecule given its molecular formula or displayed formula. Deduce the number of each different type of atom in a molecule given its molecular formula or displayed formula. Recall that there are two types of bonding: • ionic bonding • covalent bonding.
Research melting point, boiling point and electrical conductivity of carbon dioxide and water.	Describe carbon dioxide as a gas with a low melting point. Describe water as a liquid with a low melting point.
Quiz to identify different elements, symbols, groups periods etc.	Deduce, using a periodic table, elements that are in the same group. Describe a group of elements as all the elements in a vertical column of the periodic table and that the elements have similar chemical properties.
Quiz to identify different elements, symbols, groups periods etc.	Deduce, using a periodic table, elements that are in the same period. Describe a period of elements as all the elements in a horizontal row of the periodic table.

Module C4: The Periodic Table

Item C4c: The Periodic Table and Covalent bonding
Links to other modules:

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Recall that non-metals combine together by sharing electron pairs and this is called covalent bonding.	Describe the formation of simple molecules containing single and double covalent bonds by the “dot and cross” model, limited to the molecules: • H_2 • Cl_2 • CH_4 • CO_2 • H_2O.
Understand that carbon dioxide and water do not conduct electricity.	Describe carbon dioxide and water as simple molecules with weak intermolecular forces between molecules. Relate the properties of carbon dioxide and water to their structure: • weak intermolecular forces so low melting points • no free electrons so do not conduct electricity.
Recognise that the group number is the same as the number of electrons in the outer shell: • Group 1 elements have 1 electron in the outer shell • Group 7 elements have 7 electrons in the outer shell • Group 8 elements have a full outer shell.	Deduce the group to which an element belongs from its electronic structure (limited to the first 20 elements).
Recognise that the period to which the element belongs corresponds to the number of occupied shells in the electronic structure.	Deduce the period to which the element belongs from its electronic structure.

Module C4: The Periodic Table

Item C4d: The Group 1 Elements

Summary: This item studies the properties of the Group 1 elements. The item links the similarity of their properties to the position of the elements in the periodic table.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Research properties of alkali metals eg using the internet. Demonstrate reactions of sodium, lithium and potassium with water. Show video of reactions of rubidium and caesium with water.	Recall that Group 1 elements are known as the alkali metals. Recognise sodium, lithium and potassium as Group 1 elements. Recognise that Group 1 elements react vigorously with water. Explain that Group 1 elements are stored under oil because they react with air and water. Describe the order of reactivity with water of the Group 1 elements: • potassium is more reactive than sodium • sodium is more reactive than lithium. Construct the word equation for the reaction of a Group 1 element with water (all reactants and products given)
Candidates carry out flame tests on alkali metal chlorides.	Recall the flame test colours for lithium, sodium and potassium compounds. Interpret information about flame tests eg deduce the alkali metal present from flame colours.

Module C4: The Periodic Table

Item C4d: The Group 1 Elements
Links to other modules:

Assessable learning outcomes both tiers: standard demand	**Assessable learning outcomes Higher Tier only: high demand**
Describe the reaction of lithium, sodium and potassium with water: • hydrogen is formed • an alkali is formed which is the hydroxide of the metal • the reactivity with water increases down Group 1 • potassium gives a lilac flame. Construct the word equation for the reaction of a Group 1 element with water. Construct the balanced symbol equation for the reaction of a Group 1 element with water (given all or some formulae).e.g: $2Na + 2H_2O \rightarrow 2NaOH + H_2$	Construct the balanced symbol equation for the reaction of a Group 1 element with water (formulae not given) e.g: $2Na + 2H_2O \rightarrow 2NaOH + H_2$ Predict the properties of Group 1 elements eg: • reactivity of rubidium and/or caesium with water • the physical properties of rubidium and/or caesium given information about the other Group 1 elements.
Recall that the Group 1 elements have one electron in their outer shell. Explain that Group 1 elements have similar properties because they have one electron in their outer shell.	Explain that Group 1 elements have similar properties because when they react, an atom loses one electron to form a positive ion with a stable electronic structure. Construct a balanced symbol equation to show the formation of an ion of a Group 1 element from its atom. Explain that the more reactive the Group 1 element the easier it for an atom to lose one electron. Describe the loss of electrons as oxidation. Explain why a process is oxidation from its ionic equation.
Describe how to carry out a flame test to test for the presence of lithium, sodium and potassium compounds: • use of moistened flame test wire • flame test wire dipped into solid sample • flame test wire put into blue Bunsen flame.	

Module C4: The Periodic Table

Item C4e: The Group 7 Elements

Summary: This item studies the properties of the Group 7 elements. The item links the similarity of their properties to the position of the elements in the periodic table. Researching the properties of the halogens allows the use of ICT as a teaching and learning tool.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Research the physical properties and uses of the halogens	Recall that the Group 7 elements are known as the halogens. Recognise fluorine, chlorine, bromine and iodine as Group 7 elements. Describe the uses of some Group 7 elements: • chlorine is used to sterilise water • chlorine is used to make pesticides and plastics • iodine is used to sterilise wounds.
Demonstrate or show video of reaction of sodium with chlorine also see RSC web-site www.practicalchemistry.org	Recognise that Group 7 elements react vigorously with Group 1 elements. Construct the word equation for the reaction between a Group 1 element and a Group 7 element (product given).
Investigation of displacement reactions of the halogens. (good opportunity for predicting / hypothesising)	Describe the order of reactivity of the Group 7 elements: • fluorine is more reactive than chlorine • chlorine is more reactive than bromine • bromine is more reactive than iodine. Construct the word equation for the reaction between a Group 7 element and a metal halide (reactants and products given).

Module C4: The Periodic Table

Item C4e: The Group 7 Elements
Links to other modules:

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe the physical appearance of the Group 7 elements at room temperature: • chlorine is a green gas • bromine is an orange liquid • iodine is a grey solid.	Predict the properties of fluorine or astatine given the properties of the other Group 7 elements eg • physical properties • melting point • boiling point • displacement reactions.
Describe the reaction between Group 1 elements and Group 7 elements to give metal halides. Identify the metal halide formed when a Group 1 element reacts with a Group 7 element. Construct the word equation for the reaction between a Group 1 element and a Group 7 element (product not given). Construct the balanced symbol equation for the reaction of a Group 1 element with a Group 7 element (some or all formulae given)	Construct the balanced symbol equation for the reaction of a Group 1 element with a Group 7 element (formulae not given)
Recall that the reactivity of the Group 7 elements decreases down the group. Describe the displacement reactions of Group 7 elements with solutions of metal halides: • chlorine displaces bromides and iodides • bromine displaces iodides. Construct the word equation for the reaction between a Group 7 element and a metal halide (not all reactants and products given). Construct balanced symbol equations for the reactions between Group 7 elements and metal halides (some or all formulae given)	Construct balanced symbol equations for the reactions between Group 7 elements and metal halides (formulae not given)
Explain that Group 7 elements have similar properties because they have seven electrons in their outer shell.	Explain that Group 7 elements have similar properties because when they react, an atom gains one electron to form a negative ion with a stable electronic structure. Construct an equation to show the formation of a halide ion from a halogen molecule. Explain that the more reactive the Group 7 element the easier it is for an atom to gain one electron. Describe the gain of electrons as reduction. Explain why a process is reduction from its ionic equation.

Module C4: The Periodic Table

Item C4f: Transition Elements

Summary: This item covers some properties and chemistry of the transition elements and introduces thermal decomposition and precipitation. The experiments on thermal decomposition allow opportunities to collect and analyse science data, working as an individual or in a group, to analyse results and present the information using scientific conventions and symbols.

Suggested practical and research activities to select from	**Assessable learning outcomes Foundation Tier only: low demand**
Show a large number of transition elements and ask pupils to deduce or research their properties.	Identify whether an element is a transition element from its position in the periodic table. Recognise that all transition elements are metals and have typical metallic properties. Deduce the name or symbol of a transition element using the periodic table. Recall that copper and iron are transition elements.
Investigation of thermal decomposition of transition metal carbonates including test for carbon dioxide.	Describe thermal decomposition as a reaction in which a substance is broken down into at least two other substances by heat. Construct word equations for thermal decomposition reactions (all reactants and products given) Describe that the test for carbon dioxide is that it turns limewater milky.
Investigation of precipitation reactions of transition metal ions with sodium hydroxide.	Describe precipitation as a reaction between solutions that makes an insoluble solid.

Module C4: The Periodic Table

Item C4f: Transition Elements
Links to other modules:

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Recall that compounds of transition elements are often coloured: • copper compounds are blue • iron(II) compounds are light green • iron(III) compounds are orange/brown. Recall that transition elements and their compounds are often used as catalysts: • iron in the Haber process • nickel in the manufacture of margarine.	
Describe the thermal decomposition of carbonates of transition elements illustrated by $FeCO_3$, $CuCO_3$, $MnCO_3$ and $ZnCO_3$: • metal oxide and carbon dioxide formed • word equations (not all products given) • colour change occurs (colours not needed).	Construct the balanced symbol equations for the thermal decomposition of: • $FeCO_3$ • $CuCO_3$ • $MnCO_3$ • $ZnCO_3$
Describe the use of sodium hydroxide solution to identify the presence of transition metal ions in solution: • Cu^{2+} gives a blue solid • Fe^{2+} gives a grey/green solid • Fe^{3+}gives an orange/solid solid • the solids are called precipitates.	Construct balanced symbol equations for the reactions between Cu^{2+}, Fe^{2+} and Fe^{3+} with OH^- (without state symbols) given the formulae of the ions.

Module C4: The Periodic Table

Item C4g: Metal Structure and Properties

Summary: Metals are a very important class of materials. This item relates the properties of metals to their structure. The item also includes information on superconductors. The research and data interpretation activities allow the analysing and interpretation of scientific information and the collection of secondary data using ICT.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Research uses of some metals and relate to properties – a poster could be produced.	Describe that iron is used to make steel and to make cars and bridges because it is strong. Describe that copper is used to make brass and to make electrical wiring because it is a good electrical conductor.
Data search or experimental comparison of different metal properties. Data interpretation activity.	Describe the physical properties of metals: • lustrous, hard and high density • high tensile strength • high melting and boiling points • good conductors of heat and electricity. Interpret data about the properties of metals eg hardness, density and electrical conductivity. Recognise that the particles in a metal are held together by metallic bonds.
Internet research into superconductors. Displacement reactions to show metal crystals eg copper in aqueous silver nitrate.. Produce a poster on superconductors. Bubble raft demonstration.	Describe that metals have a structure which contains crystals. Describe that particles in solid metals are close together and in a regular arrangement. Recall that at low temperatures some metals can be superconductors.

Module C4: The Periodic Table

Item C4g: Metal Structure and Properties
Links to other modules:

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Suggest properties needed by a metal for a particular given use eg saucepan bases need to be good conductors of heat. Explain why metals are suited to a given use (data may or may not be provided). Describe that metals have high melting points and boiling points because of strong metallic bonds.	Explain why metals are suited to a given use (data may or may not be provided). Describe metallic bonding as the strong attraction between a sea of delocalised electrons and close packed positive metal ions. Explain that metals often have high melting points and boiling points because of the strong attraction between the electrons and the positive ions which needs to be overcome.
Describe that when metals conduct electricity electrons move. Describe that superconductors are materials that conduct electricity with little or no resistance. Describe the potential benefits of superconductors: • loss free power transmission • super-fast electronic circuits • powerful electromagnets.	Explain that metals conduct electricity because the delocalised electrons can move easily. Explain the drawbacks of superconductors: • only work at very low temperatures so applications are limited • the need to develop superconductors that will work at 20°C.

Module C4: The Periodic Table

Item C4h: Purifying and Testing Water

Summary: Young people see many examples of famine and disaster in the world. Often a lack of pure water is associated with the disaster. This item develops ideas about the importance of clean water both in the United Kingdom and in the developing nations of the world. The purification of water is considered as well as simple ways to test for dissolved substances in water.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Use text-books, video and/or internet and information from local water companies to find out about the water resources in the United Kingdom and the need to conserve water.	Interpret data about water resources in the United Kingdom (no recall is expected). Recall different types of water resources found in the United Kingdom: • lakes • rivers • aquifers • reservoirs. Understand that water is an important resource for many important industrial chemical processes: • a cheap raw material • as a coolant • as a solvent.
Research the pollutants found in water.	Describe some of the pollutants that may be found in domestic water supplies: • nitrate residues • lead compounds • pesticide residues.
Visit a water purification plant. Design a poster to describe the purification of domestic water.	Describe the types of substances present in water before it is purified: • dissolved salts and minerals • microbes • pollutants • insoluble materials. Describe that chlorination kills microbes in water.
Investigate the solution chemistry of some dissolved ions. Preparation of an insoluble salt eg barium sulfate, by precipitation, filtration, washing and drying.	Recall that barium chloride solution is used to test for sulfate ions: • gives a white precipitate. Recall that silver nitrate solution is used to test for halide ions: • chloride ions give a white precipitate • bromide ions give a cream precipitate • iodide ions give a pale yellow precipitate. Construct word equations for the reactions of barium chloride with sulfates and silver nitrate with halides (all reactants and products given).

Module C4: The Periodic Table

Item C4h: Purifying and Testing Water
Links to other modules:

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Interpret data about water resources in the United Kingdom (no recall is expected). Explain why it is important to conserve water.	
Describe the source of pollutants in water: • nitrate from fertiliser run off • lead compounds from lead pipes • pesticide from spraying near to water resources.	
Describe the water purification process to include filtration, sedimentation and chlorination.	Explain the processes involved in water purification. Explain that some soluble substances are not removed from water during purification and that these may be poisonous. Explain the disadvantages of using distillation of sea water to make large quantities of fresh water.
Interpret data about the testing of water with aqueous silver nitrate and barium chloride solutions. Construct word equations for the reactions of barium chloride with sulfates and silver nitrate with halides (not all reactants and products given). Understand that the reactions of barium chloride with sulfates and silver nitrate with halides are examples of precipitation reactions.	Construct balanced symbol equations for the reaction of barium chloride with sulfates and silver nitrate with chlorides given the appropriate formulae.

Module C5: How Much (Quantitative Analysis)

Item C5: Fundamental Chemical Concepts

Summary: Throughout the study of chemistry there are a number of ideas and concepts that are fundamental. These ideas and concepts have not been put into a particular item but should permeate all the Chemistry units. They will be assessed in the context of any of the modules C1 to C6.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
These learning outcomes are intended to be taught throughout this specification.	Describe that in a chemical reaction reactants are changed into products. Recognise the reactants and products in a word equation. Construct word equations given the reactants and the products.
These learning outcomes are intended to be taught throughout this specification.	Recognise the reactants and products in a symbol equation.
These learning outcomes are intended to be taught throughout this specification.	Deduce the number of elements in a compound given its formula. Deduce the number of atoms in a formula with no brackets. Deduce the number of each different type of atom in a formula with no brackets.
These learning outcomes are intended to be taught throughout this specification.	Recognise whether a substance is an element or a compound from its formula. Deduce the names of the different elements in a compound given its formula
These learning outcomes are intended to be taught throughout this specification.	Understand that a molecule is made up of more than one atom joined together. Explain that a molecular formula shows the number and type of atom in a molecule. Deduce the number of atoms in a displayed formula. Deduce the names of the different elements in a compound given its displayed formula. Deduce the number of each different type of atom in a displayed formula.
These learning outcomes are intended to be taught throughout this specification.	Recognise whether a particle is an atom, molecule or ion given its formula. Understand that atoms contain smaller particles one of which is a negative electron
These learning outcomes are intended to be taught throughout this specification.	Describe that atoms in a compound are held together by chemical bonds

Module C5: How Much (Quantitative Analysis)

Item C5: Fundamental Chemical Concepts
Links to other modules: C1 to C6

Assessable learning outcomes both tiers: standard demand	**Assessable learning outcomes Higher Tier only: high demand**
Construct balanced symbol equations given the formulae (no brackets) of the reactants and products. Explain that a symbol equation is balanced when the number of each type of atom is the same on both sides of an equation.	Construct balanced symbol equations given the formulae (some or all with brackets) of the reactants and products. Construct balanced symbol equations given the names of the reactants and products (limited to the learning outcomes in C5).
Deduce the number of atoms in a formula with brackets. Deduce the number of each type of different atom in a formula with brackets. Recall the formula of the following substances: • hydrochloric acid and ethanoic acid • carbon dioxide, hydrogen and water • sodium chloride and potassium chloride • ammonia and calcium carbonate	Recall the formula of the following substances: • sulfuric acid and nitric acid • sodium hydroxide, potassium hydroxide and magnesium carbonate • sodium sulfate, potassium sulfate, magnesium sulfate and barium sulfate • lead(II) nitrate and lead iodide • potassium iodide and potassium nitrate.
Explain that a displayed formula shows both the atoms and the bonds in a molecule. Write the molecular formula of a compound given its displayed formula.	Construct balanced equations that use displayed formulae.
Understand that positive ions are formed when electrons are lost atoms Understand that negative ions are formed when electrons are gained by atoms	
Recall that two types of chemical bond holding atoms are • ionic bonds • covalent bonds	Describe that an ionic bond is the attraction between a positive ion and a negative ion Describe that a covalent bond is a shared pair of electrons

Module C5: How Much (Quantitative Analysis)

Item C5a: Moles and Molar mass

Summary: This item develops the concept of relative formula mass into the scientific measure for the amount of a substance, moles. The mole concept will be used as an alternative way to calculate reacting masses.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Review relative formula mass calculations. Molar mass calculations.	Recall that the unit for the amount of a substance is the mole. Describe the molar mass of substance as its relative formula mass in grams. Calculate the molar mass of a substance from its formula (without brackets) using the appropriate relative atomic masses. Recall that the unit for molar mass is g/mol.
Carry out an experiment to measure the increase in mass on complete oxidation of magnesium ribbon in a crucible. Class practical involving the mass changes when carbonates are heated	Understand that mass is conserved during a chemical reaction. Interpret experimental results involving mass changes during chemical reactions. Use understanding of conservation of mass to carry out very simple calculations: • mass of gas or water lost during thermal decomposition • mass of gas gained during reaction • determine a reacting amount for a simple reaction given all the other reacting amounts.

Module C5: How Much (Quantitative Analysis)

Item C5a: Moles and Molar mass

Links to other modules: C1x Cooking, C3d Reacting masses, C5c Quantitative Analysis, C5d Titrations, C5e Gas Volumes

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Calculate the molar mass of a substance from its formula (with brackets) using the appropriate relative atomic masses.	Recall and use the relationship between molar mass, number of moles and mass: • number of moles = mass ÷ molar mass • determine the number of moles of an element from the mass of that element • determine the number of moles of a compound from the mass of that compound • determine the masses of the different elements present in a given number of moles of a compound. Describe that the relative atomic mass of an element is the average mass of an atom of the element compared to the mass of 1/12th of an atom of carbon-12.
Given a set of reacting masses, calculate further reacting amounts by simple ratio.	Calculate mass of products and / or reactants using the mole concept from a given balanced equation and the appropriate relative atomic masses.

Module C5: How Much (Quantitative Analysis)

Item C5b: Percentage composition and empirical formula

Summary: Every compound has a fixed percentage composition by mass and this composition can be used to identify an unknown sample. This item shows how the mole concept and percentage composition can be used to determine the simplest or empirical formula of a compound.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Carry out an experiment to measure the increase in mass on complete oxidation of magnesium ribbon in a crucible. Can also see www.practicalchemistry.org Carry out an experiment to measure the decrease in mass on reduction of copper oxide eg reduction with methane gas. Can also see www.practicalchemistry.org	Determine the mass of an element in a known mass of compound given the masses of the other elements present.
Carry out an experiment to determine the percentage of water of crystallisation in a sample of hydrated salt. Research the percentage by mass of essential elements in fertilisers	Calculate the molar mass of a substance from its formula (without brackets) using the appropriate relative atomic masses.

Module C5: How Much (Quantitative Analysis)

Item C5b: Percentage composition and empirical formula
Links to other modules: C5a Moles and molar mass

Assessable learning outcomes both tiers: standard demand	**Assessable learning outcomes Higher Tier only: high demand**
Understand that an empirical formula gives the simplest whole number ratio of each type of atom in a compound. Deduce the empirical formula of a compound given its chemical formula. Calculate the percentage by mass of an element in a compound given appropriate experimental data about the mass of the element and the mass of the compound.	Explain that an empirical formula gives the simplest whole number ratio of each type of atom in a compound. Recall and use the relationship between molar mass, number of moles and mass: • number of moles = mass ÷ molar mass. Determine the number of moles of an element from the mass of that element. Calculate empirical formula of a compound from the: • percentage composition by mass • mass of each element in a sample of the compound.
Calculate the molar mass of a substance from its formula (with brackets) using the appropriate relative atomic masses.	Calculate the percentage by mass of an element in a compound given its formula and the appropriate atomic masses.

Module C5: How Much (Quantitative Analysis)

Item C5c: Quantitative Analysis

Summary: An understanding of quantities and concentrations is important for everyday tasks in the home as well as being vital for medical and other technological applications. Performing calculations involving concentration develops the skill of analysing scientific information quantitatively.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
ICT simulations about concentration.	Recall that concentration of solutions may be measured in g/dm^3 (g per dm^3). Recall that concentration of solutions may be measured in mol/dm^3 (mol per dm^3). Recall that volume is measured in dm^3 or cm^3. Recall that 1000 cm^3 equals 1 dm^3.
Follow simple instruction to dilute solutions by specified amounts.	Describe how to dilute a concentrated solution.
Survey everyday examples of dilution eg: • dilution of concentrated orange juice • dilution of windscreen wash fluid for different temperatures • dilution of liquid medicines.	Explain the need for dilution in areas such as food preparation, medicine and baby milk: • concentrated orange cordial needs to be diluted to make sure the taste is not too strong • medicines may need to be diluted to avoid giving overdoses • baby milk must be of the correct concentration so as not to harm the baby.
Survey information on food packaging with particular regard to GDA values.	Interpret information on food packaging about guideline daily amounts for example: • the smallest or largest amount of a particular substance.

Module C5: How Much (Quantitative Analysis)

Item C5c: Quantitative Analysis

Links to other modules: C5a Moles and Molar mass, C5b Percentage Composition and Empirical Formulae , C5x Titrations, C5x Gas Volumes

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Understand that the more concentrated a solution the more solute particles there are in a given volume (the more crowded the solute particles). Convert volume in cm^3 into dm^3 or vice versa.	Recall and use the relationship between the amount in moles, concentration in mol/dm^3 and volume in dm^3: • amount in moles = concentration × volume • concentration = amount in moles ÷ volume • volume = amount in moles ÷ concentration.
Perform calculations involving concentration for simple dilutions of solutions eg how to dilute a 1.0 mol/dm^3 solution into a 0.1 mol/dm^3 solution.	
Interpret information on food packaging about guideline daily amounts for example: • percentage of GDA in a portion.	Interpret more complex food packaging information and its limitations for example: • convert amounts of sodium to amounts of salt • understand that sodium ions may come from several sources, so the above conversion may be inaccurate.

Module C5: How Much (Quantitative Analysis)

Item C5d: Titrations

Summary: Titrations are the historical backbone of so many analytical procedures. Whilst instrumental techniques have now removed much of the need for repetitive titrations, it is the technique that chemists often fall back on for 'one off' analysis. This item will enable students to perform acid-base titrations and use the results for volumetric analysis.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Demonstrate or carry out an investigation to find out how pH changes during the neutralisation of an alkali with an acid (pH titration curve) using a strong acid and using a pH meter.	Describe the changes in pH of a reaction mixture when an acid reacts with an alkali: • pH decreases when acid is added to alkali • pH increases when alkali is added to a acid • interpret a simple pH curve • determine the pH at a particular volume added or vice versa (major grid lines).
Carry out a simple acid-alkali titration using an indicator such as litmus or phenolphthalein Microscale titrations details from RSC web-site www.practicalchemistry.org.	Label or identify the apparatus used in an acid-base titration: • burette and conical flask • pipette and pipette filler. Describe the procedure for carrying out a simple acid-base titration: • acid in burette, alkali in pipette (or vice versa) • acid slowly added to alkali (or vice versa) until end point is reached • end point detected by the change in colour of an indicator. Calculate the titre given appropriate information from tables or diagrams.
Simple investigation of the colour changes of indicators limited to universal indicator, phenolphthalein and litmus during neutralisation. Universal indicator rainbow see details from RSC web-site www.practicalchemistry.org	Describe the colours of the following indicators in acids and alkalis: • universal indicator, litmus and phenolphthalein.

Module C5: How Much (Quantitative Analysis)

Item C5d: Titrations

Links to other modules: C4a Acids and Bases, C5a Moles and Empirical Formulae, C5c Quantitative, C5e Gas Volumes, C5g Strong and Weak Acids

Assessable learning outcomes both tiers: standard demand	**Assessable learning outcomes Higher Tier only: high demand**
Recall that there is a sudden change in pH at the end point of a titration. Explain why the pH changes during the reaction of an acid with an alkali: • neutralisation • acid + alkali → salt + water. Interpret a simple pH curve: • determine the volume of acid or alkali at neutralisation • determine the pH when a particular volume added or vice versa (not major grid lines). Explain how universal indicator can be used to estimate the pH value of a solution	Sketch a pH titration curve for the titration of an acid or an alkali.
Explain the need for several consistent titre readings in titrations.	Calculate the concentration of an acid or alkali from titration results, limited to examples involving a one to one molar ratio (acid:alkali). Recall and use the relationship between the amount in moles, concentration in mol/dm^3 and volume in dm^3: • amount in moles = concentration × volume • concentration = amount in moles ÷ volume • volume = amount in moles ÷ concentration.
Describe that a single indicator such as litmus produces a sudden colour change during titration whereas a mixed indicator such as universal produces a continuous colour change.	Explain why an acid-base titration should use a single indicator rather than a mixed indicator.

Module C5: How Much (Quantitative Analysis)

Item C5e: Gas Volumes

Summary: Many reactions involve gases either as reactants or as products. It is often easier to measure the volume of a gas rather than the mass. The course of a reaction can be monitored by measuring how the volume of gas collected changes with time. This item describes a few ways in which the volume of a gas can be measured and how this can be used to follow the course of a reaction. The item also describes how the volume of gas produced can be predicted by calculation.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Carry out simple experiments to show how the volume of a gas produced in a reaction can be measured eg displacement of water in a burette or measuring cylinder, use of a gas syringe.	Identify or recognise apparatus used to collect the volume of a gas produced in a reaction: • gas syringe • upturned measuring cylinder • upturned burette.
Carry out experiments to measure the mass of a gas being produced during a reaction eg marble and acid and/or thermal decomposition of zinc carbonate.	Describe that measurement of change of mass may be used to monitor the amount of gas made in a reaction.
Carry out simple experiments to measure the volume of gas evolved as the amounts of reactants are changed eg magnesium and dilute hydrochloric acid, marble chips and acid.	Explain that a reaction stops when one of the reactants is all used up. Describe that the greater amount of reactant the greater amount of gas is made.
ICT simulation of the progress of a reaction showing how the amount of reactant and/or amount of product present changes with time.	Interpret graphs or tables of data about the volume of gas produced during the course of a reaction (limited to major grid lines on graphs): • deduce total volume of gas produced • deduce when the reaction has stopped • deduce volume of gas at a particular time and vice versa • deduce when the reaction is at its fastest.

Module C5: How Much (Quantitative Analysis)

Item C5e: Gas Volumes

Links to other modules: C3a Faster or Slower (1), C3b Faster or Slower (2), C3c Faster or Slower (3), C5a Moles and molar mass, C5c Quantitative Analysis, C5d Titrations, C5g Strong and Weak Acids

Assessable learning outcomes both tiers: standard demand	**Assessable learning outcomes Higher Tier only: high demand**
Describe an experimental method to measure the volume of gas produced in a reaction given appropriate details about the reaction.	
Describe an experimental method to measure the mass of gas produced in a reaction given appropriate details about the reaction.	
Describe that the amount of product formed depends on the amount of reactant used: • amount of product is directly proportional to the amount of reactant. Explain that the limiting reactant is the reactant not in excess that is used up at the end of the reaction. Explain why a reaction stops in terms of the limiting reactant present given appropriate qualitative information about the reaction.	Explain that the amount of product formed depends on the amount of limiting reactant used: • more reactant means more reactant particles and so more of these particles react making more product particles. Calculate the volume of a known number of moles of gas given the molar gas volume of 24 dm^3 at room temperature and pressure (rtp). Calculate the amount in moles of a volume of gas at rtp given the molar gas volume at rtp.
Interpret graphs or tables of data about the volume of gas produced during the course of a reaction (not major grid lines): • deduce total volume of gas produced • deduce when the reaction has stopped • deduce volume of gas at a particular time and vice versa • deduce the volume of gas produced with different amounts of limiting reactant.	Sketch a graph to show how the volume of gas produced during the course of a reaction changes, given appropriate details: • change in the rate of the reaction • total volume of gas collected • when the reaction stops.

Module C5: How Much (Quantitative Analysis)

Item C5f: Equilibria

Summary: Many important industrial chemical processes rely on reversible reactions that can reach a chemical equilibrium. This item focuses on the equilibrium between the two directions of a reversible reaction and on the nature of the equilibrium position.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Reversible reactions between acids and alkalis using an indicator. Reversible reactions between chromate and dichromate. Demonstration of the reaction of $BiCl_3$ in concentrated HCl with water.	Describe that in a reversible reaction there is a forward and a backward reaction. Describe that in some reversible reactions both forward and backward reactions are proceeding at the same time. Understand that the symbol $\rightleftharpoons$ is used to show that a reaction is reversible. Recognise, given the word or balanced symbol equations, reactions that are reversible.
	Interpret data in the form of tables or graphs (using major grid-lines) about the equilibrium composition: • composition at particular temperatures • composition at particular pressures • effect of temperature and pressure on composition.
Show a video about Contact Process.	Recall that the Contact Process is used to make sulfuric acid. Recall the raw materials used to make sulfuric acid by the Contact Process: • sulfur • air • water. Describe that the production of sulfuric acid by the Contact Process involves the reversible reaction between sulfur dioxide and oxygen: sulfur dioxide + oxygen $\rightleftharpoons$ sulfur trioxide.

Module C5: How Much (Quantitative Analysis)

Item C5f: Equilibria

Links to other modules: C3a Faster or Slower (1), C3b Faster or Slower (2), C3c Faster or Slower (3) C2x Making Ammonia – Haber Process and Costs

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe that some reversible reactions may reach an equilibrium: • at equilibrium the rate of the forward reaction equals the rate of the backward reaction • the concentrations of the reactants and the products do not change. Explain that when the position of equilibrium is on the right the concentration of product is greater than the concentration of reactant. Explain that when the position of equilibrium is on the left the concentration of reactant is greater than the concentration of product.	Explain why a reversible reaction may reach an equilibrium: • importance of a closed system • initially rate of forward reaction decreases • initially rate of backward reaction increases • eventually rate of forward equals rate of backward reaction.
Describe that a change in temperature, pressure or concentration of reactant or product may change the position of equilibrium. Interpret data in the form of tables or graphs about the equilibrium composition: • composition at particular temperatures • composition at particular pressures • effect of temperature and pressure on composition.	Explain in simple qualitative terms factors that affect the position of equilibrium: • removing a product moves the position of equilibrium to the right or vice versa • adding extra reactant moves the position of equilibrium to the right or vice versa • increasing the pressure moves the position of equilibrium to the side with the least number of moles of gas molecules.
Describe the conditions used in the Contact Process: • V_2O_5 catalyst • around 450°C • atmospheric pressure. Describe that sulfur dioxide needed for the Contact Process often comes from burning sulfur: • sulfur + oxygen → sulfur dioxide.	Recall the balanced symbol equations for the three stages in the manufacture of sulfuric acid by the Contact Process: • $S + O_2 \rightarrow SO_2$ • $2SO_2 + O_2 \rightleftharpoons 2SO_3$ • $SO_3 + H_2O \rightarrow H_2SO_4$ Explain the conditions used in the Contact Process: • high temperature decreases yield and increases rate of reaction so an optimum is used • catalyst increases rate but does not change position of equilibrium • position of equilibrium is already on right so high pressure is expensive and is not needed.

Module C5: How Much (Quantitative Analysis)

Item C5g: Strong and Weak Acids

Summary: Weak acids are of enormous importance in situations where we want an acid reaction without the aggressive effects of a very low pH. This item compares the reactions and properties of ethanoic acid a weak acid and hydrochloric acid a strong acid.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Measure the pH values of strong and weak acids of the same concentrations.	Recognise that ethanoic acid is a weak acid. Recognise that hydrochloric, nitric and sulfuric acids are strong acids. Describe that strong acids have a lower pH than weak acids of the same concentration.
Compare the rate of reaction of 1.0 mol/dm^3 hydrochloric acid and 1.0 mol/dm^3 ethanoic acid with calcium carbonate and magnesium	Describe that both ethanoic acid and hydrochloric acid react with magnesium to give hydrogen. Describe that both ethanoic acid and hydrochloric acid react with calcium carbonate to give carbon dioxide. Describe that magnesium and calcium carbonate react slower with ethanoic acid than with hydrochloric acid of the same concentration.
Investigate the volumes of gas produced when equal amounts of strong and weak acids react with a substance such as magnesium or with marble chips.	Describe that the same amount of hydrochloric and of ethanoic acid produce the same volume of gaseous products in their reaction with magnesium and calcium carbonate.
Comparison of the electrical conductivities and electrolysis of strong and weak acids.	Describe that ethanoic acid has a lower electrical conductivity than hydrochloric acid of the same concentration. Describe that electrolysis of both ethanoic acid and hydrochloric acid makes hydrogen at the negative electrode.
Data-search of the use of some weak acids.	Describe some uses of weak acids, such as descalers.

Module C5: How Much (Quantitative Analysis)

Item C5g: Strong and Weak Acids
Links to other modules: C2x Acids and Bases, C5d Titrations, C5e Gas Volumes

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Recall that an acid ionises in water to produce H^+ ions. Describe that a strong acid completely ionises in water. Explain that the ionisation of a weak acid is an example of a reversible reaction. Explain that the ionisation of a weak acid produces an equilibrium mixture.	Explain why the pH of a weak acid is much higher than the pH of a strong acid of the same concentration. Explain the difference between acid strength and acid concentration: • acid strength (strong or weak) is a measure of the degree of ionisation of the acid • concentration of an acid is a measure of how many moles of acid in one dm^3. Construct equations for the ionisation of weak and strong acids given the formula of the acid limited to: • $CH_3COOH \rightleftharpoons CH_3COO^- + H^+$ • $HCl \rightarrow H^+ + Cl^-$
Explain that ethanoic acid reacts slower than hydrochloric acid of the same concentration because • there are fewer hydrogen ions in ethanoic acid • in ethanoic acid there are fewer collisions between hydrogen ions and reactant particles	Explain that ethanoic acid reacts slower than hydrochloric acid of the same concentration because: • ethanoic acid is weak and hydrochloric acid is strong • hydrochloric acid has a greater concentration of hydrogen ions • in hydrochloric acid the hydrogen ions have a greater collision frequency with reactant particles
Explain that the volume of hydrogen or carbon dioxide formed is determined by the amounts of reactants present not the acid strength.	
Describe that ethanoic acid is less conductive than hydrochloric acid of the same concentration because there are fewer hydrogen ions available to move. Explain why hydrogen is produced during the electrolysis of ethanoic acid and of hydrochloric acid.	Explain that ethanoic acid is less conductive than hydrochloric acid of the same concentration because: • ethanoic acid is weak and hydrochloric acid is strong • greater concentration of hydrogen ions to carry the charge.
Explain why strong acids are inappropriate as descaling agents.	Explain why a weak acid may be more useful than the more dilute strong acid.

Module C5: How Much (Quantitative Analysis)

Item C5h: Ionic Equations and Precipitation

Summary: Precipitation is a process used to test for ions in solutions. In this item we explore several precipitation reactions and the associated concept of ionic equations. This provides the opportunity to apply scientific information using quantitative approaches.

Suggested practical and research activities to select from	**Assessable learning outcomes Foundation Tier only: low demand**
Carry out simple precipitation reactions: • Cl^-, Br^- and I^- with $Pb(NO_3)_2(aq)$ • SO_4^{2-} with $BaCl_2(aq)$	Describe that a precipitation reaction involves two solutions reacting together to make an insoluble substance. Describe that most precipitation reactions involve ions from one solution reacting with ions from another solution.
	Describe that lead nitrate solution can be used to test for halide ions: • white precipitate with Cl^- • cream precipitate with Br^- • bright yellow precipitate with I^-. Describe that barium chloride solution can be used to test for sulfate ions (form a white precipitate).
	Identify the reactants and the products from an ionic equation. Recognise and use the state symbols (aq), (s), (g) and (l).
Preparation of an insoluble salt using precipitation eg lead(II) iodide or magnesium carbonate	Label the apparatus used during the preparation of an insoluble compound by precipitation.

Module C5: How Much (Quantitative Analysis)

Item C5h: Ionic Equations and Precipitation
Links to other modules: C4x Transition Elements, C4x Water

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe that ionic substances contain ions which are in fixed positions in the solid but can move in solution. Describe in a precipitation reaction ions must collide with other ions to react to form a precipitate.	Explain that most precipitation reactions are extremely fast reactions between ions because there is an extremely large collision frequency between the ions.
Interpret experimental data about the testing of solutions using aqueous barium chloride and aqueous lead nitrate.	
Construct word equations for simple precipitation reactions eg for the reaction between solutions of barium chloride and sodium sulfate (products not given)	Construct ionic equations, with state symbols, for simple precipitation reactions, given the ions present and the identity of the products eg: • $Pb^{2+}(aq) + 2Cl^{-}(aq) \rightarrow PbCl_2(s)$ • $Pb^{2+}(aq) + 2Br^{-}(aq) \rightarrow PbBr_2(s)$ • $Pb^{2+}(aq) + 2I^{-}(aq) \rightarrow PbI_2(s)$ • $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$ Explain the concept of 'spectator ions'.
Describe the stages involved in the preparation of a dry sample of an insoluble compound by precipitation given the names of the reactants • mix solutions of reactants • filtration • wash and dry residue.	

Module C6: Chemistry Out There

Item C6: Fundamental chemical concepts

Summary: Throughout the study of chemistry there are a number of ideas and concepts that are fundamental. These ideas and concepts have not been put into a particular item but should permeate all the Chemistry units. They will be assessed in the context of any of the modules C1 to C6.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
These learning outcomes are intended to be taught throughout this specification.	Describe that in a chemical reaction reactants are changed into products. Recognise the reactants and products in a word equation. Construct word equations given the reactants and products.
	Recognise the reactants and products in a symbol equation.
These learning outcomes are intended to be taught throughout this specification.	Deduce the number of elements in a compound given its formula. Deduce the number of atoms in a formula with no brackets. Deduce the number of each different type of atom in a formula with no brackets.
These learning outcomes are intended to be taught throughout this specification.	Recognise whether a substance is an element or a compound from its formula. Deduce the names of the different elements in a compound given its formula.
These learning outcomes are intended to be taught throughout this specification.	Understand that a molecule is made up of more than one atom joined together. Explain that a molecular formula shows the number and type of atom in a molecule. Deduce the number of atoms in a displayed formula. Deduce the names of the different elements in a compound given its displayed formula. Deduce the number of each different type of atom in a displayed formula.
These learning outcomes are intended to be taught throughout this specification.	Recognise whether a particle is an atom, molecule or ion given its formula Understand that atoms contain smaller particles one of which is a negative electron.
These learning outcomes are intended to be taught throughout this specification.	Describe that atoms in a compound are held together by chemical bonds

Module C6: Chemistry Out There

Item C6: Fundamental chemical concepts
Links to other modules: C1 to C6

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Construct balanced symbol equations given the formulae (no brackets) of the reactants and products. Explain that a symbol equation is balanced when the number of each type of atom is the same on both sides of an equation.	Construct balanced symbol equations given the formulae (some or all with brackets) of the reactants and products. Construct balanced symbol equations given the names of the reactants and products (limited to the learning outcomes in module C6).
Deduce the number of atoms in a formula with brackets. Deduce the number of each type of different atom in a formula with brackets. Recall the formula of the following substances: • chlorine, hydrogen, oxygen and water • calcium carbonate and carbon dioxide • ethanoic acid	Recall the formula of the following substances: • sulfates and chlorides of calcium, iron(II), magnesium, tin(II) and zinc • calcium hydrogencarbonate and sodium carbonate • ethanol and glucose.
Explain that a displayed formula shows both the atoms and the bonds in a molecule. Write the molecular formula of a compound given its displayed formula.	Construct balanced equations that use displayed formulae.
Understand that positive ions are formed when electrons are lost atoms Understand that negative ions are formed when electrons are gained by atoms	
Recall that two types of chemical bond holding atoms are • ionic bonds • covalent bonds	Describe that an ionic bond is the attraction between a positive ion and a negative ion Describe that a covalent bond is a shared pair of electrons

Module C6: Chemistry Out There

Item C6a: Electrolysis

Summary: Some industrial processes involve electrolysis. This item describes how it is possible to predict the products of electrolysis. It explains how it is possible to predict the amount of product formed during electrolysis and provides the opportunity to plan to test a scientific idea. Predicting the outcome of the electrolysis of molten lead bromide illustrates the use of scientific modelling.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
	Describe electrolysis as the decomposition of a liquid by passing an electric current through it. Recall the anode is the positive electrode and the cathode is the negative electrode. Recall that cations are positively charged and anions are negatively charged. Describe the electrolyte as the liquid which conducts electricity and is decomposed during electrolysis. Recognise anions and cations from their formula.
Class investigation to identify the products of electrolysis of aqueous solutions such as KNO_3(aq), NaOH(aq) and H_2SO_4(aq).	Label the apparatus needed to electrolyse aqueous solutions in a school laboratory: • anode, cathode, d.c. power supply. Recognise that positive ions discharge at the negative electrode and negative ions at the positive electrode. Describe the chemical tests for hydrogen and oxygen: • hydrogen burns with a 'pop' when lit using a lighted splint • oxygen relights a glowing splint.
Class practical - the electrolysis of copper(II) sulfate using carbon electrodes either qualitative or quantitative Use of Hoffmann voltameter to investigate the effect of current and time on the volume of oxygen and/or hydrogen produced	Describe the electrolysis of copper(II) sulfate solution using carbon electrodes: • the cathode gets plated with copper and the anode bubbles. Describe the factors that affect the amount of substance produced during electrolysis: • time • current.
Fume cupboard demonstration of the electrolysis of molten $PbBr_2$ or PbI_2.	Predict the products of electrolytic decomposition of the following molten electrolytes: Al_2O_3(l) $PbBr_2$(l) PbI_2(l) NaC*l*(l).

Module C6: Chemistry Out There

Item C6a: Electrolysis

Links to other modules: C2d Metals and Alloys, C2e Cars for Scrap, C3f Electrolysis, C6d Chemistry of Sodium Chloride (NaCl)

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe electrolysis in terms of flow of charge by moving ions and the discharge of ions at the electrodes.	
Describe the key features in the electrolysis of: • KNO_3(aq) – hydrogen at cathode and oxygen at anode • NaOH(aq) – hydrogen at cathode and oxygen at anode • H_2SO_4(aq) – hydrogen at cathode and oxygen at anode.	Construct the half equations for the electrode processes that happen during the electrolysis of KNO_3(aq), NaOH(aq) or H_2SO_4(aq) given the formula of the ions present in the electrolyte: • cathode – $2H^+ + 2e^- \rightarrow H_2$ • anode – $4OH^- - 4e^- \rightarrow O_2 + 2H_2O$. Explain in the electrolysis of aqueous solutions it may be easier to discharge ions from the water rather than from the solute.
Describe the key features in the electrolysis of $CuSO_4$(aq) with carbon electrodes: • copper is formed at the cathode and oxygen at the anode. Describe the factors that affect the amount of substance produced during electrolysis: • as time increases amount made increases • as current increases amount made increases.	Construct the half equations for electrode processes that happen during the electrolysis of $CuSO_4$(aq) using carbon electrodes: • cathode – $4OH^- - 4e^- \rightarrow O_2 + 2H_2O$ • anode – $Cu^{2+} + 2e^- \rightarrow Cu$. Describe that the amount of substance produced during electrolysis is directly proportional to the time and to the current. Perform simple calculations based on current, time and the amount of substance produced in electrolysis.
Explain why an ionic solid cannot be electrolysed but the molten liquid can be electrolysed: • ionic solid has ions which are in fixed positions and cannot move • ions in the molten liquid can move.	Write the half equations for the electrode processes that happen during the electrolysis of each of the following molten substances given the formula of the ions present in the electrolyte: • Al_2O_3(l) • $PbBr_2$(l) • PbI_2(l) • NaC*l*(l).

Module C6: Chemistry Out There

Item C6b: Energy Transfers – Fuel cells

Summary: This item describes the use of hydrogen in fuel cells. The item also considers the advantages of fuel cells over the use of more conventional fossil fuels.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Carry out an experiment blowing air through a straw next to one of a pair of copper electrodes dipped in brine to produce a measurable potential difference.	Describe that hydrogen and oxygen react to produce water.
Carry out an experiment to electrolyse sodium hydroxide and then measure a potential difference between the electrodes (see Nuffield Sample Scheme Teachers Guide II p619). Internet research about fuel cells.	Describe that a fuel cell produces electrical energy efficiently. Understand that hydrogen is the fuel in a hydrogen-oxygen fuel cell.
	Understand that one important use of fuel cells is to provide electrical power in spacecraft.
	Explain that a hydrogen-oxygen fuel cell does not form a polluting waste product because water is the only product. Describe that the combustion of fossil fuels such as petrol produces carbon dioxide which has been linked with climate change and global warming.

Module C6: Chemistry Out There

Item C6b: Energy Transfers – Fuel cells
Links to other modules: : C1x Using Carbon Fuels, C3h Energy

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain that the reaction between hydrogen and oxygen is exothermic because it releases energy.	Draw and interpret an energy level diagram for the reaction of hydrogen and oxygen.
Describe a fuel cell as a cell supplied with fuel and oxygen that uses the energy released from the reaction between the fuel and oxygen to create a potential difference. Construct the word equation for the overall reaction in a hydrogen-oxygen fuel cell: hydrogen + oxygen → water. Construct the balanced symbol equation for the overall reaction in a hydrogen-oxygen fuel cell: • $2H_2 + O_2 \rightarrow 2H_2O$.	Explain the changes that take place at each electrode in a hydrogen-oxygen fuel cell: • construct the equations for the electrode reactions given the formula of the ions present and the products • redox reactions at each electrode.
Describe some advantages of using a fuel cell to provide electrical power in a spacecraft: • provides water that can be used by astronauts • lightweight • compact • no moving parts.	Explain the advantages of a hydrogen-oxygen fuel cell over conventional methods of generating electricity: • more efficient • fewer stages • direct energy transfer • less pollution.
Explain why the car industry is developing fuel cells: • no carbon dioxide emissions from the car • fossil fuels such as petrol are non-renewable • large source of hydrogen available by decomposing water.	Explain that the use of hydrogen-oxygen fuel cells will still produce pollution: • fuel cells often contain poisonous catalysts that have to be disposed of at the end of the life-time of the fuel cell • production of the hydrogen and oxygen will involve the use of energy which may have come from the burning of fossil fuels.

Module C6: Chemistry Out There

Item C6c: Redox reactions

Summary: Redox is an important type of chemical reaction. Examples of redox reactions include corrosion of metals, electrolysis and the corrosion of metals. This item will describe redox reactions using an electron transfer model.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Teacher exposition about redox reactions.	Understand that redox reactions involve oxidation and reduction.
Carry out experiments to find the conditions necessary for rusting of iron and steel to take place.	Describe that rusting of iron and steel requires both oxygen (or air) and water.
Research ways of rust protection. Preventing rusting as demonstration or class practical see www.practicalchemistry.org	Describe methods of preventing rust limited to: • oil and grease • paint • galvanising • sacrificial protection • alloying • tin plate. Explain that oil, grease and paint prevent iron from rusting because they stop oxygen or water reaching the surface of the iron.
Carry out displacement reactions between metals and metal salt solutions limited to zinc, magnesium, iron and tin. Exothermic metal displacement reactions see RSC web-site www.practicalchemistry.org	Interpret observations made during displacement reactions including temperature changes. Recall the following order of reactivity (most to least): • magnesium, zinc, iron and tin.

Module C6: Chemistry Out There

Item C6c: Redox reactions

Links to other modules: C3d The Group 1 Element, C3e The Group 7 Element, C3g Transition Elements

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe and/or recognise that oxidation is the addition of oxygen or the reaction of a substance with oxygen. Describe and/or recognise reduction as the removal of oxygen from a substance.	Describe that oxidation involves loss of electrons and reduction the gain of electrons. Recognise and use the terms: • oxidation and reduction • oxidising agent and reducing agent. Explain, in terms of oxidation and reduction, the interconversion of the following types of systems: • Fe and Fe^{2+} • Fe^{2+} and Fe^{3+} • Cl_2 and Cl^- • electrode reactions.
Explain that rusting involves oxidation because iron reacts with oxygen. Understand that rusting of iron is a redox reaction.	Recall that the chemical name for rust is hydrated iron(III) oxide. Construct the word equation for the rusting of iron: iron + oxygen + water → hydrated iron(III) oxide. Explain why rusting is a redox reaction: • iron loses electrons • oxygen gains electrons.
Explain how galvanising protects iron from rusting: • galvanised iron is covered with a layer of zinc • layer of zinc stops water and oxygen from reaching the surface of the iron • zinc also acts as a sacrificial metal.	Explain how sacrificial protection protects iron from rusting: • use of a metal such as magnesium or zinc • sacrificial metal is more reactive than iron • sacrificial metal will lose electrons in preference to iron. Explain the disadvantage of using tin plate as a means of protecting iron from rusting: • tin only acts as a barrier stopping water and air reaching the surface of the iron • when the tin layer is scratched the iron will lose electrons in preference to tin and so the iron rusts even faster than on its own.
Construct word equations for displacement reactions between metals and metal salt solutions. Predict, with a reason, whether a displacement reaction will take place.	Construct symbol equations for displacement reactions between metals and metal salt solutions. Explain displacement reactions in terms of oxidation and reduction: • metal ion is reduced by gaining electrons • metal atom is oxidised by losing electrons.

Module C6: Chemistry Out There

Item C6d: Alcohols

Summary: There is a large number of compounds called alcohols. Ethanol is one of this family of alcohols. Ethanol, which is renewable, can provide an alternative to crude oil as a source of fuel and organic compounds.

Suggested practical and research activities to select from	**Assessable learning outcomes** **Foundation Tier only: low demand**
Use of molecular models.	Explain that alcohols are not hydrocarbons because they contain carbon, hydrogen and oxygen bonded together.
Carry out an experiment to produce ethanol by fermentation.	Describe the conditions needed for fermentation: • 25 – 50°C • presence of water • yeast.
The 'Whoosh' bottle demonstration details from RSC web-site www.practicalchemistry.org	Recall the main uses of ethanol: • alcoholic beverages • solvent (industrial methylated spirits) • fuel for cars.
ICT simulation.	Recall that hydration of ethene produces ethanol.

Module C6: Chemistry Out There

Item C6d: Alcohols

Links to other modules: B6c Microorganisms – factories for the future?, C4f Batch or Continuous?

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Recall the molecular formula and displayed formula of ethanol.	Recall the general formula of an alcohol. Use the general formula of alcohols to write the molecular formula of an alcohol given the number of carbon atoms in one molecule of the alcohol. Draw the displayed formulae of alcohols containing up to five carbon atoms.
Recall the word equation for fermentation: • glucose → carbon dioxide + ethanol. Construct the balanced symbol equation for fermentation (given all the formulae) $C_6H_{12}O_6 \rightarrow 2CO_2 + 2C_2H_5OH$. Describe how ethanol can be made by fermentation: • glucose solution • reaction catalysed by enzymes in yeast • absence of oxygen • fractional distillation to get ethanol.	Construct the balanced symbol equation for fermentation (some or no formulae given) $C_6H_{12}O_6 \rightarrow 2CO_2 + 2C_2H_5OH$. Explain the conditions used in fermentation: • temperature too low yeast inactive • temperature too high enzyme in yeast denatured • absence of air to prevent formation of ethanoic acid.
Explain why ethanol made by fermentation is a renewable fuel. Explain why ethanol made by hydration of ethene is a non-renewable fuel.	Evaluate the merits of the two methods of making ethanol (fermentation and hydration) in terms of: • conditions used • batch versus continuous • sustainability • purification • percentage yield and atom economy.
Describe how ethanol is produced for industrial use by passing ethene and steam over a heated phosphoric acid catalyst. Construct the word equation for the hydration of ethene: • ethene + water → ethanol.	Construct the balanced symbol equation for the hydration of ethene: • $C_2H_4 + H_2O \rightarrow C_2H_5OH$.

Module C6: Chemistry Out There

Item C6e: Depletion of the ozone layer

Summary: This item describes the environmental problem of the depletion of the ozone layer and how Chemistry can provide safer alternatives to CFCs.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Discussion on the use of CFCs.	Describe that a chlorofluorocarbon (CFC) is an organic molecule containing chlorine, fluorine and carbon atoms. Describe the use of CFCs as refrigerants and aerosol propellants.
Data-search on CFCs and ozone depletion eg use of satellite data.	Recall that ozone is a form of oxygen with the formula O_3. Describe some properties of CFCs: • chemically inert • low boiling point • insoluble in water.
Data-search on CFCs and ozone depletion.	Describe that increased levels of ultraviolet light can lead to medical problems: • increased risk of sunburn • accelerated ageing of skin • skin cancer • increased risk of cataracts.
Survey of safer alternatives to CFCs.	Describe that hydrocarbons can provide safe alternatives to CFCs.

Module C6: Chemistry Out There

Item C6e: Depletion of the ozone layer
Links to other modules: C2f Clean Air, P1h Stable Earth

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain why the use of CFCs has been banned in the UK. • society has agreed with scientists' views that CFCs deplete the ozone layer	Describe and explain how scientists' attitude to CFCs has changed: • initial enthusiasm for the use of CFCs based upon their inertness • later discovery of ozone depletion and link to presence of CFCs • acceptance by scientists and the rest of the world community that the use of CFCs should be banned.
Describe that the action of ultraviolet light on CFCs leads to the formation of chlorine atoms. Describe that the formation of chlorine atoms in the stratosphere leads to the depletion of the ozone layer. Recall that a chlorine radical is a chlorine atom. Describe that CFCs are only removed slowly from the stratosphere.	Explain how a covalent bond can break to form highly reactive radicals. Describe that only a small number of chlorine atoms are required because a chain reaction is set up. Interpret the symbol equations for the reactions that take place when chlorine atoms and ozone react. Explain why CFCs will continue to deplete ozone a long time after their use has been banned.
Describe how depletion of the ozone layer allows more ultraviolet light to reach the surface of the Earth.	Explain how ozone absorbs ultraviolet light in the stratosphere.
Describe that CFCs can be replaced with alkanes or HFCs and that these will not damage the ozone layer.	

Module C6: Chemistry Out There

Item C6f: Hardness of water

Summary: Hardness of water is a problem in many areas for processes where water has to be heated or where soap is used. The survey on ways of removing water hardness allows the use of ICT tools to look at the benefits and drawbacks of technological developments.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Compare hard and soft water using soap. Compare hard and soft water using soapless detergents.	Describe that hard water does not lather well with soap but soft water does. Describe that both hard and soft water lather well with soapless detergents.
Which ions cause hardness in water? Class practical details from RSC web-site www.practicalchemistry.org	Describe that boiling destroys temporary hardness in water but not permanent hardness in water. Recall that hardness is caused by dissolved calcium and magnesium ions in water. Describe that water hardness depends upon which rocks the water has flowed through and so varies across the UK.
Survey ways of removing hardness by using water softeners.	Describe that hardness in water can be removed by: • passing the water through an ion-exchange column • adding washing soda (sodium carbonate).
Carry out an experiment to compare the hardness of water samples using soap solution.	Interpret data about water hardness experiments for example: • choosing the softest or hardest water sample.
Compare different commercial limescale removers.	Recall that limescale is calcium carbonate. Recall that limescale removers are weak acids.

Module C6: Chemistry Out There

Item C6f: Hardness of water
Links to other modules: C4h How Pure is Our Water?

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe that dissolved carbon dioxide causes water to be slightly acidic. Describe that calcium carbonate in rocks reacts with water and carbon dioxide to form soluble calcium hydrogencarbonate in water. Construct the word equation for the reaction between calcium carbonate, water and carbon dioxide. calcium carbonate + water + carbon dioxide → calcium hydrogencarbonate Construct the balanced symbol equation for the reaction between calcium carbonate, water and carbon dioxide (all or some formulae given) $CaCO_3 + H_2O + CO_2 \rightarrow Ca(HCO_3)_2$.	Construct the balanced symbol equation for the reaction between calcium carbonate, water and carbon dioxide (formulae not given) • $CaCO_3 + H_2O + CO_2 \rightarrow Ca(HCO_3)_2$.
Recall that temporary hardness is caused by dissolved calcium hydrogencarbonate Recall that permanent hardness is caused by dissolved calcium sulfate.	
Describe how boiling removes temporary hardness: • decomposition of calcium hydrogencarbonate to give insoluble calcium carbonate, water and carbon dioxide • soluble calcium ions are changed into insoluble compounds. Explain how an ion-exchange resin can soften water.	Construct the symbol equation for the decomposition of calcium hydrogencarbonate occurring when water containing temporary hardness is boiled (formulae not given) • $Ca(HCO_3)_2 \rightarrow CaCO_3 + H_2O + CO_2$. Explain how washing soda (sodium carbonate) can soften hard water.
Interpret data about water hardness experiments for example: • explaining why a sample of water contains permanent and temporary hardness. Plan experiments to compare the hardness in samples of different sources of water.	
Explain why a weak acid is used as a limescale remover: • reacts with limescale to give carbon dioxide, water and soluble calcium salt • weak acid will not react with metals.	

Module C6: Chemistry Out There

Item C6g: Natural fats and oils

Summary: Plants are grown for the natural fats and oils that they contain. These fats and oils have a large number of industrial uses. They can provide alternatives to chemicals made from crude oil.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Research the composition of various plant oils and animal fats. Comparing the amount of unsaturated fats in food stuffs by titration against bromine see RSC web-site www.practicalchemistry.org	Understand that natural fats and oils are important raw materials for the chemical industry. Describe that vegetable oils can be used to make bio-diesel, an alternative to diesel from crude oil. Describe that, at room temperature: • oils are liquids • fats are solids.
Examine milk and butter under a microscope. Also examine after adding water or oil based dyes. Prepare a sample of an emulsion eg a cold cream.	Describe that an emulsion is one liquid finely dispersed in another. Describe that oil and water can form an emulsion when shaken. Recall that milk is an oil–in-water emulsion and butter is a water–in-oil emulsion.
Prepare a sample of a soap using a vegetable oil.	Describe that a vegetable oil reacts with sodium hydroxide to produce a soap.

Module C6: Chemistry Out There

Item C6g: Natural fats and oils

Links to other modules: C1b Food Additives, C1c Smells, C1d Making Crude Oil Useful, C1e Making Polymers

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Recall that animal and vegetable fats and oils are esters. Describe that all the carbon-carbon bonds in a saturated fat or oil are single bonds. Describe that an unsaturated fat or oil has at least one carbon-carbon double bond. Describe how unsaturation in fats and oils can be shown using bromine water: • with saturated fats the bromine water stays orange • with unsaturated fats the bromine water goes colourless. Describe how margarine is manufactured from vegetable oils.	Explain why unsaturated fats are healthier as part of diet. Explain why bromine can be used to test for unsaturated fats and oils: • addition reaction takes place at the carbon-carbon double bond • a colourless dibromo compound is formed • saturated compounds cannot react with bromine since they do not have a carbon-carbon double bond.
Describe that a vegetable oil and water are immiscible liquids and they can be made to mix as an emulsion. Describe an oil-in-water emulsion and a water-in-oil emulsion.	
Describe how natural fats and oils can be split up by hot sodium hydroxide solution to produce soap and glycerol. Recall that this process of splitting up natural fats and oils using sodium hydroxide solution is called saponification.	Explain the saponification of fats and oils: • fat + sodium hydroxide → soap + glycerol • hydrolysis reaction.

Module C6: Chemistry Out There

Item C6h: Detergents

Summary: Many consumers are looking at effective and efficient cleaning agents that take less time and can work at low temperatures. This item develops ideas about the use of cleaning agents such as detergents and solvents. A simple explanation of the action of detergents and solvents is considered as well as the scientific accuracy of some advertisements for detergents.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Look at the constituents of washing powders.	Describe the function of each ingredient in a washing powder: • active detergent does the cleaning • water softener to soften hard water • bleaches to remove coloured stains • optical brighteners to give the whiter than white appearance • enzymes used in low temperature washes to remove food stains. Predict the correct washing conditions using the wash label on an item.
Investigate the action of some solvents to remove stains, paints, varnishes, wax and grease.	Describe and use the terms solvent, solute, solution, soluble and insoluble. Recognise that different solvents will dissolve different substances. Identify the correct solvent to remove a stain given the appropriate information.
Survey of constituents of different brands of washing up liquids.	Describe the function of each ingredient in a washing-up liquid: • active detergent does the cleaning • water to thin out detergent so it can be dispensed easily • colouring agent and fragrance to improve attractiveness of product • rinse agent to help water drain off crockery.
Critical analysis of advertisements for washing up liquids and washing powders.	Interpret data from experiments on the effectiveness of washing up liquids and washing powders for example: • which detergent washed the most plates • description of a simple trend.

Module C6: Chemistry Out There

Item C6h: Detergents
Links to other modules: B6x Enzymes in Action, Cxx Food Additives, Cxx Cooking, C6g Fats and Oils

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain the advantages of using low temperature washes in terms of energy saving and the type of clothes that can be washed.	Describe the chemical nature of a detergent • hydrophilic head • hydrophobic tail. Explain how detergents can remove fat or oil stains: • hydrophilic end of detergent molecule forms strong intermolecular forces with water molecules • hydrophobic end of detergent forms strong intermolecular forces with molecules of oil and fat.
Describe dry cleaning as a process used to clean clothes that does not involve water: • solvent that is not water • stain will not dissolve in water.	Explain in terms of intermolecular forces, how a dry cleaning solvent removes stains: • there are weak intermolecular forces between molecules of grease • there are weak intermolecular forces between solvent molecules • solvent molecules form intermolecular forces with molecules of grease and so solvent molecules can surround molecules of grease
Interpret data from experiments on the effectiveness of washing up liquids and washing powders for example: • making simple conclusions from data.	Interpret data from experiments on the effectiveness of washing up liquids and washing powders for example: • deducing which detergent contains an enzyme.