GATEWAY SCIENCE SUITE

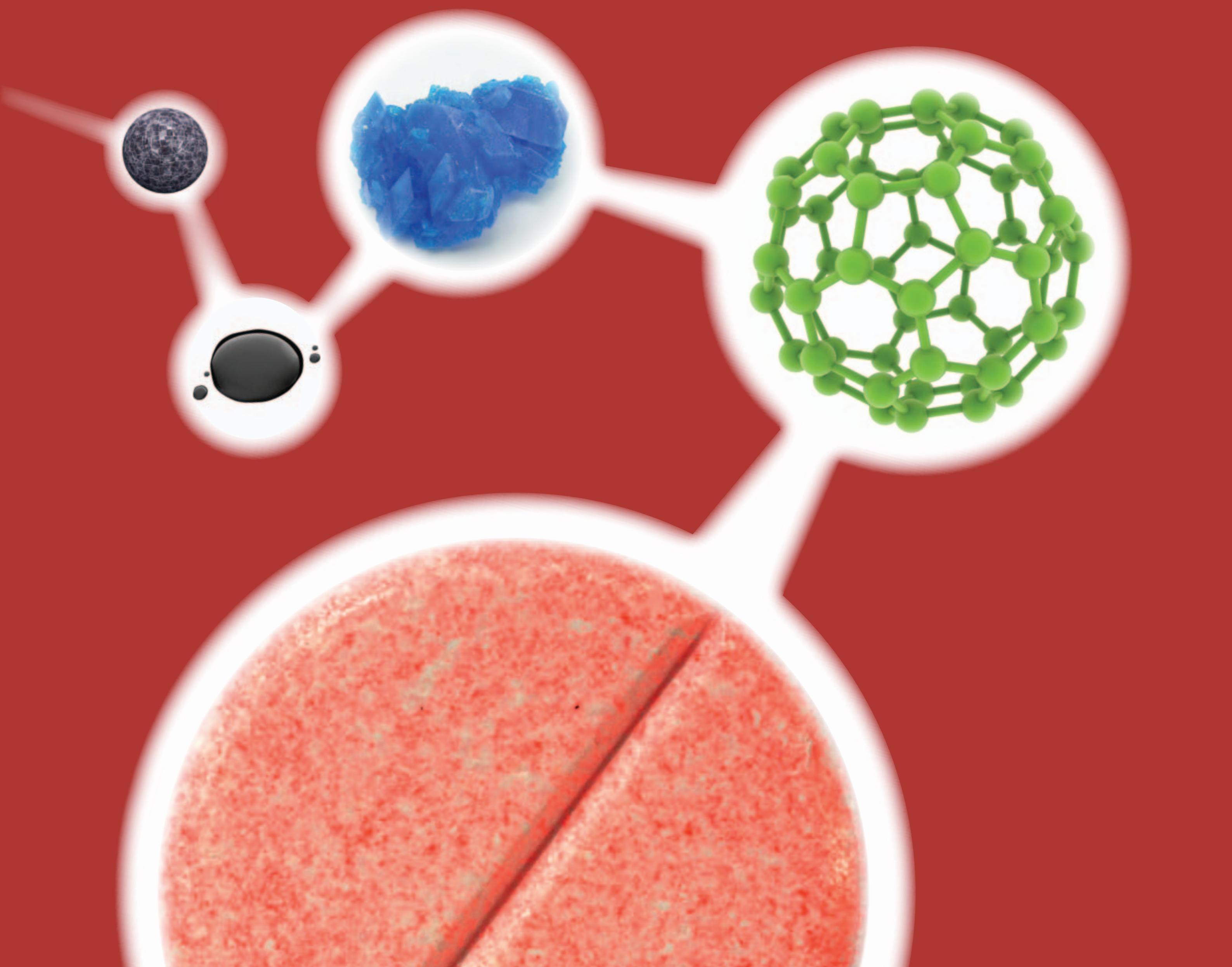
GCSE CHEMISTRY B

ACCREDITED SPECIFICATION

J264

VERSION 2

MAY 2012



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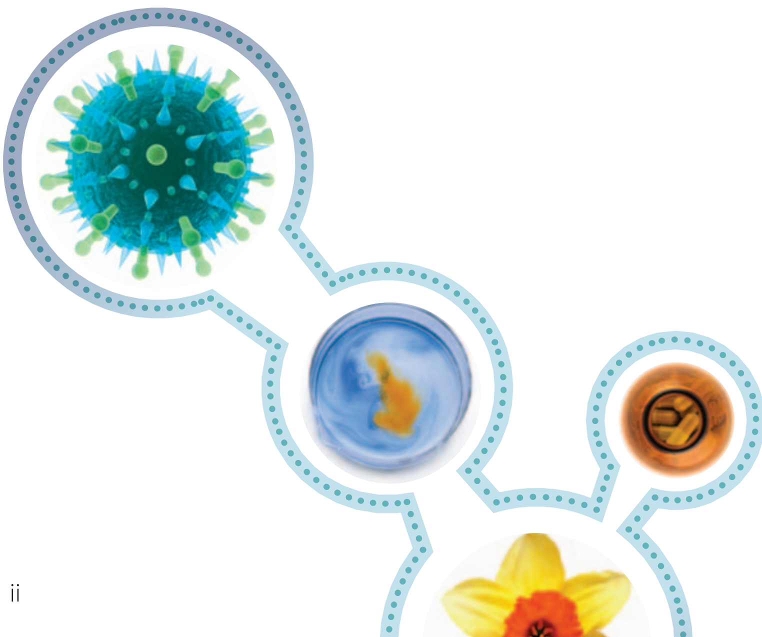
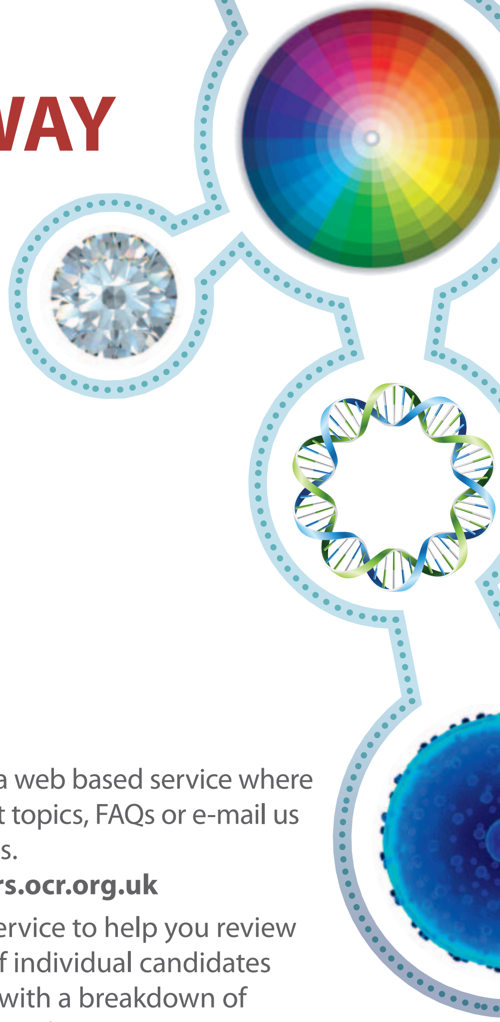


SUPPORTING YOU ALL THE WAY



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GATEWAY SCIENCE SUITE

Science in Action

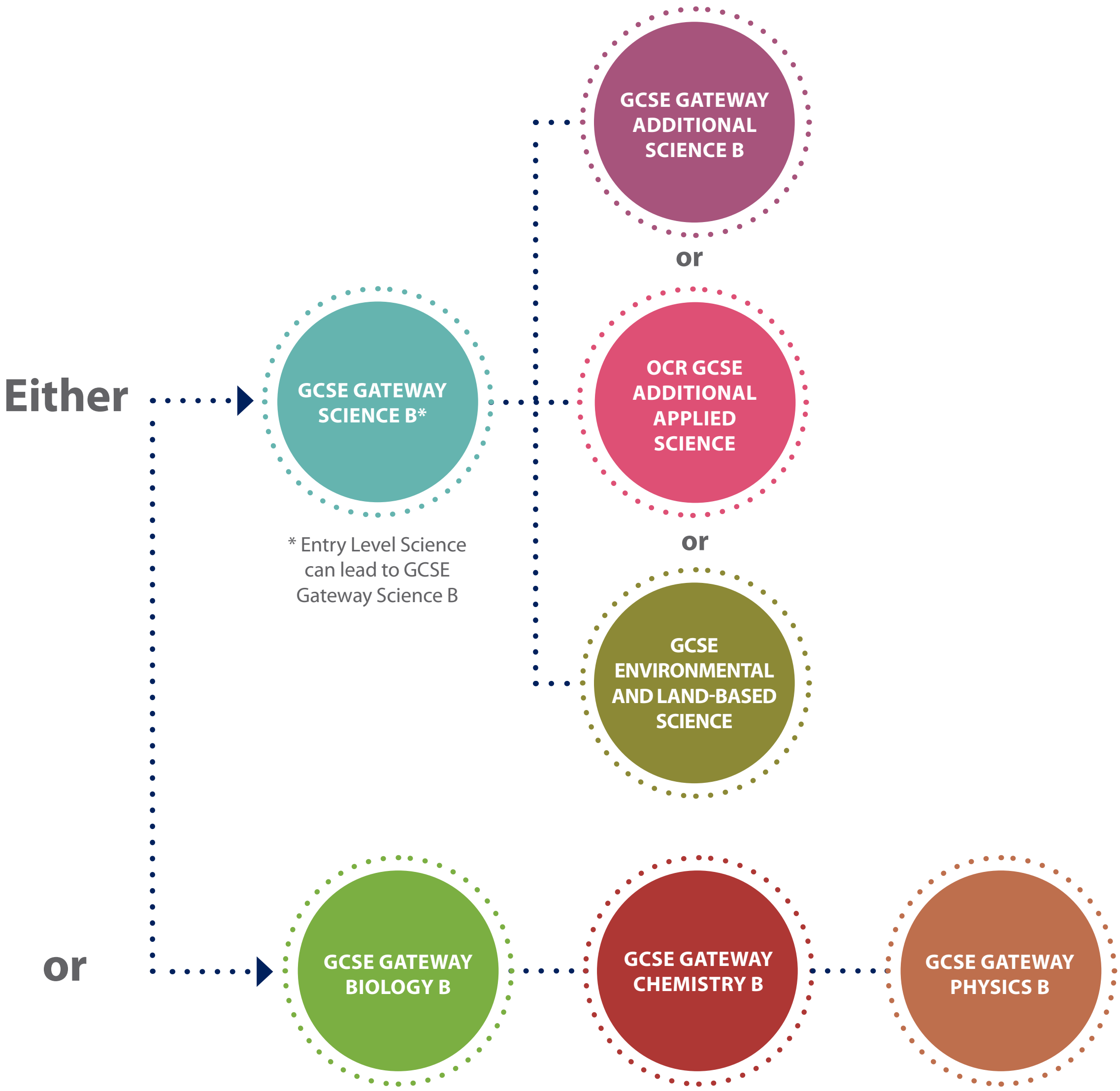
Understand the questions that science can answer. Unpick the scientific concepts and investigate their familiar applications through active learning.

KEY FEATURES

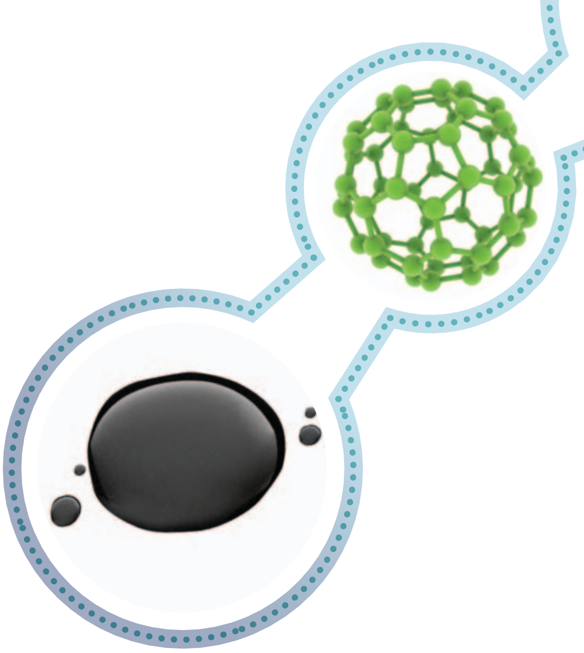
Our Gateway Science Suite gives you and your students:

- an emphasis on getting more involved in the learning process through a variety of interesting activities and experiences, identifying links to scientific ideas and their implications for society
- the opportunity to develop scientific explanations and theories.
- **Practical work** is at the heart of the Gateway Science Suite.

POSSIBLE GCSE COMBINATIONS



GCSE CHEMISTRY B



KEY FEATURES

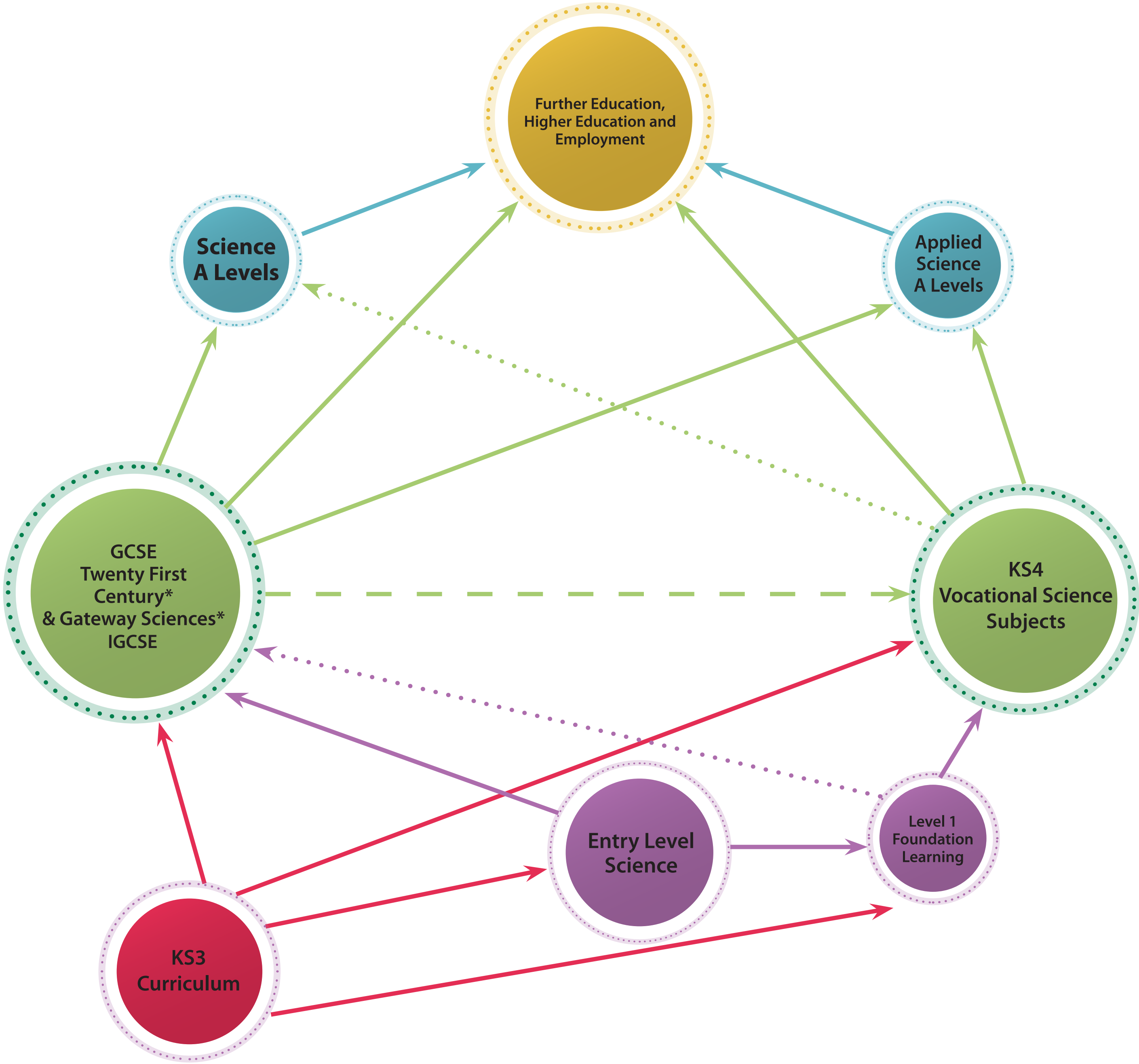
GCSE Chemistry B aims to give students the opportunity to:

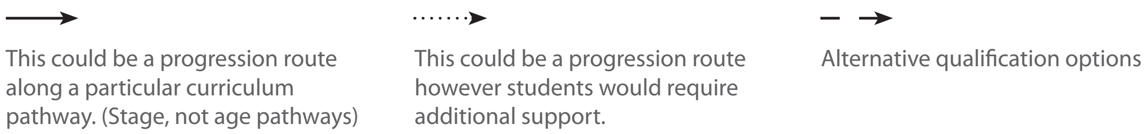
- develop their interest in, and enthusiasm for, chemistry
- develop a critical approach to scientific evidence and methods
- acquire and apply skills, knowledge and understanding of how science works and its essential role in society
- acquire scientific skills, knowledge and understanding necessary for progression to further learning.

GCSE Chemistry B provides distinctive and relevant experience for students who wish to progress to Level 3 qualifications.

COURSE OVERVIEW	ASSESSMENT OVERVIEW		
UNIT B741 Module C1: Carbon Chemistry Module C2: Chemical Resources Module C3: Chemical Economics	75 marks 1 hour 15 minutes written paper	**35%** of total GCSE	Two written exams, assessed externally by OCR, each of which: • is offered in Foundation and Higher Tiers • uses structured questions (there is no choice of questions) • assesses the quality of written communication Unit B742 also includes a 10 mark data response section which assesses AO3 (analyse and evaluate evidence, make reasoned judgements and draw conclusions based on evidence)
UNIT B742 Module C4: The Periodic Table Module C5: How Much? Module C6: Chemistry Out There	85 marks 1 hour 30 minutes written paper	**40%** of total GCSE	
UNIT B743 Controlled assessment	48 marks Approx 7 hours	**25%** of total GCSE	Comprises one assessment task, split into three parts Assessed by teachers, internally standardised and then externally moderated by OCR Assesses the quality of written communication

PROGRESSION PATHWAYS IN SCIENCE





* Offered as
Science, Additional Science, Biology, Chemistry and Physics.

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Contents

Introduction to the Gateway Suite

The Gateway Science Suite comprises five specifications which share a common approach, utilise common material, use a similar style of examination questions and have a common approach to skills assessment.

The qualifications available as part of this suite are:

- GCSE Science
- GCSE Additional Science
- GCSE Biology
- GCSE Chemistry
- GCSE Physics.

The suite emphasises explanations, theories and modelling in science along with the implications of science for society. Strong emphasis is placed on the active involvement of candidates in the learning process and each specification encourages a wide range of teaching and learning activities.

The suite is supported by resources published by Collins.

OCR also offers a specification in GCSE Additional Applied Science which may be taken as an alternative to GCSE Additional Science.

2 Introduction to GCSE Chemistry B

2.1 Overview of GCSE Chemistry B

Unit B741 ***Chemistry modules C1, C2, C3***	
This is a tiered unit offered in Foundation and Higher Tiers.	Written paper 1 hour 15 mins – 75 marks 35% of the qualification Question paper comprises structured questions. Candidates answer all questions.

+

Unit B742 ***Chemistry modules C4, C5, C6***	
This is a tiered unit offered in Foundation and Higher Tiers.	Written paper 1 hour 30 mins – 85 marks 40% of the qualification Question paper comprises structured questions and analysis of data. Candidates answer all questions.

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Unit B743 ***Chemistry controlled assessment***	
This unit is not tiered.	Controlled assessment 48 marks 25% of the qualification

2.2 What is new in GCSE Chemistry B?

	What stays the same?	What changes?
Structure	• Three units, comprising two externally assessed units and one internally assessed unit. • Externally assessed units are tiered – Foundation and Higher Tier. • Unit weightings – Unit B741 still 35%, Unit B742 still 40%. • Controlled assessment still 25% weighting.	• The course will be assessed as linear.
Content	• Content is divided into 6 modules, C1 – C6.	
Assessment	• Papers include structured questions and objective questions. • The internally assessed unit is based on a single investigative task divided into three parts. • There will be a choice of controlled assessment tasks, set by OCR, and valid for entry in one year only. • Unit B741 paper is 1 hour 15 mins long, with a total of 75 marks. • Unit B742 paper is 1 hour 30 mins long, with a total of 85 marks including a 10 mark analysis of evidence section. • How Science Works will be assessed in all units. • Quality of written communication will be assessed in all units.	• New 100% assessment rules apply to science GCSEs. All units, including written papers, available for assessment in June series only.

2.3 Guided learning hours

GCSE Chemistry B requires 120–140 guided learning hours in total.

2.4 Aims and Learning outcomes

The aims of this specification are to enable candidates to:

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

2.5 Prior learning

Candidates entering this course should have achieved a general educational level equivalent to National Curriculum Level 3, or an Entry 3 at Entry Level within the National Qualifications Framework.

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 (e.g. 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 Manufacturing chemicals: 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 yields	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 transfers – fuel cells
c The Periodic Table and covalent bonding	c Quantitative analysis	c Redox reactions
d The Group 1 elements	d Titrations	d Alcohols
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 testing 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 (e.g. Understanding Organisms)	
Item code and title: e.g. 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 practical and research activities 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	
Item code and title: e.g. B1a: Fitness and health	
Links to other items: 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.

It may be necessary to teach the content of the Foundation Tier only column to provide the underpinning knowledge required by Higher Tier candidates.

Candidates who are following this specification should have underpinning knowledge of chemistry through familiarity with the chemistry content of the Key Stage 3 programme of study within the National Curriculum.

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.

Links to other items	Assessable learning outcomes Foundation Tier only: low demand
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 scientists use a scientific idea to explain experimental observations or results.
C2a, C4a	Recognise that scientific explanations are provisional but more convincing when there is more evidence to support them.
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, C1e	Describe risks from new scientific or technological advances.
C2d	Distinguish between claims/opinions and scientific evidence in sources.
C2a, C4a	Recognise the importance of the peer review process in which scientists check each other's work.
C2e, C3a, C3b, C3c, C3d, C3e, C3f, C5a, C5b, C5d, C5e, C5f, C6a, C6h	Present data as tables, pie charts or line graphs, 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 an understanding of:

- how scientific explanations have been developed,
- their limitations, and
- how they may impact on individuals and society.

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 that 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 scientists plan a series of investigations/make 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 scientific explanations are provisional because they only explain the current evidence and that some evidence/observations cannot yet be explained.	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.	Describe the ways in which the values of society have influenced the development of science and technology.
Identify some arguments for and against a scientific or technological development, in terms of its impact on different groups of people or the environment.	Evaluate the application of science and technology, recognising the need to consider what society considers right or wrong, and the idea that the best decision will have the best outcome for the majority of the people involved.
Suggest ways of limiting risks and recognise the benefits of activities that have a known risk.	Analyse personal and social choices in terms of a balance of risk and benefit.
Evaluate a claim/opinion in terms of its link to scientific evidence.	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 how publishing results through scientific conferences and publications enables results to be replicated and further evidence to be collected.	Explain the value of using teams of scientists to investigate scientific problems.
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. Use range bars and understand their significance for data sets.
Determine the level of confidence for a conclusion based on scientific evidence 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.

3.4 Module C1: Carbon Chemistry

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.	Understand 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. Understand 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.	Recall that two types of chemical bond holding atoms together are: • ionic bonds • covalent 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 word equations (not all reactants and products given).	
Construct balanced symbol equations given the formulae (no brackets) of the reactants and products. Explain why a symbol equation is balanced.	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.
Understand 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 from atoms. Understand that negative ions are formed when electrons are gained by atoms.	
Understand that an ionic bond is the attraction between a positive ion and a negative ion. Understand that a covalent bond is a shared pair of electrons.	Explain how an ionic bond is formed. Explain how a covalent bond is formed.

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.	Recall 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. Understand 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.	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 items: C1b: Using carbon fuels, C1d: Making polymers, C1e: Designer polymers, C3f: Energy, C6d: Alcohols, C6g: Natural fats and oils

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 how fractional distillation separates 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 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 in terms of molecular size, intermolecular forces and boiling point why crude oil can be separated by fractional distillation. Understand that during boiling the intermolecular forces between molecules break but covalent bonds within the molecule do not.
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 that 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 (e.g. choosing the right fuel for heating/lighting a remote house in Scotland, powering a car, use in an electricity generating station).	Interpret simple data about fuels in order to choose the best fuel for a particular purpose (no recall expected). List the factors about fuels in order to choose the best fuel for a particular purpose: • energy value • availability • storage • cost • toxicity • pollution e.g. acid rain, greenhouse effect • ease of use.
Carry out an experiment to show that combustion of a hydrocarbon in a plentiful supply of air produces carbon dioxide and water.	Recall that the combustion of a fuel releases useful heat energy. Understand why 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 e.g. using appropriate ICT software. Investigate the products of complete and incomplete combustion by experiment.	Understand why incomplete combustion takes place. Explain why a blue Bunsen flame releases 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. Recall 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 items: C1a: Making crude oil useful, C1c: Clean air, C1d: Making polymers, C3c: Rate of reaction (3), C6b: Energy transfers – fuel cells, C6d: Alcohols

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Interpret data about fuels in order to choose the best fuel for a particular purpose (no recall expected). Suggest the key factors that need to be considered when choosing a fuel for a particular purpose.	Evaluate the use (no recall expected) of different fuels. Explain why the amount of fossil fuels being burnt is increasing: • increasing world population • growth of use in developing countries e.g. India and China.
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 the advantages of complete combustion over incomplete combustion of hydrocarbon fuels. 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. Understand how photosynthesis, respiration and combustion affect the level of carbon dioxide and the level of oxygen in the air. Understand that oxygen, nitrogen and carbon dioxide levels in the present day atmosphere are approximately constant.
Research the increase in occurrences of asthma in the UK and possible links with air pollution e.g. 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 and/or to the source of the pollutant: • carbon monoxide – a poisonous gas formed by the incomplete combustion of petrol or diesel in car engines • oxides of nitrogen – causes photochemical smog and acid rain and are formed in the internal combustion engine • sulfur dioxide – causes acid rain that will kill plants, kill aquatic life, erode stonework and corrode metals and is formed when sulfur impurities in fossil fuels burn.
Research the methods of preventing atmospheric pollution.	Recall 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 items: C1b: Using carbon fuels, C6e: Depletion of the ozone layer

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, for example: • deforestation • 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.
Interpret data about the effects of atmospheric pollutants.	Explain why 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.	Explain how use of a catalytic converter removes carbon monoxide from exhaust fumes using the balanced symbol equation: $2CO + 2NO \rightarrow N_2 + 2CO_2$

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.
Test for unsaturation using bromine water.	Recognise that alkenes are hydrocarbons.
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 website www.practicalchemistry.org. PVA polymer slime details from RSC website www.practicalchemistry.org.	Recall that large molecules, called polymers, are made when many small molecules, called monomers, join together in a polymerisation reaction.

Module C1: Carbon Chemistry

Item C1d: Making polymers

Links to other items: C1a: Making crude oil useful, C1b: Using carbon fuels, C1e: Designer polymers

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Recall that a hydrocarbon is a compound formed between carbon atoms and hydrogen atoms only. Given the molecular or displayed formula of a compound, explain why it is a hydrocarbon.	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.
Recall that alkanes are hydrocarbons which contain single covalent bonds only. Interpret information on displayed formulae of alkanes.	Interpret information from the displayed formula of a saturated hydrocarbon.
Recall that alkenes are hydrocarbons which contain a double covalent bond(s) between carbon atoms. Understand that double bonds involve two shared pairs of electrons. 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 • formation of a colourless dibromo compound.
Recognise the displayed formula for a polymer.	Draw the displayed formula of an addition polymer given the displayed formula of its monomer. Draw the displayed formula of a monomer given the displayed formula of its addition polymer.
Describe addition polymerisation as a process in which many alkene monomer molecules react together to give a polymer which requires high pressure and a catalyst.	Explain addition polymerisation in terms of addition of unsaturated molecules.

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 in the 21st century, including health care. 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 e.g. using appropriate ICT. Identification of polymers (plastics).	Recall that nylon is used in clothing.
Research how local councils dispose of public waste.	Understand that many polymers are non-biodegradable and so will not decay or decompose by bacterial action. Recall 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 items: C1a: Making crude oil useful, C1d: Making polymers

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
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.	Understand 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.
Compare the properties of nylon and GORE-TEX® fabric: • nylon is tough, lightweight, keeps water out and keeps UV light out but does not let water vapour through it which means that sweat condenses • GORE-TEX® fabric 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.	Explain why GORE-TEX® type materials are waterproof and yet breathable: • nylon laminated with PTFE / polyurethane membrane • holes in membrane are too small for water to pass through but are big enough for water vapour to pass through • membrane is too fragile on its own and so is combined with nylon.
Explain why chemists are developing new types of polymers: • polymers that dissolve • biodegradable polymers. Explain environmental and economic issues related to the use and disposal of polymers.	

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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 stop it 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. Explain why cooking food is a chemical change: • a new substance is formed • the process cannot be reversed.
Data search into the types of food additive e.g. 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.	Relate types of food additive to their function: • antioxidants stop foods from reacting with oxygen • food colours give food an improved colour • flavour enhancers improve the flavour of a food • emulsifiers help oil and water to mix and not separate.
Investigate the action of heat on baking powder.	Explain how baking powder helps make cakes rise. Recall that the chemical test for carbon dioxide is that it turns lime water cloudy.

Module C1: Carbon Chemistry

Item C1f: Cooking and food additives

Links to other items: C5c: Quantitative analysis, C6g: Natural fats and oils

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Recall that protein molecules in eggs and meat change shape when eggs and meat are cooked: this is called denaturing.	Explain why the texture of egg or meat changes when it is cooked: • shape of protein molecules permanently changes. Explain why potato is easier to digest if it is cooked: • cell walls rupture resulting in loss of rigid structure and a softer texture • starch grains swell up and spread out.
Describe emulsifiers as molecules that have a water loving (hydrophilic) part and an oil or fat loving (hydrophobic) part.	Explain why an emulsifier helps to keep oil and water from separating: • hydrophilic end bonds to water molecules • hydrophobic end bonds with oil or fat molecules.
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): $2NaHCO_3 \rightarrow Na_2CO_3 + CO_2 + H_2O$	Construct the balanced symbol equation for the decomposition of sodium hydrogencarbonate (formulae not given): $2NaHCO_3 \rightarrow Na_2CO_3 + CO_2 + H_2O$

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 e.g. butyl ethanoate. Microscale preparation of a range of esters and identification of the smells. Research the uses of esters.	Understand that cosmetics are either synthetic or natural depending on their source. Recall that esters are perfumes that can be made synthetically.
Research and display the properties of perfumes.	Recall 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.	Understand that nail-varnish remover dissolves nail varnish colours. Understand the terms solvent, solute, solution, soluble and insoluble.
Debate: “Is testing of cosmetics on animals ever justified?”	Recall that testing of cosmetics on animals is banned in the EU. Explain why new cosmetic products need to be thoroughly tested before they are permitted to be used.

Module C1: Carbon Chemistry

Item C1g: Smells

Links to other items: C6g: Natural fats and oils

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Recall 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 it is 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 testing of cosmetics on animals has been banned in the EU.	Explain why people have different opinions about whether the testing of cosmetics on animals is ever justified.

Module C1: Carbon Chemistry

Item C1h: Paints and pigments

Summary: Pigments and paints play an important part in our modern 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.	Relate the ingredients of a paint to their function: • 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. Recall 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.	Explain why paint is used (in a given context).
Investigate thermochromic pigments using materials e.g. material from Middlesex University Teaching Resources. Demonstrate some objects that contain thermochromic pigments.	Recall that thermochromic pigments change colour when heated or cooled. Recall uses of thermochromic pigments.
Investigate phosphorescent pigments using material e.g. material from Middlesex University Teaching Resources.	Recall that phosphorescent pigments can glow in the dark.

Module C1: Carbon Chemistry

Item C1h: Paints and pigments

Links to other items: C6c: Redox reactions

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 why the components of a colloid will not separate.
Describe how most paints dry: • paints are applied as a thin layer • the solvent evaporates. Describe emulsion paints as water based paints that dry when the solvent evaporates.	Explain how oil paints dry: • the solvent evaporates • the oil is oxidised by atmospheric oxygen.
Explain why thermochromic pigments are suited to a given use.	Explain how acrylic paints can be added to thermochromic pigments to make even more colour changes.
Explain why phosphorescent pigments glow in the dark: • they absorb and store energy • then release it as light over a period of time.	Recall that phosphorescent pigments are much safer than the alternative radioactive substances.

3.5 Module C2: Chemical Resources

Module C2: Chemical Resources

Item C2: 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.	Understand 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. Understand 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.	Recall that two types of chemical bond holding atoms together are: • ionic bonds • covalent 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 word equations (not all reactants and products given).	
Construct balanced symbol equations given the formulae (no brackets) of the reactants and products. Explain why a symbol equation is balanced.	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.
Understand 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 from atoms. Understand that negative ions are formed when electrons are gained by atoms.	
Understand that an ionic bond is the attraction between a positive ion and a negative ion. Understand that a covalent bond is a shared pair of electrons.	Explain how an ionic bond is formed. Explain how a covalent bond is formed.

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 the Collins Ideas and Evidence CD.	Describe the structure of the Earth as a sphere with a thin rocky crust, a mantle and an iron core. Understand how the movement of tectonic plates results in volcanic activity and earthquakes. Recall that the movement of tectonic plates is very slow (about 2.5cm per year). Understand the timescales involved in the movement of continents. Recognise that: • many theories have been put forward to explain the nature of the Earth's surface • Earth scientists accept the theory of plate tectonics.
Model a volcano using the candle wax experiment. Look for clues contained in volcanic rocks that show how they formed. Video clips of volcano types. Treacle investigation.	Explain how the size of crystals in an igneous rock is related to the rate of cooling of molten rock. Describe magma as molten rock beneath the surface of the Earth and lava as molten rock at the Earth's surface. Recall 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 why some people choose to live near volcanoes.

Module C2: Chemical Resources

Item C2a: The structure of the Earth

Links to other items: C2b: Construction materials

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe the lithosphere as the (relatively) cold rigid outer part of the Earth that includes the crust and part of the mantle. Describe the lithosphere as made of tectonic plates that 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 why the theory of plate tectonics is now widely accepted: • 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 crust 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 crust more dense than continental crust • collision between oceanic plate and continental plate leads to subduction and partial 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 subsequent research has supported the theory.
Understand that the type of volcanic eruption depends on the composition of the magma.	Describe different types of igneous rocks that are formed from lava: • iron-rich basalt is formed from runny lava from a fairly safe volcanic eruption • silica-rich rhyolite is formed from thick lava from an explosive eruption.
Explain why geologists study volcanoes: • to be able to forecast future eruptions • to reveal information about the structure of the Earth.	Explain why 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 the Earth 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.	Recall that some rocks are used in construction of buildings and roads: • granite, limestone, marble and aggregates.
Look at samples of marble, limestone and granite. Video clips of mining and quarrying.	Explain why there are environmental problems when rocks are quarried or mined 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.	Recall that limestone and marble are both forms of calcium carbonate. Recall limestone thermally decomposes to make calcium oxide and carbon dioxide.
Making a sample of concrete.	Describe how concrete is made: • cement, sand, aggregate and water are mixed together • mixture then allowed to set.
Investigating the strength of concrete beams.	Describe how concrete can be reinforced using a steel support.

Module C2: Chemical Resources

Item C2b: Construction materials

Links to other items: C2a: The structure of the Earth, C2d: Making cars

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Relate some construction materials to the substances found in the Earth's crust from which they are manufactured: • aluminium and iron from ores • brick from clay • glass from sand.	
Compare the hardness of limestone, marble and granite.	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): $CaCO_3 \rightarrow CaO + CO_2$
Recall that cement is made when limestone and clay are heated together.	
Recall that reinforced concrete is a composite material.	Explain why reinforced concrete is a better construction material than 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	Assessable learning outcomes Foundation Tier only: low demand
Extraction of copper by heating malachite and carbon. Experimental purification of copper by electrolysis.	Understand how copper can be extracted by heating its ore with carbon. Describe reduction as the removal of oxygen from a substance. 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 website www.practicalchemistry.org. Making solder and comparing its properties with lead and tin – see RSC website www.practicalchemistry.org.	Recall that alloys are mixtures containing one or more metal elements. Recognise that brass, bronze, solder, steel, and amalgam are alloys. Recall 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 e.g. 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 e.g. hardness, density, boiling point and strength. Suggest properties needed by a metal or alloy for a particular given use.

Module C2: Chemical Resources

Item C2c: Metals and alloys

Links to other items: C2d: Making cars, C4f: Transition elements, C4g: Metal structure and properties, C6a: Electrolysis, C6c: Redox reactions

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Label the apparatus needed to purify copper by electrolysis. Explain some of the advantages and disadvantages of recycling copper.	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 • anode loses mass as copper dissolves. Explain why the electrolytic purification of copper involves both oxidation and reduction: • $Cu^{2+} + 2e^{-} \rightarrow Cu$ as an example of reduction because electrons are gained • $Cu - 2e^{-} \rightarrow Cu^{2+}$ as an example of oxidation because electrons are lost.
Recall the main metals in each of the following alloys: • amalgam – mercury • brass – copper and zinc • solder – lead and tin.	
Explain why metals, including alloys are suited to a given use given appropriate data (no recall expected).	Evaluate the suitability of metals for a given use given appropriate data. 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 (e.g. salt water, acid rain, moist air). Comparing rate of corrosion of cars in the UK with that of Mediterranean countries.	Recall that rusting needs iron, water and oxygen. Recall that aluminium does not corrode in moist conditions. Describe oxidation as the addition of oxygen or the reaction of a substance with oxygen. Interpret simple 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.	Compare 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.
Research all the materials that are used to manufacture cars (e.g. 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 items: C2b: Construction materials, C2c: Metals and alloys, C4g: Metal structure and properties, C6c: Redox reactions

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Understand how salt water and acid rain affect rusting. Understand that rusting is an oxidation reaction (iron reacts with oxygen forming an oxide). Construct the word equation for rusting: iron + oxygen + water → hydrated iron(III) oxide Explain why aluminium does not corrode in moist conditions. Interpret data about the rate of corrosion of different metals in different conditions (no recall is expected).	
Understand 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, to include: • 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: • get better fuel economy because the car body of the same car will be lighter with aluminium • longer lifetime because the car body with aluminium will corrode less.
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 why 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: Manufacturing chemicals: making ammonia

Summary: This item is introduced using the context of the industrial preparation of ammonia using chemicals from the air 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 has to be struck between rate and percentage conversion is explored more generally. 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 e.g. Multimedia Science School 11-16 or Boardworks. Industrial case study. Watch video of Haber process with pre-prepared questions.	Recall that in the Haber process ammonia is made from nitrogen from the air and hydrogen that 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 proceeds in both directions.
Survey of household chemicals containing ammonia and their uses.	Recall some of the uses of ammonia: • manufacture of fertilisers • manufacture of nitric acid.

Module C2: Chemical Resources

Item C2e: Manufacturing chemicals: making ammonia

Links to other items: C2g: Fertilisers and crop yields, C3a: Rate of reaction (1), C3b: Rate of reaction (2), C3c: Rate of reaction (3), C5f: Equilibria

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 $\rightleftharpoons$ 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 the 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 how 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 starting 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 data logger.) Test everyday household substances.	Describe how universal indicator can be used to estimate the pH of a solution. Recall the colour changes with litmus.
Simple investigation into the change in pH during neutralisation (not pH titration curves).	Recall that an alkali is a soluble base.
Investigate the reactions of acids with bases and carbonates e.g. 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 items: C2g: Fertilisers and crop yields, C3a: Rate of reaction (1), C3b: Rate of reaction (2), C3c: Rate of reaction (3), C5d: Titrations, C5g: Strong and weak acids

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Understand that indicators use colour change to show changes in pH, including: • sudden or gradual changes • colour changes over different pH ranges.	
Recall that in neutralisation: acid + base → salt + water. Recall that in solution all acids contain H^+ ions. Understand that the pH of an acid is determined by the concentration of H^+ ions.	Explain why an acid is neutralised by an alkali in terms of the ions present: • acids contain H^+ • alkalis contain OH^- • neutralisation involves the reaction $H^+ + OH^- \rightleftharpoons H_2O$
Explain why metal oxides and metal hydroxides neutralise acids. Recall 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	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.	Recall that fertilisers increase crop yield. 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 (e.g. potassium nitrate or ammonium sulfate).	Identify 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 e.g.: • ammonium nitrate • ammonium phosphate • ammonium sulfate • urea.

Module C2: Chemical Resources

Item C2g: Fertilisers and crop yields

Links to other items: C2e: Manufacturing chemicals: making ammonia, C2f: Acids and bases

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain why fertilisers must be dissolved in water before they can be absorbed by plants.	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.
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 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 a named fertiliser for example: • ammonium 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.	Recall that sodium chloride (salt) 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. Recall that the chemical test for chlorine is that it bleaches moist litmus paper.
Survey the range of products formed from salt.	Recall that sodium chloride is used: • as a preservative • as a flavouring. Understand that sodium chloride is an important raw material in the chemical industry, including use as a 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 items: C4b: Ionic bonding, C4e: The Group 7 elements, C4h: Purifying and testing water

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 how mining for salt can lead to subsidence.	
Recall the products of the electrolysis of concentrated sodium chloride solution (brine): • hydrogen made at the cathode • chlorine made at the anode • sodium hydroxide is also made. Explain why it is important to use inert electrodes in the electrolysis of sodium chloride solution.	Explain how the electrolysis of sodium chloride solution (brine) produces sodium hydroxide, hydrogen and chlorine: • $NaCl(aq)$ contains Na^+, OH^-, Cl^-, H^+ • cathode $2H^+ + 2e^- \rightarrow H_2$ • anode $2Cl^- - 2e^- \rightarrow Cl_2$ • ions not discharged make sodium hydroxide. Explain why the electrolysis of sodium chloride involves both reduction and oxidation.
Describe how sodium hydroxide and chlorine are used to make household bleach.	Explain the economic importance of the chlor-alkali industry.

3.6 Module C3: Chemical Economics

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.	Understand 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. Understand 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.	Recall that two types of chemical bond holding atoms together are: • ionic bonds • covalent bonds.

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 word equations (not all reactants and products given).	
Construct balanced symbol equations given the formulae (no brackets) of the reactants and products. Explain why a symbol equation is balanced.	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.
Understand 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 from atoms. Understand that negative ions are formed when electrons are gained by atoms.	
Understand that an ionic bond is the attraction between a positive ion and a negative ion. Understand that a covalent bond is a shared pair of electrons.	Explain how an ionic bond is formed. Explain how a covalent bond is formed.

Module C3: Chemical Economics

Item C3a: Rate of reaction (1)

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

Suggested practical and research 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 reactions.
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. Investigate the rate of reaction of magnesium ribbon or calcium carbonate and dilute hydrochloric acid using a 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. Plot experimental results involving gas volumes or mass loss on a graph. Plot experimental results involving reaction times on a graph. Interpret data in tabular, graphical and written form about the rate of reaction or reaction time for example: • reading off values from a graph • comparing rates of reaction by comparing gradients of graphs • comparing rates of reaction using reaction times.
	Explain why a reaction stops.

Module C3: Chemical Economics

Item C3a: Rate of reaction (1)

Links to other items: C2e: Manufacturing chemicals: making ammonia, C2f: Acids and bases, C3b: Rate of reaction (2), C3c: Rate of reaction (3), C4d: The Group 1 elements, C5e: Gas volumes, C5f: Equilibria, C5g: Strong and weak acids

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Understand that the rate of a reaction measures how much product is formed in a fixed time period. Understand common units for the rate of reaction: • g/s or g/min • cm^3/s or cm^3/min.	
Interpret data in tabular, graphical and written form about the rate of reaction or reaction time for example: • comparing the rate of reaction during a reaction.	Interpret data from tabular, graphical and written form about the rate of reaction or reaction time for example: • calculating the rate of reaction from the slope of an appropriate graph including determining units • extrapolation • interpolation.
Recognise and use the idea that the amount of product formed is directly proportional to the amount of limiting reactant used. Recall that the limiting reactant is the reactant not in excess that is all used up at the end of the reaction.	Explain, in terms of reacting particles, why the amount of product formed is directly proportional to the amount of limiting reactant used.

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 chemical reactions take 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.
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.
Look at the application of rate of reaction in everyday life (e.g. speed of cooking with pressure cooker, the rusting of metals, rate of dissolving tablets for medicinal use).	Describe the effect of changing the pressure on the rate of a chemical reaction of gases.
Investigate the rate of reaction using magnesium ribbon or calcium carbonate and dilute hydrochloric acid using a gas syringe to collect gas.	Interpret data in tabular, graphical and written form about the effect of temperature, concentration and pressure on the rate of reaction for example: • reading off values from a graph • comparing rates of reaction by comparing gradients of graphs • comparing rates of reaction using reaction times.

Module C3: Chemical Economics

Item C3b: Rate of reaction (2)

Links to other items: C2e: Manufacturing chemicals: making ammonia, C2f: Acids and bases, C3a: Rate of reaction (1), C3c: Rate of reaction (3), C4d: The Group 1 elements, C5e: Gas volumes, C5f: Equilibria, C5g: Strong and weak acids

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Understand that the rate of reaction depends on the number of collisions between reacting particles.	Understand 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, in terms of the reacting particle model, why changes in temperature change the rate of reaction.	Explain, using the reacting particle model, why changes in temperature change the rate of reaction in terms of successful collisions between particles.
Explain, in terms of the reacting particle model, why changes in concentration change the rate of reaction.	Explain, using the reacting particle model, why changes in concentration change the rate of reaction in terms of successful collisions between particles.
Explain, in terms of the reacting particle model, why changes in pressure change the rate of reaction.	Explain, using the reacting particle model, why changes in pressure change the rate of reaction in terms of successful collisions between particles.
Interpret data in tabular, graphical and written form about the effect of temperature and concentration on the rate of reaction for example: • deciding when a reaction has finished • comparing the rate of reaction during a reaction. 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 tabular, graphical and written form about 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.	Recall 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 and powder with acid.	Recall 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 e.g. knocking down a building, explosion in a quarry. Demonstrate explosive reactions (cornflour or custard powder).	Describe an explosion as a very fast reaction which releases a large volume of gaseous products.
Look at the application of rate of reaction in everyday life (e.g. resin and hardener in car body filler, catalytic converters).	Interpret data in tabular, graphical and written form about the effect of surface area and the addition of a catalyst on the rate of reaction, for example: • reading off values from a graph • comparing rates of reaction by comparing gradients of graphs • comparing rates of reaction using reaction times.

Module C3: Chemical Economics

Item C3c: Rate of reaction (3)

Links to other items: C2e: Manufacturing chemicals: making ammonia, C2f: Acids and bases, C3a: Rate of reaction (1), C3b: Rate of reaction (2), C4d: The Group 1 elements, C5e: Gas volumes, C5f: Equilibria, C5g: Strong and weak acids

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. Understand why only a small amount of a catalyst is needed to catalyse large amounts of reactants and that a catalyst is specific to a particular reaction.	
Explain, in terms of reacting particles and surface area, the difference in rate of reaction between a lump and powdered reactant.	Explain, in terms of collisions between reacting particles, the difference in rate of reaction between a lump and powdered reactant.
Explain the dangers of fine combustible powders in factories (e.g. custard powder, flour or sulfur).	
Interpret data in tabular, graphical and written form about 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. 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 tabular, graphical and written form about the effect of 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 (M_r) calculations.	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. 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.
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 simple ratios to calculate reacting masses and product masses given the mass of a reactant and a product.

Module C3: Chemical Economics

Item C3d: Reacting masses

Links to other items: C3e: Percentage yield and atom economy, C5a: Moles and molar mass, C5b: Percentage composition and empirical formula

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. Explain why mass is conserved in chemical reactions.	Use relative formula masses and a provided symbol equation to show that mass is conserved during a reaction.
Recognise and use the idea that the mass of product formed is directly proportional to the mass of limiting reactant used.	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.	Understand 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. 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 • not all reactants react to make product.
Class practical involving the 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.	Understand 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 simple percentage yield and atom economy data.

Module C3: Chemical Economics

Item C3e: Percentage yield and atom economy

Links to other items: C3d: Reacting masses, C5b: Percentage composition and empirical formula

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Recall and use the formula: $\text{percentage yield} = \frac{\text{actual yield}}{\text{predicted yield}} \times 100$	Explain why an industrial process wants as high a percentage yield as possible, to include: • reducing the reactants wasted • reducing cost.
Recall and use the formula: $\text{atom economy} = \frac{M_r \text{ of desired products}}{\text{sum of } M_r \text{ of all products}} \times 100$ Calculate atom economy when given balanced symbol equation (1:1 molar ratio) and appropriate relative formula masses.	Calculate atom economy when given balanced symbol equation and appropriate relative formula masses. Explain why an industrial process wants as high an atom economy as possible: • to reduce the production of unwanted products • to make the process more sustainable.
Interpretation of complex percentage yield and atom economy data.	

Module C3: Chemical Economics

Item C3f: Energy

Summary: This item develops ideas about how the amount of energy released during 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).	Recall that an exothermic reaction is one in which energy is transferred into the surroundings (releases energy). Recall that an endothermic reaction is one in which energy is taken from the surroundings (absorbs energy). Recognise exothermic and endothermic reactions 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.	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 fuels to compare which fuel releases the most energy.

Module C3: Chemical Economics

Item C3f: Energy

Links to other items: C1a: Making crude oil useful, C1b: Using carbon fuels, C6b: Energy transfers – fuel cells

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Recall bond making as an exothermic process and 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 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 valid tests. Calculate the energy transferred by using the formula (no recall needed): • energy transferred (in J) = m × c × ΔT • where m = mass of water heated • c = specific heat capacity (4.2 J/g °C) • ΔT = temperature change.	Use the formula energy transferred (in J) = m × c × ΔT to calculate: • m = mass of water heated • ΔT = temperature change. Calculate the energy output of a fuel in J/g by recalling and using the formula: $\text{energy per gram} = \frac{\text{energy released (in J)}}{\text{mass of fuel burnt (in g)}}$

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.atworkwithscience.com.	Describe the differences between a batch and a continuous process.
Industrial case studies.	List 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. Explain why pharmaceutical drugs need to be thoroughly tested before they can be licensed for use.
Practical extraction of a natural oil from a plant. Research plants and animals used as sources of drugs.	Recall that the raw materials for speciality chemicals such as pharmaceuticals can be either made synthetically or extracted from plants.
	Explain why it is important to manufacture pharmaceutical drugs to be as pure as possible. Describe how melting point, boiling point and thin layer chromatography can be used to establish the purity of a compound.

Module C3: Chemical Economics

Item C3g: Batch or continuous?

Links to other items: C2e: Manufacturing chemicals: making ammonia, C6d: Alcohols

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain why batch processes are often used for the production of pharmaceutical drugs but continuous processes are used to produce chemicals such as ammonia.	Evaluate the advantages and disadvantages of batch and continuous manufacturing processes given relevant data and information.
Explain why it is often expensive to make and develop new pharmaceutical drugs.	Explain why it is difficult to test and develop new pharmaceutical drugs that are safe to use.
Describe how chemicals are extracted from plant sources: • crushing • boiling and dissolving in suitable solvent • chromatography.	
Interpret melting point, boiling point and chromatographic data relating to the purity of a substance.	

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.	Explain why diamond, graphite and Buckminster fullerene are all forms of carbon. Recognise the structures of diamond, graphite and Buckminster fullerene.
	List the physical properties of diamond: • lustrous, colourless and clear (transparent) • hard and has a high melting point • insoluble in water • does not conduct electricity.
Examine samples of graphite.	List the physical properties of graphite: • black, lustrous and opaque • slippery • insoluble in water • conducts electricity.
Build models of fullerenes and nanotubes. (RSC – contemporary chemistry for schools and colleges has useful worksheets etc). Survey of uses of fullerenes (via internet).	Recall that nanotubes are used to reinforce graphite in tennis rackets because nanotubes are very strong. Recall that nanotubes are used as semiconductors in electrical circuits.

Module C3: Chemical Economics

Item C3h: Allotropes of carbon and nanochemistry

Links to other items: C4c: The Periodic Table and covalent bonding

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain why diamond, graphite and fullerenes are allotropes of carbon.	
Explain, in terms of properties, why diamond is used in cutting tools and jewellery.	Explain, in terms of structure and bonding, why diamond: • does not conduct electricity • is hard and has a high melting point.
Explain, in terms of properties, why graphite is used: • in pencil leads • in lubricants.	Explain, in terms of structure and bonding, why graphite: • conducts electricity • is slippery • has a high melting point.
Explain why diamond and graphite have a giant molecular structure.	Predict and explain the properties of substances that have a giant molecular structure.
Explain why fullerenes can be used in new drug delivery systems.	Explain how the structure of nanotubes enables them to be used as catalysts.

3.7 Module C4: The Periodic Table

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.	Understand 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. Understand 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.	Recall that two types of chemical bond holding atoms together are: • ionic bonds • covalent 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 why a symbol equation is balanced.	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(II), 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.
Understand 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 from atoms. Understand that negative ions are formed when electrons are gained by atoms.	
Understand that an ionic bond is the attraction between a positive ion and a negative ion. Understand that a covalent bond is a shared pair of electrons.	Explain how an ionic bond is formed. Explain how a covalent bond is formed.

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.	Recall that an atom has 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 or vice versa by using a Periodic Table. Recall that atomic number is the number of protons in an atom. Recall that mass number is the total number of protons and neutrons in an atom.
Identify elements and numbers of atoms of each element from formulae.	Explain why a substance is an element or a compound given its formula.
Draw electronic structures given atomic numbers.	Deduce the number of occupied shells or the number of electrons from the electronic structure of an element.
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 items: C4b: Ionic bonding, C4c: The Periodic Table and covalent bonding

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 why an atom is neutral in terms of its sub-atomic particles. Understand that atoms have a radius of about 10^{-10}m and a mass of about 10^{-23}g.
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 and mass number: • using data in a table • using the conventional symbolism e.g. carbon-12 or ${}^{12}_{6}C$.	Deduce the number of protons, electrons and neutrons in a charged particle given its atomic number, mass number and the charge on the particle: • using data in a table • using the conventional symbolism e.g. carbon-12 or ${}^{12}_{6}C$. Identify isotopes from data about the number of electrons, protons and neutrons in particles.
Describe the arrangement of elements in the Periodic Table.	
Explain how the identity of an element can be deduced from its electronic structure.	Deduce the electronic structure of the first 20 elements in the periodic table e.g. 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.	Recall 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.	Compare the electrical conductivity of sodium chloride in solid, molten liquid and solution. Compare the melting points of sodium chloride and magnesium oxide.

Module C4: The Periodic Table

Item C4b: Ionic bonding

Links to other items: C2h: Chemicals from the sea: the chemistry of sodium chloride, C4a: Atomic structure, C4d: The Group 1 elements, C4e: The Group 7 elements, C4f: Transition elements

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Understand that atoms with an outer shell of 8 electrons have a stable electronic structure. Explain how and why metal atoms form positive ions. Explain how and why non-metal atoms form negative ions. Understand 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. Deduce the formula of an ionic compound from the formula of the positive and negative ions.	Explain, using the "dot and cross" model, the ionic bonding in simple binary compounds.
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, in terms of structure and bonding, some of the physical properties of sodium chloride: • high melting points • electrical conductivity of solid, molten liquid and solution. Explain, in terms of structure and bonding, why the melting point of sodium chloride is lower than that of magnesium oxide. Predict and explain the properties of substances that have a giant ionic structure.

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.	Recall that there are two types of bonding: • ionic bonding between metals and non-metals • covalent bonding between non-metals.
Research melting point, boiling point and electrical conductivity of carbon dioxide and water.	Recall that carbon dioxide and water do not conduct electricity.
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.
Research or produce a poster of the work of Dobereiner, Newlands and/or Mendeleev. Produce a timeline of events for the development of the Periodic Table and its later confirmation.	Describe the main stages in the development of the classification of elements: • Dobereiner • Newlands • Mendeleev. Understand that classification of elements was provisional, based on evidence gathered at the time.

Module C4: The Periodic Table

Item C4c: The Periodic Table and covalent bonding

Links to other items: C3h: Allotropes of carbon and nanochemistry, C4a: Atomic structure

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.	Explain, using the "dot and cross" model, the covalent bonding in simple binary compounds or molecules containing single and double covalent bonds.
Describe carbon dioxide and water as simple molecules with weak intermolecular forces between molecules.	Explain, in terms of structure and bonding, some of the physical properties of carbon dioxide and water: • low melting points • do not conduct electricity. Predict and explain the properties of substances that have a simple molecular structure.
Recognise that the group number is the same as the number of electrons in the outer shell. Deduce the group to which an element belongs from its electronic structure (limited to the s and p blocks).	
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.	
Describe the evidence or observations that caused Newlands and Mendeleev to develop new models of periodic classification of elements.	Explain how further evidence confirmed Mendeleev's ideas about the Periodic Table: • confirmation of his predictions about unknown elements • how investigations on atomic structure (mass number and electronic structure) agreed with his ideas.

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 e.g. using the internet. Demonstrate reactions of sodium, lithium and potassium with water. Show video of reactions of rubidium and caesium with water.	Explain why the Group 1 elements are known as the alkali metals. Explain why Group 1 elements are stored under oil. 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.
	Recognise sodium, lithium and potassium as Group 1 elements.
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 e.g. deduce the alkali metal present from flame colours.

Module C4: The Periodic Table

Item C4d: The Group 1 elements

Links to other items: C3a: Rate of reaction (1), C3b: Rate of reaction (2), C3c: Rate of reaction (3), C4b: Ionic bonding, C4e: The Group 7 elements, C6c: Redox reactions

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Predict the properties of Group 1 elements rubidium and/or caesium 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 physical properties of rubidium and/or caesium given information about the other Group 1 elements.
Explain why Group 1 elements have similar properties.	Explain why Group 1 elements have similar properties, in terms of forming positive ions with stable electronic structures. Construct a balanced symbol equation to show the formation of an ion of a Group 1 element from its atom. Explain, in terms of electron loss, the trend in reactivity of the Group 1 elements with water. Recall the loss of electrons as oxidation. Explain why a process is oxidation from its ionic equation.
Describe how to use a flame test to identify 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 • colours of the flames.	

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 website: 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).	Recall that the reactivity of the Group 7 elements decreases down the group. 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 items: C2h: Chemicals from the sea: the chemistry of sodium chloride, C4b: Ionic bonding, C4d: The Group 1 elements, C4h: Purifying and testing water, C5h: Ionic equations and precipitation, C6c: Redox reactions, C6e: Depletion of the ozone layer

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 e.g.: • physical properties • melting point • boiling point • displacement reactions.
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).
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). Predict the feasibility of displacement reactions e.g. will bromine react with sodium astitide solution.
Explain why Group 7 elements have similar properties.	Explain why Group 7 elements have similar properties, in terms of forming negative ions with stable electronic structures. Construct an equation to show the formation of a halide ion from a halogen molecule. Explain, in terms of electron gain, the trend in reactivity of the Group 7 elements. Recall 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). Recall 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 items: C2c: Metals and alloys, C4b: Ionic bonding, C4g: Metal structure and properties, C5h: Ionic equations and precipitation, C6c: Redox reactions

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 often blue • iron(II) compounds are often light green • iron(III) compounds are often 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 including $FeCO_3$, $CuCO_3$, $MnCO_3$ 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/brown 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.	Explain why iron is used to make cars and bridges. Explain why copper is used to make electrical wiring.
Data search or experimental comparison of different metal properties. Data interpretation activity.	List 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 e.g. hardness, density and electrical conductivity. Explain why metals are suited to a given use (data will be provided). Suggest properties needed by a metal for a particular given use e.g. saucepan bases need to be good conductors of heat.
	Recognise that the particles in a metal are held together by metallic bonds.
Internet research into superconductors. Displacement reactions to show metal crystals e.g. copper in aqueous silver nitrate. Produce a poster on superconductors. Bubble raft demonstration.	Recall that at low temperatures some metals can be superconductors.

Module C4: The Periodic Table

Item C4g: Metal structure and properties

Links to other items: C2c: Metals and alloys, C2d: Making cars, C4f: Transition elements

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain why metals are suited to a given use (data will be provided).	
Understand that metals have high melting points and boiling points due to strong metallic bonds. Describe how metals conduct electricity.	Describe metallic bonding as the strong attraction between a sea of delocalised electrons and close packed positive metal ions. Explain, in terms of structure, why metals have: • high melting points and boiling points • conduct electricity.
Describe what is meant by the term superconductor. Describe the potential benefits of superconductors: • loss free power transmission • super-fast electronic circuits • powerful electromagnets.	Explain some of the drawbacks of superconductors.

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 simple 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. Explain why water is an important resource for many important industrial chemical processes.
Research the pollutants found in water.	List 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.	List the types of substances present in water before it is purified: • dissolved salts and minerals • microbes • pollutants • insoluble materials. Recall that chlorination kills microbes in water.
Investigate the solution chemistry of some dissolved ions. Preparation of an insoluble salt e.g. 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 items: C2h: Chemicals from the sea: the chemistry of sodium chloride, C4e: The Group 7 elements, C5h: Ionic equations and precipitation, C6f: Hardness of water

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.	
Explain why drinking water may contain some of the pollutants listed below: • nitrate • lead compounds • pesticide.	
Describe the water purification process to include filtration, sedimentation and chlorination.	Explain why some soluble substances are not removed from water during purification. 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 reactions of barium chloride with sulfates and silver nitrate with halides given the appropriate formulae.

3.8 Module C5: How Much? (Quantitative Analysis)

Module C5: How Much? (Quantitative Analysis)

Item C5: 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.	Understand 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. Understand 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.	Recall that two types of chemical bond holding atoms together are: • ionic bonds • covalent 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 word equations (not all reactants and products given).	
Construct balanced symbol equations given the formulae (no brackets) of the reactants and products. Explain why a symbol equation is balanced.	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.
Understand 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 from atoms. Understand that negative ions are formed when electrons are gained by atoms.	
Understand that an ionic bond is the attraction between a positive ion and a negative ion. Understand that a covalent bond is a shared pair of electrons.	Explain how an ionic bond is formed. Explain how a covalent bond is formed.

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. Recall that the unit for molar mass is g/mol. Understand that the term molar mass of a substance refers to its relative formula mass in grams. Calculate the molar mass of a substance from its formula (without brackets) using the appropriate relative atomic masses.
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 items: C3d: Reacting masses, C5c: Quantitative analysis, 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. Recall 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 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. Also see www.practicalchemistry.org. Carry out an experiment to measure the decrease in mass on reduction of copper oxide e.g. reduction with methane gas. 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 items: C3d: Reacting masses, C3e: Percentage yield and atom economy, C5c: Quantitative analysis

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.	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 e.g.: • 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 guideline daily amounts (GDA) values.	Interpret information on food packaging about guideline daily amounts (GDA) for example: • the smallest or largest amount of a particular substance.

Module C5: How Much? (Quantitative Analysis)

Item C5c: Quantitative analysis

Links to other items: C1f: Cooking and food additives, C5a: Moles and molar mass, C5b: Percentage composition and empirical formula

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 e.g. how to dilute a 1.0 mol/dm^3 solution into a 0.1 mol/dm^3 solution or how to perform a 1 in 10 dilution.	
Interpret information on food packaging about guideline daily amounts (GDA) 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. Explain why the above conversion may be inaccurate, to include sodium ions coming from other sources.

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.	Interpret a simple pH curve to include: • determine the pH at a particular volume added or vice versa (major grid lines). Explain how universal indicator can be used to estimate the pH value of a solution.
Carry out a simple acid-alkali titration using an indicator such as litmus or phenolphthalein. Microscale titrations details from RSC website www.practicalchemistry.org.	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 conical flask (or vice versa) • acid slowly added to alkali (or vice versa) until end point is reached • end point detected by the sudden change in colour of an indicator. Explain why it is important to use a pipette filler when using a pipette in an acid-base titration. Calculate the titre given appropriate information from tables or diagrams. Understand that the titre depends on the concentration of the acid or alkali.
Simple investigation of the colour changes of indicators limited to universal indicator, phenolphthalein and litmus during neutralisation. Universal indicator rainbow see details from RSC website 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 items: C2f: Acids and bases, C5c: Quantitative analysis, C5g: Strong and weak acids

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Interpret a simple pH curve to include: • determine the volume of acid or alkali at neutralisation • determine the pH at a particular volume added or vice versa (not major grid lines).	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 the difference in colour change during a titration using a single indicator, such as litmus or phenolphthalein, compared to a mixed indicator, such as universal.	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 e.g. displacement of water in a burette or measuring cylinder, use of a gas syringe.	Identify 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 e.g. marble and acid and/or thermal decomposition of zinc carbonate.	Recall 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 e.g. magnesium and dilute hydrochloric acid, marble chips and acid.	Explain why a reaction stops.
ICT simulation of the progress of a reaction showing how the amount of reactant and/or amount of product present changes with time.	Interpret data in table, graphical and written form about the volume of gas produced during the course of a reaction (limited to major grid lines on graphs) for example: • deduce total volume of gas produced • deduce when the reaction has stopped • deduce volume of gas at a particular time and vice versa • compare rates of reaction using gradients of graphs.

Module C5: How Much? (Quantitative Analysis)

Item C5e: Gas volumes

Links to other items: C3a: Rate of reaction (1), C3b: Rate of reaction (2), C3c: Rate of reaction (3), C5a: Moles and molar mass, C5c: Quantitative analysis

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.	
Understand how the amount of product formed varies with the amount of limiting reactant used. Recall that the limiting reactant is the reactant not in excess that is all 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 in terms of reacting particles why the amount of product formed is directly proportional to the amount of limiting reactant used. 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 data in table, graphical and written form about the volume of gas produced during the course of a reaction (not major grid lines) for example: • 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 about the reaction.

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.	Understand that a reversible reaction can proceed in both directions, both forwards and backwards. Recall 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, for example: • composition at particular temperatures • composition at particular pressures • effect of temperature and pressure on composition.
Show a video about Contact Process.	Recall the raw materials used to make sulfuric acid by the Contact Process: • sulfur • air • water. Describe the manufacture of sulfuric acid: • sulfur is burnt to produce sulfur dioxide • sulfur dioxide reacts with oxygen to produce sulfur trioxide • sulfur trioxide reacts with water to produce sulfuric acid.

Module C5: How Much? (Quantitative Analysis)

Item C5f: Equilibria

Links to other items: C2e: Manufacturing chemicals: making ammonia, C3a: Rate of reaction (1), C3b: Rate of reaction (2), C3c: Rate of reaction (3)

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Recall that in a reversible reaction 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. Understand how the position of equilibrium is related to the ratio of the concentration of the products to the concentration of the reactants.	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.
Recall 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, for example: • composition at particular temperatures • composition at particular pressures • effect of temperature and pressure on composition.	Understand 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 temperature moves the position of equilibrium in the direction of the endothermic reaction or vice versa • increasing the pressure moves the position of equilibrium to the side with the least number of moles of gas molecules or vice versa. Explain the effect of changing product concentration, reactant concentration, temperature or pressure on the position of equilibrium given appropriate details about a reaction.
Understand that the reaction between sulfur dioxide and oxygen is reversible: • sulfur dioxide + oxygen $\rightleftharpoons$ sulfur trioxide • $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ Describe the conditions used in the Contact Process: • V_2O_5 catalyst • around 450°C • atmospheric pressure.	Explain the conditions used in the Contact Process: • increasing the temperature moves the position of equilibrium to the left and increases rate of reaction so a compromise temperature is used • addition of catalyst increases rate but does not change position of equilibrium • even at low pressure, the position of equilibrium is already on right so expensive high pressure 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 with 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.	Recall that ethanoic acid is a weak acid. Recall that hydrochloric, nitric and sulfuric acids are strong acids. Understand 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.	Recall that both ethanoic acid and hydrochloric acid react with magnesium to give hydrogen and with calcium carbonate to give carbon dioxide. Recall that magnesium and calcium carbonate react slower with ethanoic acid than with hydrochloric acid of the same concentration because ethanoic acid is a weak acid.
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.	Understand 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.	Understand that ethanoic acid has a lower electrical conductivity than hydrochloric acid of the same concentration. Recall that electrolysis of both ethanoic acid and hydrochloric acid makes hydrogen at the negative electrode.

Module C5: How Much? (Quantitative Analysis)

Item C5g: Strong and weak acids

Links to other items: C2f: Acids and bases, C3a: Rate of reaction (1), C3b: Rate of reaction (2), C3c: Rate of reaction (3)

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Understand that an acid ionises in water to produce H^+ ions. Understand that a strong acid completely ionises in water and a weak acid does not fully ionise and forms 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 • acid concentration is a measure of the number of moles of acid in one dm^3. Construct equations for the ionisation of weak and strong acids given the formula of the mono-basic acid.
Explain why ethanoic acid reacts slower than hydrochloric acid of the same concentration: • there are fewer hydrogen ions in ethanoic acid • in ethanoic acid there are fewer collisions between hydrogen ions and reactant particles.	Explain why ethanoic acid reacts slower than hydrochloric acid of the same concentration: • ethanoic acid has a lower concentration of hydrogen ions • in ethanoic acid the hydrogen ions have a lower collision frequency with reactant particles.
Explain why the volume of gaseous products of the reactions of acids is determined by the amounts of reactants present not the acid strength.	
Explain why ethanoic acid is less conductive than hydrochloric acid of the same concentration: • there are fewer hydrogen ions available to move. Explain why hydrogen is produced during the electrolysis of ethanoic acid and of hydrochloric acid.	Explain why ethanoic acid is less conductive than hydrochloric acid of the same concentration: • lower concentration of hydrogen ions to carry the charge in ethanoic 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 a precipitation reaction. Understand that most precipitation reactions involve ions from one solution reacting with ions from another solution.
	Describe how 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 how 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 e.g. 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 items: C4e: The Group 7 elements, C4f: Transition elements, C4h: Purifying and testing water, C6a: Electrolysis

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Understand that ionic substances contain ions which are in fixed positions in the solid but can move in solution. Understand that in a precipitation reaction ions must collide with other ions to react to form a precipitate.	Explain, in terms of collisions between ions, why most precipitation reactions are extremely fast.
Interpret experimental data about the testing of solutions using aqueous barium chloride and aqueous lead nitrate.	
Construct word equations for simple precipitation reactions e.g. 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 formulae of the ions that react. 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.	

3.9 Module C6: Chemistry Out There

Module C6: Chemistry Out There

Item C6: 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.	Understand 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. Understand 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.	Recall that two types of chemical bond holding atoms together are: • ionic bonds • covalent 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 word equations (not all reactants and products given).	
Construct balanced symbol equations given the formulae (no brackets) of the reactants and products. Explain why a symbol equation is balanced.	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 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.
Understand 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 from atoms. Understand that negative ions are formed when electrons are gained by atoms.	
Understand that an ionic bond is the attraction between a positive ion and a negative ion. Understand that a covalent bond is a shared pair of electrons.	Explain how an ionic bond is formed. Explain how a covalent bond is formed.

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 NaOH(aq) and H_2SO_4(aq).	Identify 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 observations of the electrolysis of copper(II) sulfate solution using carbon electrodes: • the cathode gets plated with copper and bubbles are formed at the anode • blue colour will slowly disappear. Recall 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 molten electrolytes.

Module C6: Chemistry Out There

Item C6a: Electrolysis

Links to other items: C2c: Metals and alloys, C5h: Ionic equations and precipitation

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.	
Recall the products of the electrolysis of: • 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 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 why the electrolysis of NaOH(aq) makes H_2 rather than Na at the cathode.
Recall the products of the electrolysis of $CuSO_4$(aq) with carbon electrodes: • copper is formed at the cathode and oxygen at the anode. Understand how the amount of substance produced during electrolysis varies with time and current.	Construct the half equations for electrode processes that happen during the electrolysis of $CuSO_4$(aq) using carbon electrodes: • cathode – $Cu^{2+} + 2e^- \rightarrow Cu$ • anode – $4OH^- - 4e^- \rightarrow O_2 + 2H_2O$ Perform 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.	Construct the half equations for the electrode processes that happen during the electrolysis of molten binary ionic compounds given the formulae of the ions present in the electrolyte.

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.	Recall that the reaction between hydrogen and oxygen is exothermic. Understand why fuel cells use exothermic reactions. Construct the word equation for the reaction between hydrogen and oxygen.
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 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 produce electrical energy efficiently. Recall that hydrogen is the fuel in a hydrogen-oxygen fuel cell.
	Recall that one important use of fuel cells is to provide electrical power in spacecraft.
	Explain why a hydrogen-oxygen fuel cell does not form a polluting waste product. Recall that the combustion of fossil fuels, such as petrol, produce carbon dioxide which has been linked to climate change and global warming.

Module C6: Chemistry Out There

Item C6b: Energy transfers – fuel cells

Links to other items: C1b: Using carbon fuels, C3f: Energy

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Construct the balanced symbol equation for the reaction between hydrogen and oxygen.	Draw and interpret an energy level diagram for the reaction between hydrogen and oxygen. Draw and interpret energy level diagrams for other reactions given appropriate information.
Construct the balanced symbol equation for the overall reaction in a hydrogen-oxygen fuel cell.	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.
List some advantages of using a hydrogen-oxygen 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.
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 why 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 lifetime 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 and electrolysis. 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.	Describe oxidation as the addition of oxygen or the reaction of a substance with oxygen. Describe reduction as the removal of oxygen from a substance.
Carry out experiments to find the conditions necessary for rusting of iron and steel to take place.	Recall 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.	List methods of preventing rust limited to: • oil and grease • paint • galvanising • sacrificial protection • alloying • tin plate. Understand how 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 website 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. Predict, with a reason, whether a displacement reaction will take place.

Module C6: Chemistry Out There

Item C6c: Redox reactions

Links to other items: C1h: Paints and pigments, C2c: Metals and alloys, C2d: Making cars, C4d: The Group 1 elements, C4e: The Group 7 elements, C4f: Transition elements

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Understand that redox reactions involve both oxidation and reduction.	Understand that oxidation involves loss of electrons and reduction involves 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.
Understand that rusting of iron is a redox reaction. 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. Evaluate different ways of rust prevention.
Construct word equations for displacement reactions between metals and metal salt solutions.	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 group of compounds called alcohols. Ethanol is an example of an alcohol. 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 why alcohols are not hydrocarbons.
Carry out an experiment to produce ethanol by fermentation.	Recall the conditions needed for fermentation: • 25 – 50°C • presence of water • yeast.
The 'Whoosh' bottle demonstration – details from RSC website 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 items: C1a: Making crude oil useful, C1b: Using carbon fuels, C3g: 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 enzymes 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 chlorofluorocarbons (CFCs).	Recall that a chlorofluorocarbon (CFC) is an organic molecule containing chlorine, fluorine and carbon atoms. Recall the use of CFCs as refrigerants and aerosol propellants.
Data-search on CFCs and ozone depletion e.g. 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 such as: • increased risk of sunburn • accelerated ageing of skin • skin cancer • increased risk of cataracts.
Survey of safer alternatives to CFCs.	Recall that hydrocarbons can provide safer alternatives to CFCs.

Module C6: Chemistry Out There

Item C6e: Depletion of the ozone layer

Links to other items: C1c: Clean air, C4e: The Group 7 elements

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 how CFCs deplete the ozone layer: • CFC molecules are broken down in the stratosphere by ultraviolet light to give highly reactive chlorine atoms • chlorine atoms react with ozone molecules • chlorine atoms are regenerated so can react with more ozone molecules. Construct an equation to show the formation of chlorine atoms from CFCs. Recall that a chlorine radical is a chlorine atom. Explain why CFCs are only removed slowly from the stratosphere.	Explain in terms of electrons how a carbon-chlorine bond can break to form highly reactive chlorine atoms. Explain why only a small number of chlorine atoms will destroy a large number of ozone molecules. 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.
Recall 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.	Recall that hard water does not lather well with soap but soft water does. Recall that both hard and soft water lather well with soapless detergents.
Which ions cause hardness in water? Class practical – details from RSC website www.practicalchemistry.org.	Recall that hardness is caused by dissolved calcium and magnesium ions in water. Recall that boiling destroys temporary hardness in water but not permanent hardness in water.
Survey ways of removing hardness by using water softeners.	Describe how hardness in water can be removed: • 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.

Module C6: Chemistry Out There

Item C6f: Hardness of water

Links to other items: C4h: Purifying and testing water

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe the origin of temporary hardness in water: • calcium carbonate in rocks reacts with dissolved carbon dioxide and water to form soluble calcium hydrogencarbonate. Construct the word equation for the reaction between calcium carbonate, water and carbon dioxide: calcium carbonate + water + carbon dioxide → calcium hydrogencarbonate	
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 (limescale), 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.	

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 website www.practicalchemistry.org.	Understand that natural fats and oils are important raw materials for the chemical industry. Recall that vegetable oils can be used to make bio-diesel, an alternative to the fuel diesel from crude oil. Recall 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 e.g. a cold cream.	Describe an emulsion. 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.	Recall 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 items: C1a: Making crude oil useful, C1f: Cooking and food additives, C1g: Smells, C6h: Detergents

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. Explain whether a fat or oil is saturated or unsaturated given its displayed formula. 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 a balanced 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 how immiscible liquids, such as vegetable oil and water, can form 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.	Relate each ingredient in a washing powder to its function: • 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.
Investigate the action of some solvents to remove stains, paints, varnishes, wax and grease.	Understand 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.	Relate each ingredient in a washing-up liquid to its function: • 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 items: C6g: Natural 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 detergents as molecules that have a hydrophilic head and a 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.

4 Assessment of GCSE Chemistry B

4.1 Overview of the assessment in GCSE Chemistry B

To claim the qualification GCSE Chemistry B (J264) candidates will need to complete all three units.

GCSE Chemistry B J264	
Unit B741: *Chemistry modules C1, C2, C3*	
35% of the total GCSE 1 hour 15 mins written paper 75 marks	This question paper: • is offered in Foundation and Higher Tiers • focuses on modules C1, C2 and C3 • uses structured questions (candidates answer all questions) • assesses the quality of written communication.
Unit B742: *Chemistry modules C4, C5, C6*	
40% of the total GCSE 1 hour 30 mins written paper 85 marks	This question paper: • is offered in Foundation and Higher Tiers • focuses on modules C4, C5 and C6 • includes a 10 mark data response section which assesses AO3 (analyse and evaluate evidence, make reasoned judgements and draw conclusions based on evidence) • uses structured questions (candidates answer all questions) • assesses the quality of written communication.
Unit B743: *Chemistry controlled assessment*	
25% of the total GCSE Controlled assessment Approximately 7 hours 48 marks	This unit: • comprises one assessment task, split into three parts • is assessed by teachers, internally standardised and then externally moderated by OCR • assesses the quality of written communication.

4.2 Tiers

All written papers are set in one of two tiers: Foundation Tier and Higher Tier. Foundation Tier papers assess grades G to C and Higher Tier papers assess grades D to A*. An allowed grade E may be awarded on the Higher Tier components.

In Units B741 and B742, candidates are entered for an option in either the Foundation Tier or the Higher Tier. Unit B743 (controlled assessment) is not tiered.

Candidates may enter for either the Foundation Tier or Higher Tier in each of the externally assessed units. So, a candidate may take, for example B741/F and B742/H.

4.3 Assessment objectives (AOs)

Candidates are expected to demonstrate their ability to:

AO1	recall, select and communicate their knowledge and understanding of chemistry
AO2	apply skills, knowledge and understanding of chemistry in practical and other contexts
AO3	analyse and evaluate evidence, make reasoned judgements and draw conclusions based on evidence.

4.3.1 AO weightings – GCSE Chemistry B

The relationship between the units and the assessment objectives of the scheme of assessment is shown in the following grid:

Unit	% of GCSE			
	AO1	AO2	AO3	Total
Unit B741: *Chemistry modules C1, C2, C3*	16	17.5	1.5	35
Unit B742: *Chemistry modules C4, C5, C6*	16	17.5	6.5	40
Unit B743: *Chemistry controlled assessment*	2	5	18	25
Total	34	40	26	100

4.4 Grading and awarding grades

GCSE results are awarded on the scale A* to G. Units are awarded a* to g. Grades are indicated on certificates. However, results for candidates who fail to achieve the minimum grade (G or g) will be recorded as *unclassified* (U or u) and this is **not** certificated.

Most GCSEs are unitised schemes. When working out candidates' overall grades OCR needs to be able to compare performance on the same unit in different series when different grade boundaries may have been set, and between different units. OCR uses a Uniform Mark Scale to enable this to be done.

A candidate's uniform mark for each unit is calculated from the candidate's raw mark on that unit. The raw mark boundary marks are converted to the equivalent uniform mark boundary. Marks between grade boundaries are converted on a pro rata basis.

When unit results are issued, the candidate's unit grade and uniform mark are given. The uniform mark is shown out of the maximum uniform mark for the unit, e.g. 60/100.

The specification is graded on a Uniform Mark Scale. The uniform mark thresholds for each of the assessments are shown below:

(GCSE) Unit Weighting	Maximum Unit Uniform Mark	Unit Grade								
		a*	a	b	c	d	e	f	g	u
25%	100	90	80	70	60	50	40	30	20	0
35% F	97	–	–	–	84	70	56	42	28	0
35% H	140	126	112	98	84	70	63	–	–	0
40% F	111	–	–	–	96	80	64	48	32	0
40% H	160	144	128	112	96	80	72	–	–	

Higher Tier candidates who fail to gain a 'd' grade may achieve an "allowed e". Higher Tier candidates who miss the allowed grade 'e' will be graded as 'u'.

A candidate's uniform marks for each unit are aggregated and grades for the specification are generated on the following scale:

Qualification	Max Uniform Mark	Qualification Grade								
		A*	A	B	C	D	E	F	G	U
GCSE	400	360	320	280	240	200	160	120	80	0

The written papers will have a total weighting of 75% and controlled assessment a weighting of 25%.

A candidate's uniform mark for each paper will be combined with the uniform mark for the controlled assessment to give a total uniform mark for the specification. The candidate's grade will be determined by the total uniform mark.

4.5 Grade descriptions

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

The grade descriptors have been produced by the regulatory authorities in collaboration with the awarding bodies.

4.5.1 Grade F

Candidates recall, select and communicate limited knowledge and understanding of chemistry. They show a limited understanding that scientific advances may have ethical implications, benefits and risks. They recognise simple inter-relationships between chemistry and society. They use limited scientific and technical knowledge, terminology and conventions, showing some understanding of scale in terms of time, size and space.

They apply skills, including limited communication, mathematical, technical and observational skills, knowledge and understanding in practical and some other contexts. They recognise and use hypotheses, evidence and explanations and can explain straightforward models of phenomena, events and processes. They use a limited range of methods, sources of information and data to address straightforward scientific questions, problems and hypotheses.

Candidates interpret and evaluate limited quantitative and qualitative data and information from a narrow range of sources. They can draw elementary conclusions having collected limited evidence.

4.5.2 Grade C

Candidates recall, select and communicate secure knowledge and understanding of chemistry. They demonstrate understanding of the nature of chemistry, its laws, principles and its applications and the relationship between chemistry and society. They understand that scientific advances may have ethical implications, benefits and risks. They use scientific and technical knowledge, terminology and conventions appropriately, showing understanding of scale in terms of time, size and space.

They apply appropriate skills, including communication, mathematical, technical and observational skills, knowledge and understanding in a range of practical and other contexts. They show understanding of the relationships between hypotheses, evidence, theories and explanations and use models, including mathematical models, to describe abstract ideas, phenomena, events and processes. They use a range of appropriate methods, sources of information and data, applying their skills to address scientific questions, solve problems and test hypotheses.

Candidates analyse, interpret and evaluate a range of quantitative and qualitative data and information. They understand the limitations of evidence and use evidence and information to develop arguments with supporting explanations. They draw conclusions based on the available evidence.

4.5.3 Grade A

Candidates recall, select and communicate precise knowledge and detailed understanding of chemistry. They demonstrate a comprehensive understanding of the nature of chemistry, its laws, its principles and applications and the relationship between chemistry and society. They understand the relationships between scientific advances, their ethical implications and the benefits and risks associated with them. They use scientific and technical knowledge, terminology and conventions appropriately and consistently showing a detailed understanding of scale in terms of time, size and space.

They apply appropriate skills, including communication, mathematical, technical and observational skills, knowledge and understanding effectively in a wide range of practical and other contexts. They show a comprehensive understanding of the relationships between hypotheses, evidence, theories and explanations and make effective use of models, including mathematical models, to explain abstract ideas, phenomena, events and processes. They use a wide range of appropriate methods, sources of information and data consistently, applying relevant skills to address scientific questions, solve problems and test hypotheses.

Candidates analyse, interpret and critically evaluate a broad range of quantitative and qualitative data and information. They evaluate information systematically to develop arguments and explanations taking account of the limitations of the available evidence. They make reasoned judgments consistently and draw detailed, evidence-based conclusions.

4.6 Quality of written communication

Quality of written communication is assessed in all units and is integrated in the marking criteria.

Candidates are expected to:

- ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
- present information in a form that suits its purpose
- use an appropriate style of writing and, where applicable, specialist terminology.

Questions assessing quality of written communication will be indicated by the icon of a pencil (✐).

Controlled assessment in GCSE Chemistry B

5

This section provides general guidance on controlled assessment: what controlled assessment tasks are, when and how they are available; how to plan and manage controlled assessment and what controls must be applied throughout the process. More specific guidance and support is provided in the *Guide to controlled assessment* for GCSE Gateway Chemistry B, available on the OCR website.

Teaching and Learning

Controlled assessment is designed to be an integral part of teaching and learning. There are many opportunities in teaching and learning to develop skills and use a variety of appropriate materials and equipment. These opportunities allow students to practise a wide range of tasks, and teachers can discuss and comment on performance as appropriate.

When all necessary teaching and learning has taken place and teachers feel that candidates are ready for assessment, candidates can be given the appropriate controlled assessment task.

5.1 Controlled assessment tasks

All controlled assessment tasks are set by OCR, are published on Interchange, and may only be submitted in the June examination series. Each year a choice of two tasks will be valid for submission. The number of tasks attempted by a candidate is at the discretion of the centre, but the results of only one may be submitted.

Each task will be valid for submission in a single examination series only. This will be clearly marked on the front cover of each task. Centres must ensure that candidates undertake a task applicable to the required year of submission by checking carefully the examination dates of the tasks on Interchange. Tasks will not be valid for submission in any examination series other than that indicated.

Each year, two new controlled assessment tasks will be made available on Interchange from 1st June for certification in the following academic year, two years ahead of the examination series for which the tasks are to be submitted. Tasks will be removed upon expiry. Guidance on how to access controlled assessment tasks from Interchange is available on the OCR website: www.ocr.org.uk.

The same OCR controlled assessment task must **NOT** be used as practice material and then as the actual live assessment material.

5.2 Nature of controlled assessment tasks

5.2.1 Introduction to controlled assessment

Controlled assessment tasks have been designed to be an integral part of the teaching of the course. The practical activities will be based on the specification content. It is expected that candidates will complete the task at the appropriate point in the teaching of the specification content.

Opportunities to develop the practical skills required for this task are highlighted in the content of the specification. It is essential that candidates have some advance practice in these skills so that they can maximise their attainment. Candidates will need to take part in a planned learning programme that covers the underpinning knowledge and skills of the unit prior to undertaking the task.

The controlled assessment unit requires the completion of one assessment task. Each task is divided into three parts which are linked into an overall theme. The three parts should be taken in the order of Part 1, Part 2 and Part 3. Stimulus material will be provided which will introduce candidates to the task and direct the work they produce.

Part 1 – Research and collecting secondary data

Part 1 requires candidates to plan and carry out research. The Part 1 stimulus material introduces the task and provides guidance for the research. The research may be conducted either in class or as a homework exercise. The information collected is required for Parts 2 and 3.

Part 2 – Planning and collecting primary data

Part 2 requires candidates to develop a hypothesis in response to the Part 2 stimulus material and to plan and carry out an investigation to collect primary data to test their hypothesis. Collecting the data, as well as an assessed skill, will help candidates in Part 3 of the task by:

- enhancing their awareness of the practical techniques involved
- focusing on the quality of the data collected
- making them aware of the risks and necessary safety precautions.

Part 3 – Analysis and evaluation

Part 3 requires candidates to process and analyse the results from their research (Part 1) and their primary data (Part 2). They will also be required to evaluate their data and the methods used to collect it, and draw and justify a conclusion. Candidates will be guided by questions in an answer booklet.

5.2.2 Summary of task in Unit B743

Assessment Task	Task Marks	Weighting
Chemistry controlled assessment task (Part 1, Part 2 and Part 3)	48	25%

5.3 Planning and managing controlled assessment

Controlled assessment tasks are available at an early stage to allow planning time prior to delivery. It is anticipated that candidates will spend a total of about 7 hours in producing the work for this unit. Candidates should be allowed sufficient time to complete the tasks.

While the wording of the stimulus material and questions must remain unchanged, practical aspects of these tasks can be adapted so that they allow the use of resources available to the centre, including the availability of equipment and materials for practical work.

Where controlled assessment tasks are adapted by centres this must be in ways that will not put at risk the opportunity for candidates to meet the marking criteria, including the chance to gain marks at the highest level.

Suggested steps and timings are included below, with guidance on regulatory controls at each step of the process. Teachers must ensure that control requirements indicated below are met throughout the process.

The parts of the task should be taken in the order of Part 1, Part 2 and Part 3. Candidates' work for Parts 1 and 2 should be collected on completion and returned to the candidates for Part 3.

5.3.1 Part 1 – Research and collecting secondary data

- Research activities **1.5 – 2 hours**

The teacher should introduce Part 1 of the task, including time allocations, an outline of the task, the methods of work, control requirements and deadlines. The teacher may introduce the stimulus material to be used in Part 1.

In Part 1, the research stage, a limited level of control is required. Candidates can undertake the research part of the process without direct teacher supervision. Candidates should be provided with access to resources and materials which allow them to access the full range of marking criteria. The work of individual candidates may be informed by working with others; however, candidates must produce an individual response for use in the Part 2 and Part 3 supervised sessions. During the research stage candidates can be given support and guidance. They should be provided with the stimulus which provides the topic for the research. Teachers can explain the task, advise on how the task could be approached, and advise on resources.

Research methods can include fieldwork, internet or paper-based research, questionnaires, audio and video files etc. It is essential that any material directly used from a source is appropriately and rigorously referenced. Further advice and guidance regarding the research stage is provided in the *Guide to controlled assessment* for GCSE Gateway Chemistry B. Research activities can be lesson or homework time.

At the end of Part 1, candidates will have individually written up their research and collected their research data. This should be collected in and retained by the teacher and returned to the candidate when completing Part 2 and Part 3.

5.3.2 Part 2 – Planning and collecting primary data

- Planning **1.5 – 2 hours**
- Practical **1 hour**

The teacher should introduce Part 2 of the task, including time allocations, an outline of the task, the methods of work, control requirements and deadlines. The teacher may introduce the stimulus material to be used in Part 2. Candidates also need access to their individual work and research from Part 1.

In Part 2 candidates are required to formulate a hypothesis, plan an investigation, provide a risk assessment of their plan and carry out the experiment they have planned to collect primary data. Candidates may work in groups of no more than three to develop the plan and carry out the investigation. However, candidates' hypothesis, plan and results must be recorded individually in supervised lesson time.

Teachers should supervise the practical work in accordance with normal practice, to ensure safety procedures (see Appendix D for further guidance). Guidance regarding levels of support is provided in the *Guide to controlled assessment* for GCSE Gateway Chemistry B. This includes guidance on adapting the tasks for the equipment and materials available to the centre. Candidates will need to be provided with materials and equipment to allow them to access the full range of the marking criteria. Further specific guidance will also be provided with each task.

The work of candidates should be collected in and retained by the teacher and returned to the candidate when completing Part 3.

5.3.3 Part 3 – Analysis and evaluation

- Analysis and evaluation **1.5 – 2 hours**

The teacher should introduce Part 3 of the task, including time allocations, an outline of the task, the methods of work, control requirements and deadlines. The teacher may introduce the answer booklet to be used in Part 3.

In Part 3 candidates must work independently under supervised conditions as this part is under high control.

The answer booklet for Part 3 requires candidates to process and analyse the secondary data and information they have collected (Part 1) and the results of their investigation (Part 2). Candidates will need access to their individual responses from Part 1 and Part 2. Questions then guide candidates to evaluate their data and the methods used to collect it, and draw and justify a conclusion.

In processing the data candidates will have opportunities to use mathematical and graphical skills. Candidates must not be instructed or advised in these areas during the task.

On completion of the task, the loose leaf pages for Parts 1 and 2 should be collated and attached to each candidate's Part 3 answer booklet.

5.3.4 Supervision by the teacher

Candidates must work individually under limited supervision to:

- record their findings from secondary research in Part 1
- record their hypothesis, experimental plan and risk assessment in Part 2
- record their experimental results in Part 2.

Candidates must work independently under supervised conditions to:

- complete the answer booklet in Part 3.

The work submitted for moderation must be produced under controlled conditions, which means under teacher supervision: teachers must be able to authenticate the work and the candidates must acknowledge and reference any sources used. As writing up of each part is carried out over several sessions, work must be collected in between sessions. The Part 2 stimulus material and Part 3 answer booklet must not be taken out of the supervised sessions.

When supervising tasks, teachers are expected to:

- exercise continuing supervision of work in order to monitor progress and to prevent plagiarism
- provide guidance on the use of information from other sources to ensure that confidentiality and intellectual property rights are maintained
- exercise continuing supervision of practical work to ensure essential compliance with Health and Safety requirements
- ensure that the work is completed in accordance with the specification requirements and can be assessed in accordance with the specified marking criteria and procedures.

Teachers must not provide templates, model answers or feedback on drafts. They may give generic, informal feedback while the task is being completed but may not indicate what candidates need to do to improve their work.

5.3.5 Presentation of the work

Candidates must observe the following procedures when producing their final piece of work for the controlled assessment tasks:

- responses to Parts 1 and 2 will be on loose leaf paper. Tables and graphs may be produced using appropriate ICT. These should all be attached to the answer booklet for Part 3
- any copied material must be suitably acknowledged
- quotations must be clearly marked and a reference provided wherever possible
- work submitted for moderation must be marked with the:

  – centre number
  – centre name
  – candidate number
  – candidate name
  – unit code and title
  – task title.

Work submitted on paper for moderation must be secured by treasury tags. Work submitted in digital format (CD or online) must be in a suitable file structure as detailed in Appendix A at the end of this specification.

5.4 Marking and moderating controlled assessment

All controlled assessed tasks are marked by the centre assessor(s) using OCR marking criteria and guidance.

This corresponds to a medium level of control.

5.4.1 Applying the marking criteria

The starting point for marking the tasks is the marking criteria (see Section 5.4.4 *Marking criteria for controlled assessment tasks* below). The criteria identify levels of performance for the skills, knowledge and understanding that the candidate is required to demonstrate. Additional guidance for each task will be provided alongside the generic marking criteria. At INSET training events and in support materials, OCR will provide exemplification through real or simulated candidate work which will help to clarify the level of achievement that assessors should be looking for when awarding marks.

5.4.2 Use of 'best fit' approach to the application of the marking criteria

A controlled assessment task should only be marked when all three parts have been completed. The task should be marked by teachers according to the marking criteria using a 'best fit' approach. For each of the skill qualities, teachers should first use their professional judgement to select one of the four band descriptors provided in the marking grid that most closely describes the quality of the work being marked.

Following the selection of the band descriptor, the most appropriate mark within the band descriptor is chosen. Teachers should use the following guidance to select this mark:

- where the candidate's work *convincingly* meets the statement, the higher mark should be awarded (for example the 3 – 4 marks band is chosen and 4 marks are awarded)
- where the candidate's work *just* meets the statement, the lower mark should be awarded (for example the 3 – 4 marks band is chosen and 3 marks are awarded).

Marking should be positive, rewarding achievement rather than penalising failure or omissions. The award of marks **must be** directly related to the marking criteria.

Teachers should use the full range of marks available to them and award *full* marks in any band for work which fully meets that descriptor. This is work which is 'the best one could expect from candidates working at that level'.

The final mark for the candidate for the controlled assessment unit is out of a total of 48 and is found by totalling the marks for each skill quality. Only one mark out of a total of 48 will be required for submission for the unit.

There should be clear evidence that work has been attempted and some work produced. If a candidate submits no work for the internally assessed unit, then the candidate should be indicated as being absent from that unit. If a candidate completes any work at all for an internally assessed unit, then the work should be assessed according to the marking criteria and the appropriate mark awarded, which may be zero.

5.4.3 Annotation of candidates' work

Each piece of internally assessed work should show how the marks have been awarded in relation to the marking criteria.

The writing of comments on candidates' work provides a means of communication between teachers during the internal standardisation and with the moderator if the work forms part of the moderation sample.

5.4.4 Marking criteria for controlled assessment tasks

Assessment objectives (AOs)

Each of the aspects to be assessed addresses one or more of the assessment objectives and these are shown in the marking criteria. The overall balance is shown in the table below:

Assessment objective	Total
AO1: Recall, select and communicate their knowledge and understanding of science	5
AO2: Apply skills, knowledge and understanding of science in practical and other contexts	10
AO3: Analyse and evaluate evidence, make reasoned judgements and draw conclusions based on evidence	33
Total	**48**

Assessment of the quality of written communication

The quality of written communication is assessed in Parts 2 and 3 of this controlled assessment and indicated by a pencil symbol (✐) for the information of candidates.

Skill quality	1 – 2 marks	3 – 4 marks	5 – 6 marks	AO
Researching: collect secondary data including the use of appropriate technology.	Some information collected and used from at least two sources.	Relevant information collected from at least three sources; information presented clearly and all sources identified.	Range of relevant sources identified and judgement used to select those appropriate to the task. Information collated and presented clearly in appropriate formats including a full bibliography.	AO1 – 1 AO2 – 3 AO3 – 2
Planning: develop hypotheses and plan practical ways to test them.	Simple hypothesis or prediction relates to the data or information provided but does not identify a trend or pattern to be investigated. Outline plan includes equipment and techniques to be used. Plan provides a 'fair test'. No evidence of modifications of plan during the data collection phase. Plan shows limited structure with errors in spelling and punctuation.	Hypothesis provides a limited scientific explanation of the data or information provided. Plan gives sufficient detail for experiment to be repeated, including choices of: equipment and techniques; range and number of data points for the independent variable: number of replicates; other variables to be controlled with the aim of collecting quality data. Some consideration given to how errors will be minimised. No evidence of modifications of plan during the data collection phase. Plan structured clearly with occasional errors in spelling and punctuation.	Complex hypothesis provides a complete scientific explanation of the data or information provided and is capable of investigation. Comprehensive plan shows scientific understanding in making appropriate choices of: equipment, including resolution, and techniques; range and number of data points for the independent variable; number of replicates; control of all other variables with the aim of collecting accurate data. Detailed consideration given to: how errors will be minimised; variables which cannot be controlled. Where appropriate, reasoned modifications made to the plan as evidence is collected. Plan structured coherently with few, if any, errors in grammar, punctuation and spelling.	AO1 – 1 AO2 – 3 AO3 – 2
Collecting data: collect primary data including the use of appropriate technology.	Results recorded clearly but not in an appropriate format.	Results tabulated to include all data expected, though not in the most appropriate format. Headings given but units not always correct.	Results tabulated clearly and logically, including use of correct headings and units; all data expected recorded to appropriate levels of precision.	AO1 – 2 AO2 – 4

* 0 marks = no response or no response worthy of credit.

Skill quality	1 – 2 marks	3 – 4 marks	5 – 6 marks	AO
Managing risk: manage risks when carrying out practical work including risk assessment.	Limited understanding of risks in procedures with only standard laboratory safety features mentioned. Some teacher intervention required to ensure safety.	Some risks in procedures analysed and some specific responses suggested to reduce risks. Risks managed successfully with no significant incidents or accidents and no requirement for teacher intervention.	All significant risks in the plan evaluated. Reasoned judgments made to reduce risks by use of appropriate specific responses. Risks managed successfully with no incidents or accidents and no requirement for teacher intervention.	AO3 – 6
Processing data: process primary and secondary data including the use of appropriate technology.	Some evidence of processing quantitative data: data presented as simple charts or graphs with some errors in scaling or plotting; use of one simple mathematical technique.	Graphical and mathematical techniques used to reveal patterns in the data: charts or graphs used to display data in an appropriate way, allowing some errors in scaling or plotting; correct use of more than one simple mathematical technique.	Appropriate graphical and mathematical techniques used to reveal patterns in the data: type of graph, scales and axes selected and data plotted accurately, including where appropriate a line of best fit; correct use of complex mathematical techniques where appropriate; appropriate quantitative treatment of level of uncertainty of data.	AO3 – 6
Analysing and interpreting: analyse and interpret primary and secondary data .	At least one trend/pattern identified and outlined correctly; an attempt is made to interpret the information linking primary and secondary data/information.	Main trend(s)/pattern(s) described and interpreted with reference to quantitative data and scientific knowledge and understanding, with some errors; reasoned comparison between primary and secondary data/information; any anomalous results identified correctly and implications discussed.	All trend(s)/pattern(s) described and interpreted correctly with reference to quantitative data and relevant scientific knowledge and understanding; links between primary and secondary data/ information evaluated; level of uncertainty of the evidence analysed.	AO3 – 6

* 0 marks = no response or no response worthy of credit.

Skill quality	1 – 2 marks	3 – 4 marks	5 – 6 marks	AO
Evaluating: review methodology to assess fitness for purpose.	Relevant comments made about the quality of the data and the method used. Answer is simplistic with limited use of specialist terms.	Comments made on the quality of the data including accuracy and sources of error, linked to the method of collection; limitations in the method of data collection identified and suggestions for improvement given. Information is relevant and presented in a structured format. Specialist terms are for the most part used appropriately.	Detailed and critical consideration given to the data and methods used to obtain them: sources of error and quality of the data discussed and explained, including accuracy, repeatability and uncertainty; limitations of the method identified and suggestions for improvements justified. Information is relevant, clear, organised and presented in a coherent format. Specialist terms are used appropriately.	AO1 – 1 AO3 – 5
Justifying a conclusion: draw evidence-based conclusions; review hypotheses in light of outcomes.	Conclusion given and hypothesis reviewed using the data collected. Answers simplistic with little scientific understanding.	Conclusion given and justified and hypothesis reviewed based on an analysis of the data and information from research and investigation, demonstrating an understanding of the underpinning science.	Conclusion given and justified and hypothesis reviewed, based on a critical analysis of the data and information from research and investigation, and clearly linked to relevant scientific knowledge and understanding.	AO3 – 6

* 0 marks = no response or no response worthy of credit.

5.4.5 Authentication of work

Teachers must be confident that the work they mark is the candidate's own. This does not mean that a candidate must be supervised throughout the completion of all work but the teacher must exercise sufficient supervision, or introduce sufficient checks, to be in a position to judge the authenticity of the candidate's work.

Wherever possible, the teacher should discuss work-in-progress with candidates. This will not only ensure that work is underway in a planned and timely manner but will also provide opportunities for assessors to check authenticity of the work and provide general feedback.

Candidates must not plagiarise. Plagiarism is the submission of another's work as one's own and/or failure to acknowledge the source correctly. Plagiarism is considered to be malpractice and could lead to the candidate being disqualified. Plagiarism sometimes occurs innocently when candidates are unaware of the need to reference or acknowledge their sources. It is therefore important that centres ensure that candidates understand that the work they submit must be their own and that they understand the meaning of plagiarism and what penalties may be applied. Candidates may refer to research, quotations or evidence but they must list their sources. The rewards from acknowledging sources, and the credit they will gain from doing so, should be emphasised to candidates as well as the potential risks of failing to acknowledge such material.

Both candidates and teachers must declare that the work is the candidate's own:

- **each candidate** must sign a declaration before submitting their work to their teacher. A candidate authentication statement that can be used is available to download from the OCR website. These statements should be retained within the centre until all enquiries about results, malpractice and appeals issues have been resolved. **A mark of zero must be recorded if a candidate cannot confirm the authenticity of their work**
- **teachers** are required to declare that the work submitted for internal assessment is the candidate's own work by sending the moderator a centre authentication form (CCS160) for each unit at the same time as the marks. If a centre fails to provide evidence of authentication, **we will set the mark for that candidate(s) to Pending (Q) for that component until authentication can be provided.**

5.5 Internal standardisation

It is important that all internal assessors of this controlled assessment work to common standards. Centres must ensure that the internal standardisation of marks across assessors and teaching groups takes place using an appropriate procedure.

This can be done in a number of ways. In the first year, reference material and OCR training meetings will provide a basis for centres' own standardisation. In subsequent years, this, or centres' own archive material, may be used. Centres are advised to hold preliminary meetings of staff involved to compare standards through cross-marking a small sample of work. After most marking has been completed, a further meeting at which work is exchanged and discussed will enable final adjustments to be made.

5.6 Submitting marks and authentication

All work for controlled assessment is marked by the teacher and internally standardised by the centre. Marks are then submitted to OCR **and** your moderator: refer to the OCR website for submission dates of the marks to OCR.

There should be clear evidence that work has been attempted and some work produced. If a candidate submits no work for an internally assessed component, then the candidate should be indicated as being absent from that component. If a candidate completes any work at all for an internally assessed component, then the work should be assessed according to the internal assessment objectives and marking instructions and the appropriate mark awarded, which may be zero.

The centre authentication form (CCS160) must be sent to the moderator with the marks.

5.7 Submitting samples of candidate work

5.7.1 Sample requests

Once you have submitted your marks, your exams officer will receive an email requesting a moderation sample. Samples will include work from across the range of attainment of the candidates' work.

The sample of work which is presented to the moderator for moderation must show how the marks have been awarded in relation to the marking criteria defined in Section 5.4.4.

When making your entries, the entry option specifies how the sample for each unit is to be submitted. For each of these units, all candidate work must be submitted using the **same entry option**. It is not possible for centres to offer both options for a unit within the same series. You can choose different options for different units. Please see the Section 8.2.1 for entry codes.

5.7.2 Submitting moderation samples via post

The sample of candidate work must be posted to the moderator within three days of receiving the request. You should use one of the labels provided to send the candidate work.

We would advise you to keep evidence of work submitted to the moderator, e.g. copies of written work or photographs of practical work. You should also obtain a certificate of posting for all work that is posted to the moderator.

5.7.3 Submitting moderation samples via the OCR Repository

The OCR Repository is a secure website for centres to upload candidate work and for assessors to access this work digitally. Centres can use the OCR Repository for uploading marked candidate work for moderation.

Centres can access the OCR Repository via OCR Interchange, find their candidate entries in their area of the Repository, and use the Repository to upload files (singly or in bulk) for access by their moderator.

The OCR Repository allows candidates to send evidence in electronic file types that would normally be difficult to submit through postal moderation; for example multimedia or other interactive unit submissions.

The OCR GCSE Chemistry B unit B743 can be submitted electronically to the OCR Repository via Interchange: please check Section 8.2.1 for unit entry codes for the OCR Repository.

There are three ways to load files to the OCR Repository:

1. Centres can load multiple files against multiple candidates by clicking on 'Upload candidate files' in the Candidates tab of the Candidate Overview screen.

2. Centres can load multiple files against a specific candidate by clicking on 'Upload files' in the Candidate Details screen.

3. Centres can load multiple administration files by clicking on 'Upload admin files' in the Administration tab of the Candidate Overview screen.

The OCR Repository is seen as a faster, greener and more convenient means of providing work for assessment. It is part of a wider programme bringing digital technology to the assessment process, the aim of which is to provide simpler and easier administration for centres.

Instructions for how to upload files to OCR using the OCR Repository can be found on OCR Interchange.

5.8 External moderation

The purpose of moderation is to ensure that the standard of the award of marks for work is the same for each centre and that each teacher has applied the standards appropriately across the range of candidates within the centre.

At this stage, if necessary, centres may be required to provide an additional sample of candidate work (if marks are found to be in the wrong order) or carry out some re-marking. If you receive such a request, please ensure that you respond as quickly as possible to ensure that your candidates' results are not delayed.

6.1 Free resources available from the OCR website

The following materials will be available on the OCR website:

- GCSE Chemistry B Specification
- specimen assessment materials and mark schemes
- Guide to controlled assessment
- sample controlled assessment materials
- exemplar candidate work
- Teachers' Handbook
- sample schemes of work and lesson plans

Essential FREE support services including:

- INSET training – for information visit www.gcse-science.com
- Interchange – a completely secure, free website to help centres reduce administrative tasks at exam time http://www.ocr.org.uk/interchange
- e-alerts – register now for regular updates at www.ocr.org.uk/2011signup
- Active Results – detailed item level analysis of candidate results.

6.2 Other resources

OCR offers centres a wealth of high quality published support with a choice of 'Official Publisher Partner' and 'Approved Publication' resources, all endorsed by OCR for use with OCR specifications.

6.2.1 Publisher partners

OCR works in close collaboration with publisher partners to ensure you have access to:

- published support materials available when you need them, tailored to OCR specifications
- high quality resources produced in consultation with OCR subject teams, which are linked to OCR's teacher support materials

OCR RECOGNISING ACHIEVEMENT — Collins FREEDOM TO TEACH

Official Publisher Partnership

Collins is the publisher partner for OCR GCSE Chemistry B.

Collins is working with a team of experienced authors to provide resources which will help you deliver the new OCR GCSE Gateway Science specifications.

With Collins New GCSE Science you can:

Explain

- be sure you're delivering the new specification with content organised and written to match the specifications
- deliver outstanding lessons every time with differentiated lesson plans that include high quality plenaries to check effectiveness of every lesson and expert guidance on how to make a good lesson outstanding

Explore

- explore Science as it happens in the real world through interactive videos and animations in Interactive Books and How Science Works integrated throughout the series
- emphasise how science is relevant with engaging facts throughout and activities based on the book Bad Science, by Ben Goldacre

Excel

- help your students excel with plenty of practice questions that provide extra support for the quality of written communication
- raise standards with more questions than ever before designed to stretch and challenge high achievers.

6.2.2 Endorsed publications

OCR endorses a range of publisher materials to provide quality support for centres delivering its qualifications. You can be confident that materials branded with OCR's 'Official Publishing Partner' or 'Approved publication' logos have undergone a thorough quality assurance process to achieve endorsement. All responsibility for the content of the publisher's materials rests with the publisher.

Approved publication
OCR
RECOGNISING ACHIEVEMENT

These endorsements do not mean that the materials are the only suitable resources available or necessary to achieve an OCR qualification.

6.3 Training

OCR will offer a range of support activities for all practitioners throughout the lifetime of the qualification to ensure they have the relevant knowledge and skills to deliver the qualification.

Please see Event Booker for further information.

6.4 OCR support services

6.4.1 Active Results

Active Results is available to all centres offering OCR's GCSE Chemistry B specification.

activeresults

Active Results is a free results analysis service to help teachers review the performance of individual candidates or whole schools.

Data can be analysed using filters on several categories such as gender and other demographic information, as well as providing breakdowns of results by question and topic.

Active Results allows you to look in greater detail at your results:

- richer and more granular data will be made available to centres including question level data available from e-marking
- you can identify the strengths and weaknesses of individual candidates and your centre's cohort as a whole
- our systems have been developed in close consultation with teachers so that the technology delivers what you need.

Further information on Active Results can be found on the OCR website.

6.4.2 OCR Interchange

OCR Interchange has been developed to help you to carry out day-to-day administration functions online, quickly and easily. The site allows you to register and enter candidates online. In addition, you can gain immediate and free access to candidate information at your convenience. Sign up on the OCR website.

7.1 Equality Act information relating to GCSE Chemistry B

GCSEs often require assessment of a broad range of competences. This is because they are general qualifications and, as such, prepare candidates for a wide range of occupations and higher level courses.

The revised GCSE qualification and subject criteria were reviewed by the regulators in order to identify whether any of the competences required by the subject presented a potential barrier to any disabled candidates. If this was the case, the situation was reviewed again to ensure that such competences were included only where essential to the subject. The findings of this process were discussed with disability groups and with disabled people.

Reasonable adjustments are made for disabled candidates in order to enable them to access the assessments and to demonstrate what they know and can do. For this reason, very few candidates will have a complete barrier to the assessment. Information on reasonable adjustments is found in *Access Arrangements, Reasonable Adjustments and Special Consideration* by the Joint Council www.jcq.org.uk.

Candidates who are unable to access part of the assessment, even after exploring all possibilities through reasonable adjustments, may still be able to receive an award based on the parts of the assessment they have taken.

The access arrangements permissible for use in this specification are in line with Ofqual's GCSE subject criteria equalities review and are as follows:

	Yes/No	Type of Assessment
Readers	Yes	All assessments
Scribes	Yes	All assessments
Practical assistants	Yes	All controlled assessments. The practical assistant may assist with assessed practical tasks under instruction from the candidate.
Word processors	Yes	All assessments
Transcripts	Yes	All assessments
BSL interpreters	Yes	All assessments
Oral language modifiers	Yes	All assessments
Modified question papers	Yes	All assessments
Extra time	Yes	All assessments

7.2 Arrangements for candidates with particular requirements (including Special Consideration)

All candidates with a demonstrable need may be eligible for access arrangements to enable them to show what they know and can do. The criteria for eligibility for access arrangements can be found in the JCQ document *Access Arrangements, Reasonable Adjustments and Special Consideration.*

Candidates who have been fully prepared for the assessment but who have been affected by adverse circumstances beyond their control at the time of the examination may be eligible for special consideration. As above, centres should consult the JCQ document *Access Arrangements, Reasonable Adjustments and Special Consideration.*

8 Administration of GCSE Chemistry B

In December 2011 the GCSE qualification criteria were changed by Ofqual. As a result, all GCSE qualifications have been updated to comply with the new regulations.

The most significant change for all GCSE qualifications is that, from 2014, unitised specifications must require that 100% of the assessment is terminal.

Please note that there are no changes to the terminal rule and re-sit rules for the January 2013 and June 2013 examination series:

- at least 40% of the assessment must be taken in the examination series in which the qualification is certificated
- candidates may re-sit each unit once before certification, i.e. each candidate can have two attempts at a unit before certification.

For full information on the assessment availability and rules that apply in the January 2013 and June 2013 examination series, please refer to the previous version of this specification GCSE Chemistry B (March 2011) available on the website (include direct link to current spec).

The sections below explain in more detail the rules that apply from the June 2014 examination series onwards.

8.1 Availability of assessment from 2014

There is one examination series available each year in June (all units are available each year in June).

GCSE Chemistry B certification is available in June 2014 and each June thereafter.

	Unit B741	Unit B742	Unit B743	Certification availability
June 2014	✓	✓	✓	✓
June 2015	✓	✓	✓	✓

8.2 Certification rules

For GCSE Chemistry B, from June 2014 onwards, a 100% terminal rule applies. Candidates must enter for all their units in the series in which the qualification is certificated.

8.3 Rules for re-taking a qualification

Candidates may enter for the qualification an unlimited number of times.

Where a candidate re-takes a qualification, **all** units must be re-entered and all externally assessed units must be re-taken in the same series as the qualification is re-certificated. The new results for these units will be used to calculate the new qualification grade. Any results previously achieved cannot be re-used.

For the controlled assessment unit, candidates who are re-taking a qualification can choose either to re-take that controlled assessment unit or to carry forward the result for that unit that was used towards the previous certification of the same qualification.

- Where a candidate decides to re-take the controlled assessment, the new result will be the one used to calculate the new qualification grade. Any results previously achieved cannot be re-used.
- Where a candidate decides to carry forward a result for controlled assessment, they must be entered for the controlled assessment unit in the re-take series using the entry code for the carry forward option (see section 8.4).

8.4 Making entries

8.4.1 Unit entries

Centres must be approved to offer OCR qualifications before they can make any entries, including estimated entries. It is recommended that centres apply to OCR to become an approved centre well in advance of making their first entries. Centres must have made an entry for a unit in order for OCR to supply the appropriate forms and administrative materials.

It is essential that correct unit entry codes are used when making unit entries.

For the externally assessed units B741 and B742 candidates must be entered for either component 01 (Foundation Tier) or 02 (Higher Tier) using the appropriate unit entry code from the table below. It is not possible for a candidate to take both components for a particular unit within the same series; however, different units may be taken at different tiers.

For the controlled assessment unit, centres can decide whether they want to submit candidates' work for moderation through the OCR Repository or by post. Candidates submitting controlled assessment must be entered for the appropriate unit entry code from the table below. Candidates who are re-taking the qualification and who want to carry forward the controlled assessment should be entered using the unit entry code for the carry forward option.

Centres should note that controlled assessment tasks can still be completed at a time which is appropriate to the centre/candidate. However, where tasks change from year to year, centres would have to ensure that candidates had completed the correct task(s) for the year of entry.

Unit entry code	Component code	Assessment method	Unit titles
B741F	01	Written Paper	*Chemistry modules C1, C2, C3* (Foundation Tier)
B741H	02	Written Paper	*Chemistry modules C1, C2, C3* (Higher Tier)
B742F	01	Written Paper	*Chemistry modules C4, C5, C6* (Foundation Tier)
B742H	02	Written Paper	*Chemistry modules C4, C5, C6* (Higher Tier)
B743A	01	Moderated via OCR Repository	*Chemistry controlled assessment*
B743B	02	Moderated via postal moderation	*Chemistry controlled assessment*
B743C	80	Carried forward	*Chemistry controlled assessment*

8.4.2 Certification entries

Candidates must be entered for qualification certification separately from unit assessment(s). If a certification entry is **not** made, no overall grade can be awarded.

Centres must enter candidates for:

- GCSE Chemistry B certification code J264.

8.5 Enquiries about results

Under certain circumstances, a centre may wish to query the result issued to one or more candidates. Enquiries about results for GCSE units must be made immediately following the series in which the relevant unit was taken and by the relevant enquiries about results deadline for that series.

Please refer to the JCQ *Post-Results Services* booklet and the OCR *Admin Guide: 14–19 Qualifications* for further guidance on enquiries about results and deadlines. Copies of the latest versions of these documents can be obtained from the OCR website at www.ocr.org.uk.

8.6 Prohibited qualifications and classification code

Every specification is assigned a national classification code indicating the subject area to which it belongs. The classification code for this specification is 1110.

Centres should be aware that candidates who enter for more than one GCSE qualification with the same classification code will have only one grade (the highest) counted for the purpose of the School and College Performance Tables.

Centres may wish to advise candidates that, if they take two specifications with the same classification code, colleges are very likely to take the view that they have achieved only one of the two GCSEs. The same view may be taken if candidates take two GCSE specifications that have different classification codes but have significant overlap of content. Candidates who have any doubts about their subject combinations should seek advice, either from their centre or from the institution to which they wish to progress.

9 Other information about GCSE Chemistry B

9.1 Overlap with other qualifications

This specification has been developed alongside GCSE Science B, GCSE Additional Science B, GCSE Biology B, GCSE Physics B and GCSE Additional Applied Science.

Modules 1 and 2 of this specification are also included in GCSE Science B. Modules 3 and 4 of this specification are also included in GCSE Additional Science B.

Aspects of the controlled assessment of skills are common across GCSE Additional Science B, GCSE Biology B, GCSE Chemistry B and GCSE Physics B.

9.2 Progression from this qualification

GCSE qualifications are general qualifications which enable candidates to progress either directly to employment, or to proceed to further qualifications.

Progression to further study from GCSE will depend upon the number and nature of the grades achieved. Broadly, candidates who are awarded mainly Grades D to G at GCSE could either strengthen their base through further study of qualifications at Level 1 within the National Qualifications Framework or could proceed to Level 2. Candidates who are awarded mainly Grades A* to C at GCSE would be well prepared for study at Level 3 within the National Qualifications Framework.

9.3 Avoidance of bias

OCR has taken great care in preparation of this specification and assessment materials to avoid bias of any kind. Special focus is given to the 9 strands of the Equality Act with the aim of ensuring both direct and indirect discrimination is avoided.

9.4 Regulatory Requirements

This specification complies in all respects with the current: *General Conditions of Recognition; GCSE, GCE, Principal Learning and Project Code of Practice; GCSE Controlled Assessment regulations* and the *GCSE subject criteria for Chemistry.* All documents are available on the Ofqual website.

9.5 Language

This specification and associated assessment materials are in English only. Only answers written in English will be assessed.

9.6 Spiritual, moral, ethical, social, legislative, economic and cultural issues

This specification offers opportunities which can contribute to an understanding of these issues.

The table below gives some examples which could be used when teaching the course:

Issue	Opportunities for developing an understanding of the issue during the course
Moral issues The commitment of scientists to publish their findings and subject their ideas to testing by others.	C1a: Discuss the problems associated with the finite nature of crude oil.
Ethical issues The ethical implications of selected scientific issues.	C1a: Describe some of the environmental problems involved in the exploitation of crude oil. C1g: Recall that testing of cosmetics on animals is banned in the UK.
Economic issues The range of factors which have to be considered when weighing the costs and benefits of scientific activity.	C1e: Explain some of the environmental and economic issues related to the use of polymers. C2e: Explain that economic considerations determine the conditions used in the manufacture of chemicals.
Cultural issues Scientific explanations which give insight into the local and global environment.	C1c: Research the increase in occurrences of asthma in the UK and possible links with air pollution.

9.7 Sustainable development, health and safety considerations and European developments, consistent with international agreements

This specification supports these issues, consistent with current EU agreements, as outlined below.

- Sustainable development issues could be supported through questions set on the changes taking place in the atmosphere and the use of alternative fuels, for example.
- Health and safety considerations will be supported through the controlled assessment which will include risk assessment of planned practical work and carrying out practical work safely. Health and safety considerations could be supported through questions set on changing reaction rates, the testing of chemicals and food and nutrition, for example.
- European developments could be supported through study of the importance of Science-based industry to European economies, for example.

9.8 Key Skills

This specification provides opportunities for the development of the *Key Skills of Communication, Application of Number, Information and Communication Technology, Working with Others, Improving Own Learning and Performance* and *Problem Solving* at Levels 1 and/or 2. However, the extent to which this evidence fulfils the Key Skills criteria at these levels will be totally dependent on the style of teaching and learning adopted for each unit.

The following table indicates where opportunities may exist for at least some coverage of the various Key Skills criteria at Levels 1 and/or 2 for each unit.

Unit	C		AoN		ICT		WwO		IoLP		PS	
	1	2	1	2	1	2	1	2	1	2	1	2
B741	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
B742	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
B743	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

9.9 ICT

In order to play a full part in modern society, candidates need to be confident and effective users of ICT. This specification provides candidates with a wide range of appropriate opportunities to use ICT in order to further their study of Science.

Opportunities for ICT include:

- using video clips to show/provide the context for topics studied and to illustrate the practical importance of the scientific ideas
- gathering information from the internet and CD-ROMs
- gathering data using sensors linked to data-loggers or directly to computers
- using spreadsheets and other software to process data
- using animations and simulations to visualise scientific ideas
- using modelling software to explore theories
- using software to present ideas and information on paper and on screen.

Particular opportunities for the use of ICT appear in the introductions to each item where appropriate.

9.10 Citizenship

From September 2002, the National Curriculum for England at Key Stage 4 includes a mandatory programme of study for Citizenship.

GCSE Science is designed as a science education for future citizens which not only covers aspects of the Citizenship programme of study but also extends beyond that programme by dealing with important aspects of science which all people encounter in their everyday lives.

Appendix A: Guidance for the production of electronic controlled assessment

A

Structure for evidence

A controlled assessment portfolio is a collection of folders and files containing the candidate's evidence. Folders should be organised in a structured way so that the evidence can be accessed easily by a teacher or moderator. This structure is commonly known as a folder tree. It would be helpful if the location of particular evidence is made clear by naming each file and folder appropriately and by use of an index called 'Home Page'.

There should be a top level folder detailing the candidate's centre number, candidate number, surname and forename, together with the unit code B743, so that the portfolio is clearly identified as the work of one candidate.

Each candidate produces an assignment for controlled assessment. The evidence should be contained within a separate folder within the portfolio. This folder may contain separate files.

Each candidate's controlled assessment portfolio should be stored in a secure area on the centre's network. Prior to submitting the controlled assessment portfolio to OCR, the centre should add a folder to the folder tree containing controlled assessment and summary forms.

Data formats for evidence

In order to minimise software and hardware compatibility issues it will be necessary to save candidates' work using an appropriate file format.

Candidates must use formats appropriate to the evidence that they are providing and appropriate to viewing for assessment and moderation. Open file formats or proprietary formats for which a downloadable reader or player is available are acceptable. Where this is not available, the file format is not acceptable.

Electronic controlled assessment is designed to give candidates an opportunity to demonstrate what they know, understand and can do using current technology. Candidates do not gain marks for using more sophisticated formats or for using a range of formats. A candidate who chooses to use only word documents will not be disadvantaged by that choice.

Evidence submitted is likely to be in the form of word processed documents, PowerPoint presentations, digital photos and digital video.

To ensure compatibility, all files submitted must be in the formats listed below. Where new formats become available that might be acceptable, OCR will provide further guidance. OCR advises against changing the file format that the document was originally created in. It is the centre's responsibility to ensure that the electronic portfolios submitted for moderation are accessible to the moderator and fully represent the evidence available for each candidate.

A Accepted file formats

Movie formats for digital video evidence
MPEG (*.mpg)
QuickTime movie (*.mov)
Macromedia Shockwave (*.aam)
Macromedia Shockwave (*.dcr)
Flash (*.swf)
Windows Media File (*.wmf)
MPEG Video Layer 4 (*.mp4)

Audio or sound formats
MPEG Audio Layer 3 (*.mp3)

Graphics formats including photographic evidence
JPEG (*.jpg)
Graphics file (*.pcx)
MS bitmap (*.bmp)
GIF images (*.gif)

Animation formats
Macromedia Flash (*.fla)

Structured markup formats
XML (*.xml)

Text formats
Comma Separated Values (.csv)
PDF (.pdf)
Rich text format (.rtf)
Text document (.txt)

Microsoft Office suite
PowerPoint (.ppt)
Word (.doc)
Excel (.xls)
Visio (.vsd)
Project (.mpp)

Appendix B: Mathematics skills for GCSE science qualifications

B

Candidates are permitted to use calculators in all assessments.

Candidates should be able to:

- understand number size and scale and the quantitative relationship between units
- understand when and how to use estimation
- carry out calculations involving +, –, ×, ÷, either singly or in combination, decimals, fractions, percentages and positive whole number powers
- provide answers to calculations to an appropriate number of significant figures
- understand and use the symbols =, <, >, ~
- understand and use direct proportion and simple ratios
- calculate arithmetic means
- understand and use common measures and simple compound measures such as speed
- plot and draw graphs (line graphs, bar charts, pie charts, scatter graphs, histograms) selecting appropriate scales for the axes
- substitute numerical values into simple formulae and equations using appropriate units
- translate information between graphical and numeric form
- extract and interpret information from charts, graphs and tables
- understand the idea of probability
- calculate area, perimeters and volumes of simple shapes.

In addition, Higher Tier candidates should be able to:

- interpret, order and calculate with numbers written in standard form
- carry out calculations involving negative powers (only –1 for rate)
- change the subject of an equation
- understand and use inverse proportion
- understand and use percentiles and deciles.

C Appendix C: Physical quantities and units

It is expected that candidates will show an understanding of the physical quantities and corresponding SI units listed below and will be able to use them in quantitative work and calculations. Whenever they are required for such questions, units will be provided and, where necessary, explained.

Fundamental physical quantities

Physical quantity	Unit(s)
length	metre (m); kilometre (km); centimetre (cm); millimetre (mm)
mass	kilogram (kg); gram (g); milligram (mg)
time	second (s); millisecond (ms)
temperature	degree Celsius (°C); kelvin (K)
current	ampere (A); milliampere (mA)
voltage	volt (V); millivolt (mV)

Derived quantities and units

Physical quantity	Unit(s)
area	cm^2; m^2
volume	cm^3; dm^3; m^3; litre (*l*); millilitre (ml)
density	kg/m^3; g/cm^3
force	newton (N)
speed	m/s; km/h
energy	joule (J); kilojoule (kJ); megajoule (MJ)
power	watt (W); kilowatt (kW); megawatt (MW)
frequency	hertz (Hz); kilohertz (kHz)
gravitational field strength	N/kg
radioactivity	becquerel (Bq)
acceleration	m/s^2; km/h^2
specific heat capacity	J/kg°C; J/g°C
specific latent heat	J/kg

Appendix D: Health and safety

In UK law, health and safety is the responsibility of the employer. For most establishments entering candidates for GCSE, this is likely to be the local education authority or the governing body. Employees, i.e. teachers and lecturers, have a duty to cooperate with their employer on health and safety matters. Various regulations, but especially the COSHH Regulations 2002 and the Management of Health and Safety at Work Regulations 1999, require that before any activity involving a hazardous procedure or harmful micro-organisms is carried out, or hazardous chemicals are used or made, the employer must provide a risk assessment.

For members, the CLEAPSS® guide, *Managing Risk Assessment in Science** offers detailed advice. Most education employers have adopted a range of nationally available publications as the basis for their Model Risk Assessments. Those commonly used include:

Safety in Science Education, DfEE, 1996, HMSO, ISBN 0 11 270915 X

Topics in Safety, 3rd edition, 2001, ASE ISBN 0 86357 316 9

Safeguards in the School Laboratory, 11th edition, 2006, ASE ISBN 978 0 86357 408 5

CLEAPSS® *Hazcards, 2007* edition and later updates*

CLEAPSS® *Laboratory Handbook**

Hazardous Chemicals, A Manual for Science Education, 1997, SSERC Limited

ISBN 0 9531776 0 2

Where an employer has adopted these or other publications as the basis of their model risk assessments, an individual school or college then has to review them, to see if there is a need to modify or adapt them in some way to suit the particular conditions of the establishment.

Such adaptations might include a reduced scale of working, deciding that the fume cupboard provision was inadequate or the skills of the candidates were insufficient to attempt particular activities safely. The significant findings of such risk assessment should then be recorded, for example on schemes of work, published teachers guides, work sheets, etc. There is no specific legal requirement that detailed risk assessment forms should be completed, although a few employers require this.

Where project work or individual investigations, sometimes linked to work-related activities, are included in specifications this may well lead to the use of novel procedures, chemicals or micro-organisms, which are not covered by the employer's model risk assessments. The employer should have given guidance on how to proceed in such cases. Often, for members, it will involve contacting CLEAPSS® (or, in Scotland, SSERC).

*These, and other CLEAPSS® publications, are on the CLEAPSS® Science Publications CD-ROM issued annually to members. Note that CLEAPSS® publications are only available to members. For more information about CLEAPSS® www.cleapss.org.uk. In Scotland, SSERC www.sserc.org.uk has a similar role to CLEAPSS® and there are some reciprocal arrangements.

Appendix E: Periodic Table

Key

relative atomic mass **atomic symbol** name atomic (proton) number

1	2											3	4	5	6	7	0
							1 **H** hydrogen 1										4 **He** helium 2
7 **Li** lithium 3	9 **Be** beryllium 4											11 **B** boron 5	12 **C** carbon 6	14 **N** nitrogen 7	16 **O** oxygen 8	19 **F** fluorine 9	20 **Ne** neon 10
23 **Na** sodium 11	24 **Mg** magnesium 12											27 **Al** aluminium 13	28 **Si** silicon 14	31 **P** phosphorus 15	32 **S** sulfur 16	35.5 **Cl** chlorine 17	40 **Ar** argon 18
39 **K** potassium 19	40 **Ca** calcium 20	45 **Sc** scandium 21	48 **Ti** titanium 22	51 **V** vanadium 23	52 **Cr** chromium 24	55 **Mn** manganese 25	56 **Fe** iron 26	59 **Co** cobalt 27	59 **Ni** nickel 28	63.5 **Cu** copper 29	65 **Zn** zinc 30	70 **Ga** gallium 31	73 **Ge** germanium 32	75 **As** arsenic 33	79 **Se** selenium 34	80 **Br** bromine 35	84 **Kr** krypton 36
85 **Rb** rubidium 37	88 **Sr** strontium 38	89 **Y** yttrium 39	91 **Zr** zirconium 40	93 **Nb** niobium 41	96 **Mo** molybdenum 42	[98] **Tc** technetium 43	101 **Ru** ruthenium 44	103 **Rh** rhodium 45	106 **Pd** palladium 46	108 **Ag** silver 47	112 **Cd** cadmium 48	115 **In** indium 49	119 **Sn** tin 50	122 **Sb** antimony 51	128 **Te** tellurium 52	127 **I** iodine 53	131 **Xe** xenon 54
133 **Cs** caesium 55	137 **Ba** barium 56	139 **La*** lanthanum 57	178 **Hf** hafnium 72	181 **Ta** tantalum 73	184 **W** tungsten 74	186 **Re** rhenium 75	190 **Os** osmium 76	192 **Ir** iridium 77	195 **Pt** platinum 78	197 **Au** gold 79	201 **Hg** mercury 80	204 **Tl** thallium 81	207 **Pb** lead 82	209 **Bi** bismuth 83	[209] **Po** polonium 84	[210] **At** astatine 85	[222] **Rn** radon 86
[223] **Fr** francium 87	[226] **Ra** radium 88	[227] **Ac*** actinium 89	[261] **Rf** rutherfordium 104	[262] **Db** dubnium 105	[266] **Sg** seaborgium 106	[264] **Bh** bohrium 107	[277] **Hs** hassium 108	[268] **Mt** meitnerium 109	[271] **Ds** darmstadtium 110	[272] **Rg** roentgenium 111	Elements with atomic numbers 112-116 have been reported but not fully authenticated						

***** *The lanthanoids (atomic numbers 58-71) and the actinoids (atomic numbers 90-103) have been omitted.***

The relative atomic masses of copper and chlorine have not been rounded to the nearest whole number.

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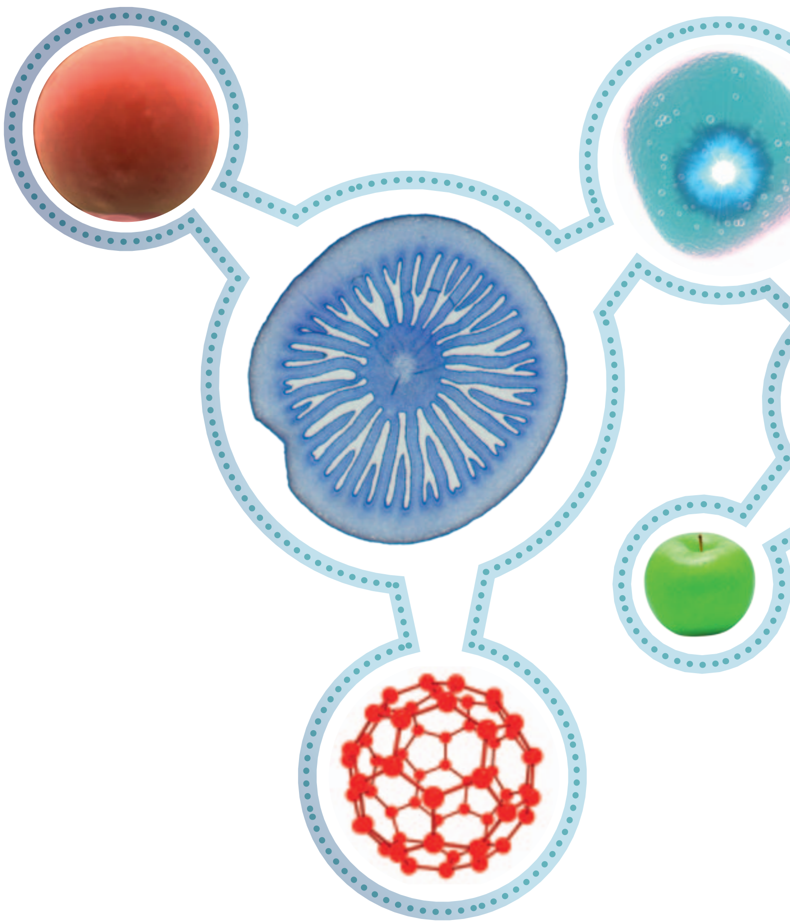
By fax: 01223 552627

By post: Customer Contact Centre, OCR, Progress House, Westwood Business Park, Coventry CV4 8JQ



GENERAL QUALIFICATIONS
Telephone 01223 553998
Facsimile 01223 552627

science@ocr.org.uk
1 Hills Road, Cambridge CB1 2EU

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