GATEWAY SCIENCE SUITE

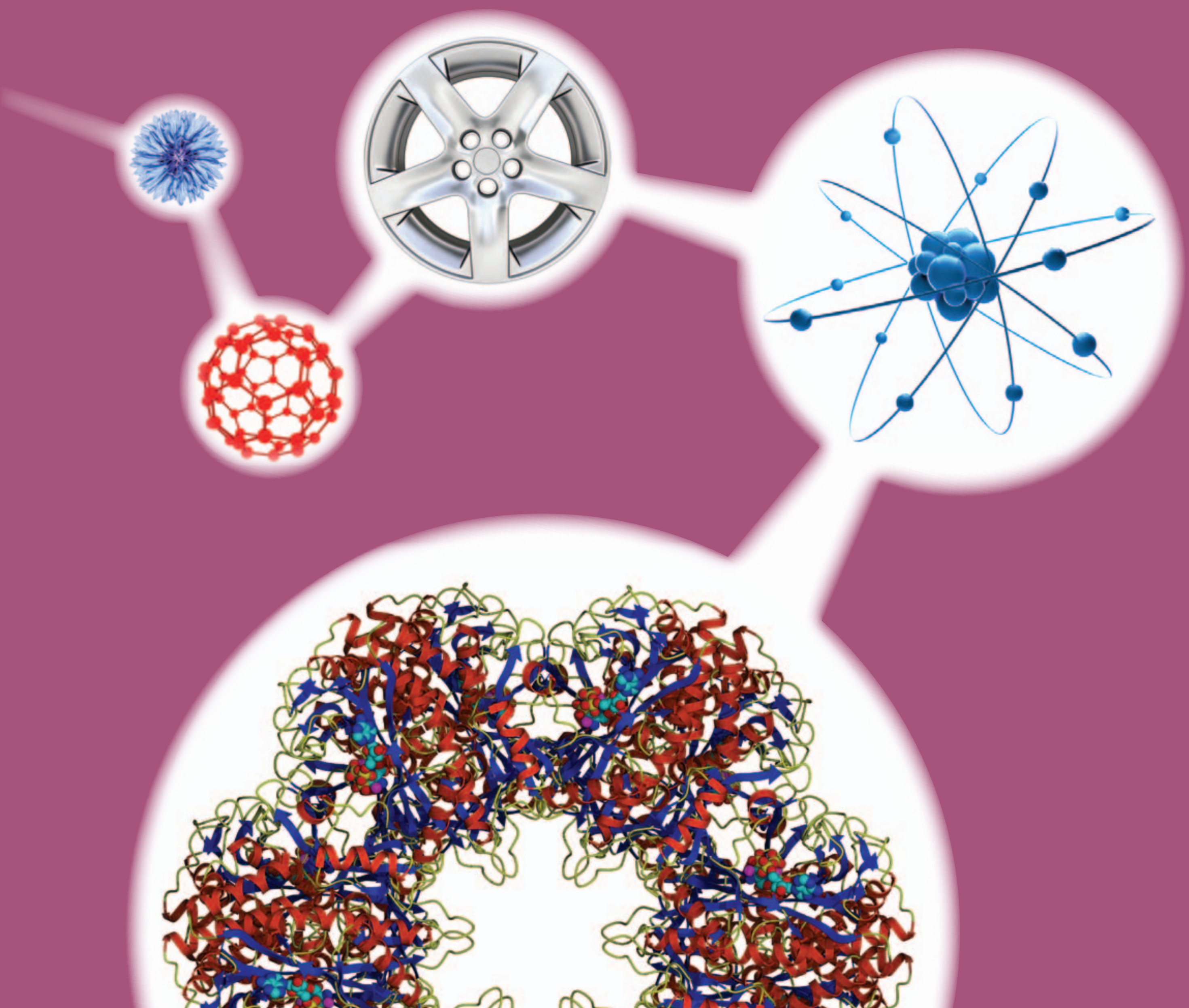
GCSE ADDITIONAL SCIENCE B

ACCREDITED SPECIFICATION

J262

VERSION 2

MAY 2012



WELCOME TO GCSE SCIENCES

THOUSANDS OF TEACHERS ALREADY UNLEASH THE JOY OF SCIENCE WITH OCR.

A FEW GOOD REASONS TO WORK WITH OCR

- You can enjoy the **freedom and excitement** of teaching science qualifications which have been developed to help you inspire students of all abilities.
- We've built specifications **with you in mind**, using a clear and easy-to-understand format, making them straightforward for you to deliver.
- Our **clear and sensible assessment** approach means that exam papers and requirements are clearly presented and sensibly structured for you and your students.
- **Pathways for choice** – we have the broadest range of science qualifications and our GCSEs provide an ideal foundation for students to progress to more-advanced studies and science-related careers.
- **Working in partnership to support you** – together with teachers we've developed a range of practical help and support to save you time. We provide everything you need to teach our specifications with confidence and ensure your students get as much as possible from our qualifications.
- **A personal service** – as well as providing you with lots of support resources, we're also here to help you with specialist advice, guidance and support for those times when you simply need a more individual service.

HERE'S HOW TO CONTACT US FOR SPECIALIST ADVICE:

By phone: 01223 553998

By email: science@ocr.org.uk

By online: http://answers.ocr.org.uk

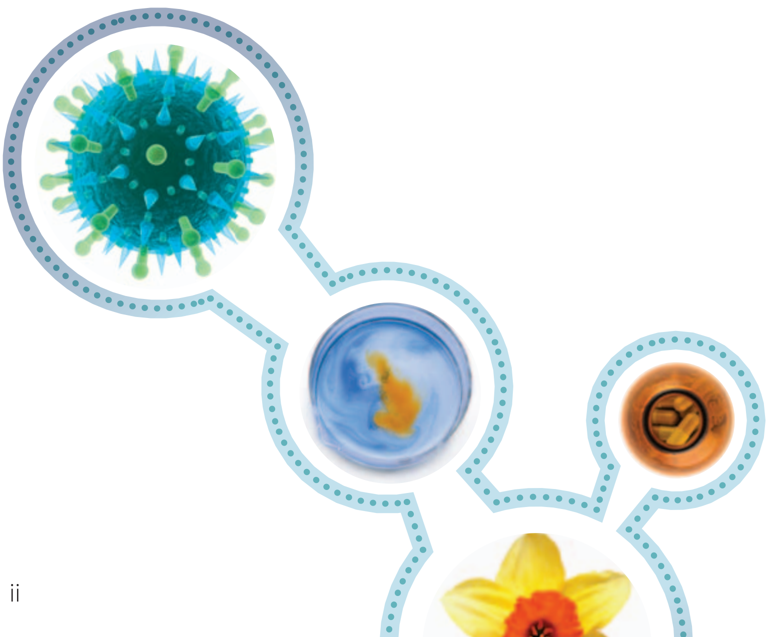
By fax: 01223 552627

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

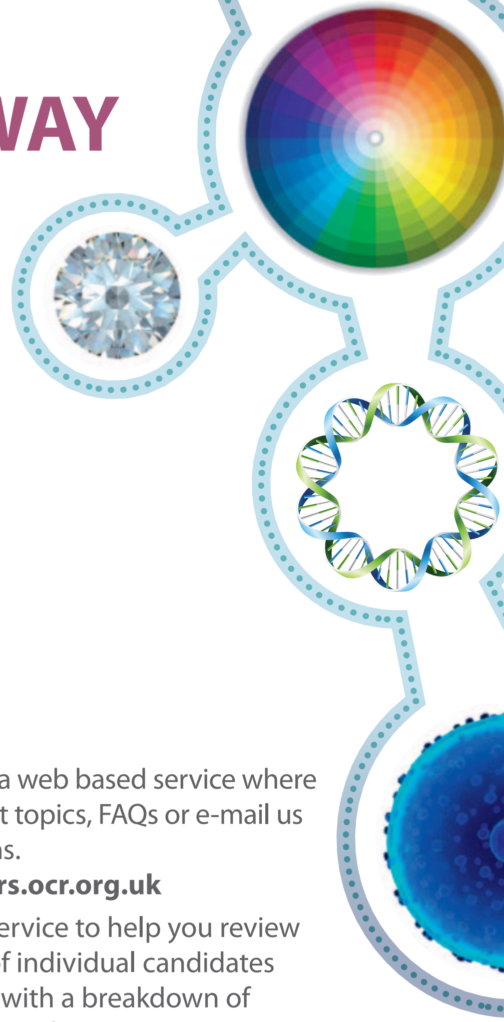
DON'T FORGET

– you can download a copy of this specification and all our support materials at

www.ocr.org.uk/gcse2012



SUPPORTING YOU ALL THE WAY



Our aim is to help you at every stage and we work in close consultation with teachers and other experts to provide a practical package of high quality resources and support.

Our support materials are designed to save you time while you prepare for and teach our new specifications. In response to what you have told us we are offering detailed guidance on key topics and controlled assessment.

Our essential FREE support includes:

Materials

- Specimen assessment materials and mark schemes
- Guide to controlled assessment
- Sample controlled assessment material
- Exemplar candidate work
- Marking commentaries
- Teacher's handbook
- Sample schemes of work and lesson plans
- Frequently asked questions
- Past papers.

You can access all of our support at:
www.ocr.org.uk/gcse2012

Science Community

Join our social network at **www.social.ocr.org.uk** where you can start discussions, ask questions and upload resources.

Services

- **Answers @ OCR –** a web based service where you can browse hot topics, FAQs or e-mail us with your questions.
  Visit **http://answers.ocr.org.uk**
- **Active Results** – service to help you review the performance of individual candidates or a whole school, with a breakdown of results by question and topic.
- **Local cluster support networks** – supported by OCR, you can join our local clusters of centres who offer each other mutual support.

Endorsed publisher partner materials

We're working closely with our publisher partner Collins Education to ensure effective delivery of endorsed materials when you need them.
Find out more at:
www.collinseducation.com/newgcsescience

GATEWAY SCIENCE SUITE

Science in Action

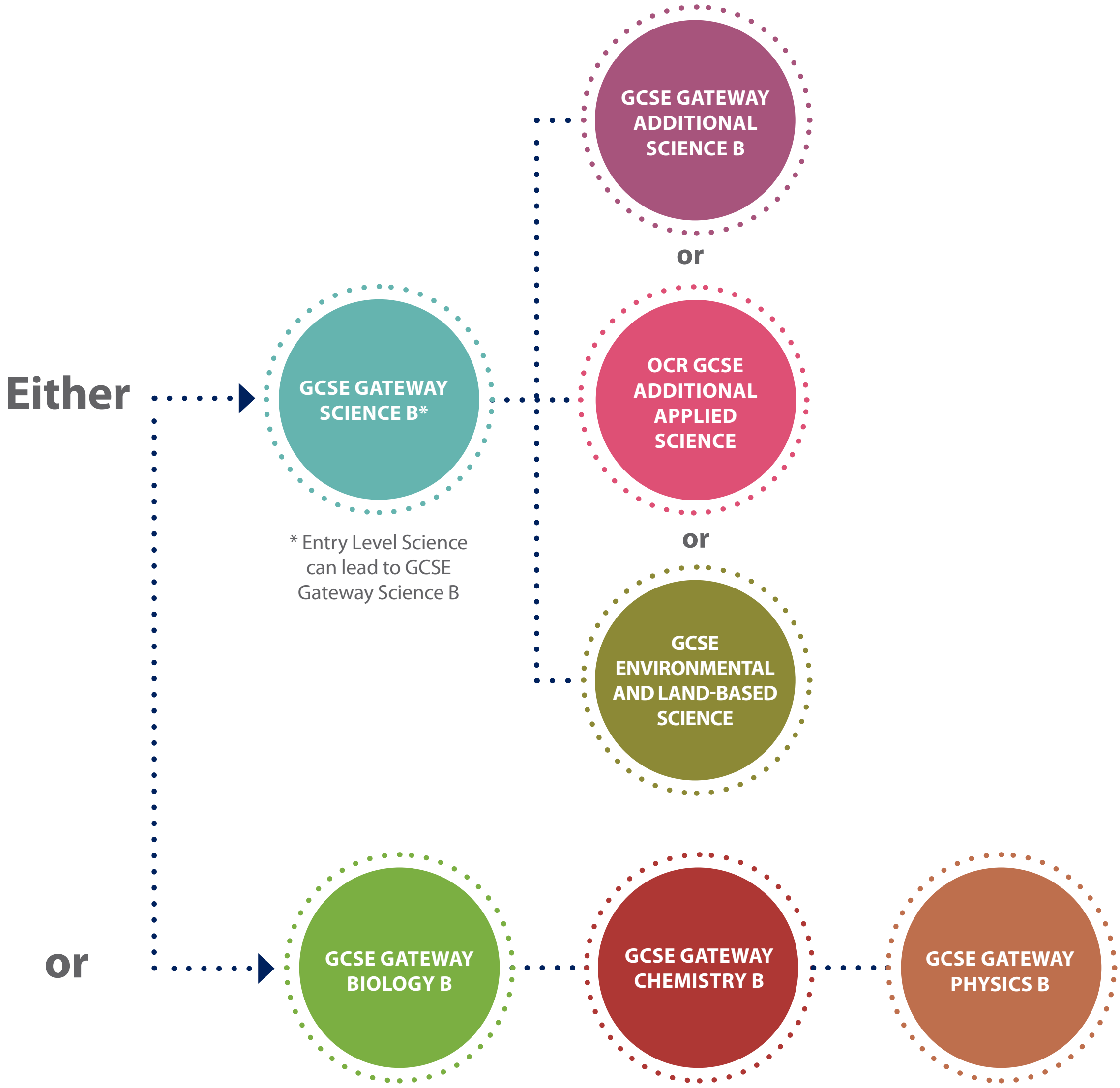
Understand the questions that science can answer. Unpick the scientific concepts and investigate their familiar applications through active learning.

KEY FEATURES

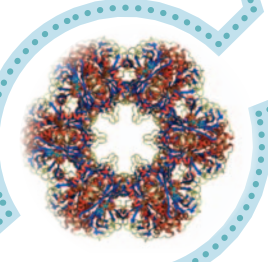
Our Gateway Science Suite gives you and your students:

- 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 ADDITIONAL SCIENCE B



KEY FEATURES

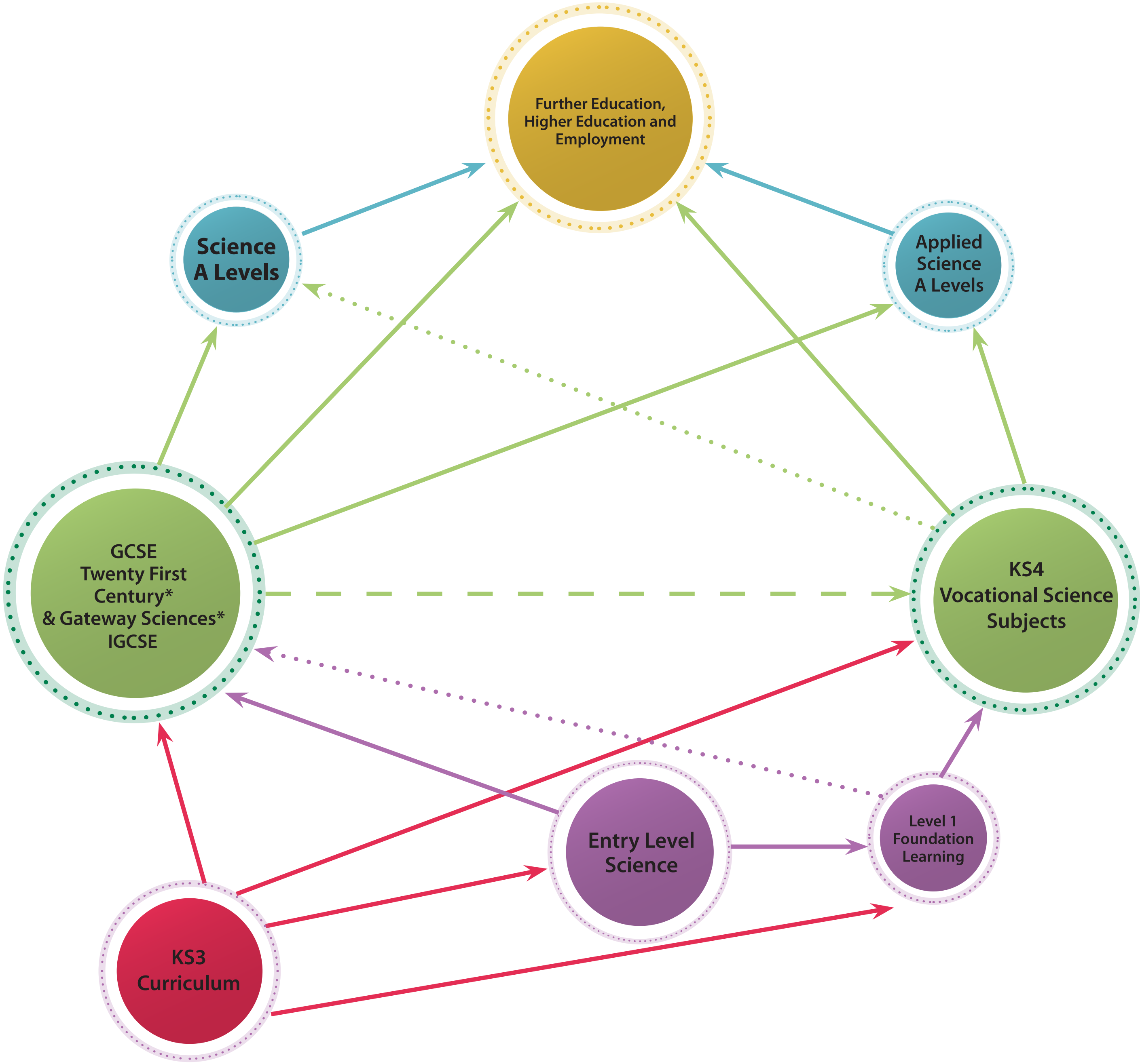
GCSE Additional Science B:

- develops the scientific skills, knowledge and understanding acquired from GCSE Science
- provides opportunities to develop scientific explanations and theories and to develop a critical approach to scientific evidence and methods.

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

COURSE OVERVIEW	ASSESSMENT OVERVIEW		
UNIT B721 Module B3: Living And Growing Module C3: Chemical Economics Module P3: Forces For Transport	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 B722 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 B722 Module B4: It's A Green World Module C4: The Periodic Table Module P4: Radiation For Life	85 marks 1 hour 30 minutes written paper	**40%** of total GCSE	
UNIT B723 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



This could be a progression route along a particular curriculum pathway. (Stage, not age pathways)

This could be a progression route however students would require additional support.

Alternative qualification options

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

Contents

Contents

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 Additional Science B

2.1 Overview of GCSE Additional Science B

Unit B721 *Additional Science modules B3, C3, P3*

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 B722 *Additional Science modules B4, C4, P4*

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.

+

Unit B723 *Additional Science controlled assessment*

This unit is not tiered.	Controlled assessment 48 marks 25% of the qualification.

2.2 What is new in GCSE Additional Science 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 B721 still 35%, Unit B722 still 40%. • Controlled assessment still 25% weighting.	• The course will be assessed as linear.
Content	• Content is divided into 6 modules, B3, B4, C3, C4, P3 and P4.	
Assessment	• Papers include structured questions and objectives 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 B721 paper is 1 hour 15 mins long, with a total of 75 marks. • Unit B722 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 Additional Science B requires 120–140 guided learning hours in total.

2.4 Aims and learning outcomes

GCSE specifications in Additional Science should encourage learners to develop their knowledge about the living, material and physical worlds and provide insight into, and experience of, how science works. They should enable learners to engage with science and to make informed decisions about further study in science and related subjects and about career choices.

The aims of this specification are to enable candidates to:

- develop their knowledge and understanding of the material, physical and living worlds
- develop their understanding of the effects of science on society
- develop an understanding of the importance of scale in science
- 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 Additional Science 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. B3a, B3b, B3c, B3d, B3e, B3f, B3g, B3h). Thus, the specification content contains a total of 48 teaching items. Each item requires approximately 2½ hours teaching time.

Module B3: *Living And Growing*		Module C3: *Chemical Economics*		Module P3: *Forces For Transport*	
a	Molecules of life	a	Rate of reaction (1)	a	Speed
b	Proteins and mutations	b	Rate of reaction (2)	b	Changing speed
c	Respiration	c	Rate of reaction (3)	c	Forces and motion
d	Cell division	d	Reacting masses	d	Work and power
e	The circulatory system	e	Percentage yield and atom economy	e	Energy on the move
f	Growth and development	f	Energy	f	Crumple zones
g	New genes for old	g	Batch or continuous?	g	Falling safely
h	Cloning	h	Allotropes of carbon and nanochemistry	h	The energy of games and theme rides
Module B4: *It's A Green World*		**Module C4: *The Periodic Table***		**Module P4: *Radiation For Life***	
a	Ecology in the local environment	a	Atomic structure	a	Sparks
b	Photosynthesis	b	Ionic bonding	b	Uses of electrostatics
c	Leaves and photosynthesis	c	The Periodic Table and covalent bonding	c	Safe electricals
d	Diffusion and osmosis	d	The Group 1 elements	d	Ultrasound
e	Transport in plants	e	The Group 7 elements	e	What is radioactivity?
f	Plants need minerals	f	Transition elements	f	Uses of radioisotopes
g	Decay	g	Metal structure and properties	g	Treatment
h	Farming	h	Purifying and testing water	h	Fission and fusion

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.

Note: 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 science through familiarity with the science content of the Key Stage 3 and Key Stage 4 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
B3a, B3b, B4d, C3b, C3c, C3h,C4b, C4c, C4d, C4e, P3b, P3g, P3h, P4d, P4e, P4h	Describe a simple scientific idea using a simple model.
B4b, C4a, P4h	Identify two different scientific views or explanations of scientific data.
B3a, B4b, C4a, P4h	Recall that scientific explanations (hypotheses) are: • used to explain observations • tested by collecting data/evidence.
B3a, B4b, C4a, P4h	Describe examples of how scientists use a scientific idea to explain experimental observations or results.
C4a, P4h	Recognise that scientific explanations are provisional but more convincing when there is more evidence to support them.
B3g, B4g, C3g, C4a, P4h	Identify different views that might be held regarding a given scientific or technological development.
B3f, B3g, B3h, B4g, C4g, P3c, P3e, P3f, P4b, P4c, P4d, P4e, P4g, P4h	Identify how a scientific or technological development could affect different groups of people or the environment.
B3g, B3h, P3c, P3e, P3f, P4a, P4b, P4c, P4d, P4e, P4f, P4g, P4h	Describe risks from new scientific or technological advances.
B4b, P3f, P4f, P4h	Distinguish between claims/opinions and scientific evidence in sources.
B3a, C4a, P3f, P4f, P4h	Recognise the importance of the peer review process in which scientists check each other's work.
B3c, B3f, B4a, C3a, C3b, C3c, C3d, C3e, C3f, P3a, P3b, P3c, P3d, P3e, P3h, P4c, P4e	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.
B4a, C4a, P3f, P4g, P4h	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 B3: Living And Growing

Module B3: Living And Growing

Item B3a: Molecules of life

Summary: The fundamental processes of life occur inside cells. This item examines the role of DNA in the production of proteins, the building blocks of living things. This item provides the opportunity to explain phenomena using scientific theories, models and ideas. Using the discovery of the structure of DNA it also illustrates the collaborative nature of science and the need for new discoveries to be validated.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Make a stained cheek cell slide and examine it using a microscope.	Identify the mitochondria in an animal cell. Recall that respiration occurs in the mitochondria providing energy for life processes.
Use of 'Cake Workshop': • 'recipe for life' – an activity to demonstrate use of a recipe (code); see www.bbsrc.ac.uk. Examine a model of DNA. Carry out role playing exercise to demonstrate base pairings. Research the Human Genome Project and efforts to sequence the genome of other organisms.	Recall that chromosomes in the nucleus: • carry coded information in the form of genes • are made of a molecule called DNA. Recall that the information in genes is in the form of coded instructions called the genetic code. Understand that the genetic code controls cell activity and consequently some characteristics of the organism. Recall that DNA controls the production of different proteins. Recall that proteins are needed for the growth and repair of cells.
Research the roles of Watson, Crick and others in increasing our understanding of the structure of DNA.	Recall that the structure of DNA was first worked out by two scientists called Watson and Crick.

Module B3: Living And Growing

Item B3a: Molecules of life

Links to other items: B3b: Proteins and mutations, B3d: Cell division, B3g: New genes for old

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain why liver and muscle cells have large numbers of mitochondria.	Recall that: • some structures in cells, such as ribosomes, are too small to be seen with the light microscope • ribosomes are in the cytoplasm and are the site of protein synthesis.
Describe the structure of DNA as two strands coiled to form a double helix, each strand containing chemicals called bases, of which there are four different types, with cross links between the strands formed by pairs of bases. Describe chromosomes as long, coiled molecules of DNA, divided up into regions called genes. Recall that each gene: • contains a different sequence of bases • codes for a particular protein. Recall that proteins are made in the cytoplasm and understand why a copy of the gene is needed: the gene itself cannot leave the nucleus.	Recall that the four bases of DNA are A, T, C and G (full names will not be required). Describe the complementary base pairings: A – T and G – C. Explain how protein structure is determined by the DNA base code, to include: • the base sequence determines amino acid sequence • each amino acid is coded for by a sequence of 3 bases. Explain how the code needed to produce a protein is carried from the DNA to the ribosomes by a molecule called mRNA. Explain how DNA controls cell function by controlling the production of proteins, some of which are enzymes.
Describe how Watson and Crick used data from other scientists to build a model of DNA, to include: • X-ray data showing that there were two chains wound in a helix • data indicating that the bases occurred in pairs.	Explain why new discoveries, such as Watson and Crick's, are not accepted or rewarded immediately, to include: • the importance of other scientists repeating or testing the work.

Module B3: Living And Growing

Item B3b: Proteins and mutations

Summary: The genetic material in the form of DNA codes for the production of proteins. This item looks at the structure and functions of proteins in living organisms, including the role of enzymes. It also introduces mutations and how they can alter the proteins that a cell produces. The study of enzyme action provides the opportunity to gain the skills of working accurately and safely, individually and with others, to collect first-hand data and to test a scientific explanation using scientific theories, models and ideas.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
	Recall some examples of proteins to include: • collagen • insulin • haemoglobin.
Build plasticine models to illustrate the 'lock and key' mechanism. Investigate the effects of changing temperature or pH on enzyme activity.	Describe enzymes as: • proteins • molecules that speed up a chemical reaction • working best at a particular temperature. Understand that enzymes have active sites that substrate molecules fit into when a reaction takes place.
	Recognise that different cells and different organisms will produce different proteins. Describe gene mutations as changes to genes.

Module B3: Living And Growing

Item B3b: Proteins and mutations

Links to other items: B3a: Molecules of life

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Recognise that proteins are made of long chains of amino acids. Describe some functions of proteins, to include: • structural (limited to collagen) • hormones (limited to insulin) • carrier molecules (limited to haemoglobin) • enzymes.	Explain how each protein has its own number and sequence of amino acids, which results in differently shaped molecules, which have different functions.
Describe enzymes as: • biological catalysts • catalysing chemical reactions occurring in living cells: respiration, photosynthesis, protein synthesis • having a high specificity for their substrate. Explain the specificity of enzymes in terms of the 'lock and key' mechanism. Describe how changing temperature and pH, away from the optimum, will change the rate of reaction of an enzyme-catalysed reaction.	Explain how enzyme activity is affected by pH and temperature, to include: • lower collision rates at low temperatures • denaturing at extremes of pH and high temperatures • denaturing as an irreversible change inhibiting enzyme function • denaturing changing the shape of the active site. Calculate and interpret the Q_{10} value for a reaction over a 10°C interval, given graphical or numerical data, using the formula: $Q_{10} = \frac{\text{rate at higher temperature}}{\text{rate at lower temperature}}$
Recall that gene mutations may lead to the production of different proteins. Understand that mutations occur spontaneously but can be made to occur more often by radiation or chemicals. Understand that mutations are often harmful but may be beneficial or have no effect.	Understand that only some of the full set of genes are used in any one cell; some genes are switched off. Understand that the genes switched on determine the functions of a cell. Explain how changes to genes alter, or prevent the production of the protein which is normally made.

Module B3: Living And Growing

Item B3c: Respiration

Summary: Respiration is a vital reaction that takes place inside cells. It releases the energy that is needed to drive many other metabolic reactions. This item provides candidates with the opportunity to collect and analyse scientific data concerning respiration rates. They can also gain the skills of working accurately and safely, individually and with others to collect first-hand data when investigating pulse recovery times.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Use lime water or hydrogen-carbonate indicator to compare rates of respiration.	Recognise that the energy provided by respiration is needed for all life processes in plants and in animals. Recall and use the word equation for aerobic respiration: glucose + oxygen → carbon dioxide + water Describe examples of life processes that require energy from respiration, to include: • muscle contraction • protein synthesis • control of body temperature in mammals.
Carry out a fist clenching exercise with arm raised and then lowered to demonstrate muscle fatigue. Carry out a weight lifting exercise by a finger to show muscle fatigue. Carry out experiments on pulse recovery times and compare data using ICT skills.	Explain why breathing and pulse rates increase during exercise. Describe an experiment to measure resting pulse rate and recovery time after exercise. Analyse given data from a pulse rate experiment.

Module B3: Living And Growing

Item B3c: Respiration

Links to other items: B4b: Photosynthesis

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Recall and use the symbol equation for aerobic respiration: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ Use data from experiments to compare respiration rates, to include: • increased oxygen consumption • increased carbon dioxide production. Calculate the respiratory quotient (RQ) using the formula (data provided): $RQ = \frac{\text{carbon dioxide produced}}{\text{oxygen used}}$	Recall that respiration results in the production of ATP and that ATP is used as the energy source for many processes in cells. Explain how the rate of oxygen consumption can be used as an estimate of metabolic rate because aerobic respiration requires oxygen. Explain why the rate of respiration is influenced by changes in temperature and pH.
Explain why anaerobic respiration takes place during hard exercise in addition to aerobic respiration. Recall that this produces lactic acid which accumulates in muscles causing pain and fatigue. Recall and use the word equation for anaerobic respiration which releases energy: glucose → lactic acid Understand that anaerobic respiration releases much less energy per glucose molecule than aerobic respiration.	Explain fatigue in terms of lactic acid build up (oxygen debt) and how this is removed during recovery, to include: • hard exercise causing lack of oxygen in cells • the incomplete breakdown of glucose • continued panting replacing oxygen allowing aerobic respiration • increased heart rate ensuring that blood carries lactic acid away to the liver.

Module B3: Living And Growing

Item B3d: Cell division

Summary: As living things grow, the number of cells in them increases. This brings significant advantages, and requires the development of complex organ systems. This item looks at the two ways cells divide, mitosis and meiosis, and the differences between these types of cell division. Software simulations and video clips which show cell division are uses of ICT in teaching and learning.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
	Describe the difference between simple organisms which are unicellular and more complex organisms which are multicellular.
Watch a video, examine photographs and use software simulations of cell division. Use models to illustrate cell division, using wool or plasticine. Examine prepared microscope slides to show cell division. Prepare a stained microscope slide of a root tip squash to show mitosis (e.g. garlic or hyacinth). Use bacterial or yeast growing kits.	Recall that most body cells contain chromosomes in matching pairs. Explain why the chromosomes have to be copied to produce new cells for growth. Recall that this type of cell division is also needed for: • replacement of worn out cells • repair to damaged tissue • asexual reproduction.
Examine bull's sperm using a microscope. Examine a hen's egg to show the large amount of stored food. Examine pollen using a microscope.	Recall that in sexual reproduction gametes join in fertilisation. Recall that gametes have half the number of chromosomes of body cells. Understand that in sexual reproduction to produce a unique individual half the genes come from each parent. Explain why sperm cells are produced in large numbers: to increase the chance of fertilisation.

Module B3: Living And Growing

Item B3d: Cell division

Links to other items: B3f: Growth and development, B4d: Diffusion and osmosis

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain the advantages of being multicellular: • allows organism to be larger • allows for cell differentiation • allows organism to be more complex.	Explain why becoming multicellular requires the development of specialised organ systems, limited to: • communication between cells • supplying the cells with nutrients • controlling exchanges with the environment.
Recall that new cells for growth are produced by mitosis. Explain why these new cells are genetically identical. Recall that in mammals, body cells are diploid (two copies of each chromosome). Explain why DNA replication must take place before cells divide.	Describe how, prior to mitosis, DNA replication occurs, to include: • ‘unzipping’ to form single strands • new double strands forming by complementary base pairing. Describe how in mitosis the chromosomes: • line up along the centre of the cell • they then divide • the copies move to opposite poles of the cell.
Recall that gametes are produced by meiosis. Describe gametes as haploid (contain one chromosome from each pair). Explain why fertilisation results in genetic variation, limited to: • gametes combine to form a diploid zygote • genes on the chromosomes combine to control the characteristics of the zygote. Explain how the structure of a sperm cell is adapted to its function, to include: • many mitochondria to provide energy • an acrosome that releases enzymes to digest the egg membrane.	Explain why, in meiosis, the chromosome number is halved and each cell is genetically different, to include: • one chromosome from each pair separate to opposite poles of the cell in the first division • chromosomes divide and the copies move to opposite poles of the cell in the second division.

Module B3: Living And Growing

Item B3e: The Circulatory system

Summary: The development of larger, multicellular organisms has resulted in the development of complex organ systems. This item describes one of these systems, the circulatory system. It explains why blood is vital for life as it transports materials around the body to and from different cells. Research and presentation of a report on disorders of the blood allows the opportunity to use ICT in teaching and learning to present information using scientific language and conventions.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Research and present a report on disorders of the blood e.g. haemophilia, sickle cell anaemia and leukaemia.	Describe the functions of components of the blood: • red blood cells • white blood cells • platelets.
Research what to do if someone has a cut and is bleeding badly.	Recall that the blood moves around the body in: • arteries • veins • capillaries.
Examine an animal heart (or model).	Describe the functions of the heart in the pumping of blood, to include: • the right side of the heart pumping blood to the lungs • the left side of the heart pumping blood to the rest of the body. Recall that blood in arteries is under higher pressure than blood in the veins. Explain, in terms of pressure difference, why blood flows from one area to another.

Module B3: Living And Growing

Item B3e: The Circulatory system

Links to other items: B4d: Diffusion and osmosis

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain how the structure of a red blood cell is adapted to its function: size, shape, contains haemoglobin, lack of nucleus. Describe the function of plasma.	Explain how the structure of a red blood cell is adapted to its function in terms of the small size providing a large surface area to volume ratio. Describe how haemoglobin in red blood cells reacts with oxygen in the lungs to form oxyhaemoglobin and how the reverse of this reaction happens in the tissues.
Describe how the parts of the circulatory system work together to bring about the transport of substances around the body, to include: • arteries transporting blood away from the heart • veins transporting blood to the heart • capillaries exchanging materials with tissues.	Explain how the adaptations of arteries, veins and capillaries relate to their functions, to include: • thick muscular and elastic wall in arteries • large lumen and presence of valves in veins • permeability of capillaries.
Identify the names and positions of the parts of the heart and describe their functions, to include: • left and right ventricles to pump blood • left and right atria to receive blood • semilunar, tricuspid and bicuspid valves to prevent backflow • four main blood vessels of the heart. Explain why the left ventricle has a thicker muscle wall than the right ventricle.	Explain the advantage of the double circulatory system in mammals, to include: • higher pressures • therefore greater rate of flow to the tissues.

Module B3: Living And Growing

Item B3f: Growth and development

Summary: The growth of organisms can be measured in different ways. Whilst there are similarities in the patterns of growth and development in all organisms there are some major variations between plants and animals. This item explores some of these differences. Research into human stem cells and cancer provides opportunities to discuss how and why decisions about science are made and the related ethical issues. These discussions can also provide the opportunity to show that there are some questions that science cannot currently answer.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Make an onion cell slide and examine it using a microscope.	Describe the functions of parts of a plant cell to include: • vacuole, containing cell sap and providing support • the cell wall, made of cellulose to provide support. Describe how to make a stained slide of an onion cell. Understand that bacterial cells are smaller and simpler than plant and animal cells.
Grow seedlings from seeds and measure their growth rate using different measurements. Plot data on weight gain of a baby using a case study or collected data. See Personal Child Health Record from Local Health Authority.	Recall that growth can be measured as an increase in height, wet mass or dry mass. Interpret data on a typical growth curve for an individual.
Research human stem cells. Research cancer (uncontrolled growth of cells).	Describe the process of growth as cell division followed by cells becoming specialised. Recall that the process of cells becoming specialised is called differentiation.
	Understand that animals grow in the early stages of their lives whereas plants grow continually. Understand that all parts of an animal are involved in growth whereas plants grow at specific parts of the plant.

Module B3: Living And Growing

Item B3f: Growth and development

Links to other items: B3d: Cell division

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Identify simple differences between bacterial cells and plant and animal cells. Recall that bacterial cells lack: • a 'true' nucleus • mitochondria • chloroplasts.	Describe the difference between the arrangement of DNA in a bacterial cell and a plant/animal cell to include: • presence/absence of a nucleus • single circular strand/chromosomes.
Recall that dry mass is the best measure of growth. Interpret data on increase in mass (including wet and dry mass). Describe the main phases of a typical growth curve. Recall that in human growth there are two phases of rapid growth, one just after birth and the other in adolescence.	Explain the advantages and disadvantages of measuring growth by: • length • wet mass • dry mass. Explain why the growth of parts of an organism may differ from the growth rate of the whole organism.
Recall that undifferentiated cells called stem cells can develop into different cells, tissues and organs. Recall that stem cells can be obtained from embryonic tissue and could potentially be used to treat medical conditions. Discuss issues arising from stem cell research in animals.	Explain the difference between adult and embryonic stem cells.
Explain why plant growth differs from animal growth, to include: • animals tend to grow to a finite size but many plants can grow continuously • plant cell division is mainly restricted to areas called meristems • cell enlargement is the main method by which plants gain height • many plant cells retain the ability to differentiate but most animal cells lose it at an early stage.	

Module B3: Living And Growing

Item B3g: New genes for old

Summary: Genetic engineering and genetic modification are relatively recent terms but humans have been genetically modifying animals and plants using selective breeding for thousands of years. Debating the arguments for and against GM and gene therapy provides opportunities to discuss how and why decisions about science are made. These discussions demonstrate the limitations of science to providing factual information and new techniques. The decisions as to whether to use these techniques need to be taken by representatives of the whole population.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Research examples of different animal and plant breeds that have been produced by selective breeding.	Describe the process of selective breeding as involving the: • selection of desired characteristics • cross breeding • selection of suitable offspring over many generations. Explain how selective breeding can contribute to improved agricultural yields.
Survey foods that contain GM ingredients. Research and present evidence for the benefits and risks of GM food. Research the differences between gene therapy and germ line treatment as possible treatments for genetic disorders.	Recall that: • selected genes can be artificially transferred from one living organism to another • this transfer of genes is called genetic engineering or genetic modification • the transfer of genes can produce organisms with different characteristics. Identify features of plants and animals that might be selected for in a genetic engineering programme.
	Recognise that in the future it may be possible to use genetic engineering to change a person's genes and cure certain disorders.

Module B3: Living And Growing

Item B3g: New genes for old

Links to other items: B3a: Molecules of life, B3h: Cloning

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Recognise that a selective breeding programme may lead to inbreeding, which can cause health problems within the species.	Explain how a selective breeding programme may reduce the gene pool leading to problems of inbreeding, to include: • accumulation of harmful recessive characteristics • reduction in variation.
Explain some potential advantages and risks of genetic engineering: • advantage – organisms with desired features are produced rapidly • risks – inserted genes may have unexpected harmful effects. Describe, in outline only, some examples of genetic engineering: • taking the genes that control beta-carotene production and putting them into rice. Humans can then convert the beta-carotene from rice into Vitamin A (solving the problem of parts of the world relying on rice but lacking vitamin A) • the production of human insulin by genetically engineered bacteria • transferring resistance to herbicides, frost damage or disease to crop plants. Discuss the ethical issues involved in genetic modification.	Understand the principles of genetic engineering, to include: • selection of desired characteristics • isolation of genes responsible • insertion of the genes into other organisms • replication of these organisms.
Recall that changing a person's genes in an attempt to cure disorders is called gene therapy.	Recall that gene therapy could involve body cells or gametes. Explain why gene therapy involving gametes is controversial.

Module B3: Living And Growing

Item B3h: Cloning

Summary: Human individuals are unique, yet modern science has the ability to create genetically identical copies of complex organisms. This item considers the advantages and disadvantages of using this scientific knowledge. Finding out about the techniques used to produce Dolly, the first cloned animal, provides the opportunity to illustrate the use of ICT in science, ethical issues about contemporary scientific developments and the role of the science community in validating changes in scientific knowledge.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Research information on the techniques used to produce Dolly, the first cloned mammal. Research the current scientific and legal position on xenotransplants.	Recall that: • cloning is an example of asexual reproduction • cloning produces genetically identical copies (clones). Recall that Dolly the sheep was the first mammal cloned from an adult. Recognise that identical twins are naturally occurring clones.
Carry out a meristem tissue culture using cauliflower.	Recognise that plants grown from cuttings or tissue culture are clones. Describe how spider plants, potatoes and strawberries reproduce asexually. Describe how to take a cutting.

Module B3: Living And Growing

Item B3h: Cloning

Links to other items: B3d: Cell division, B3g: New genes for old

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Understand that Dolly the sheep was produced by the process of nuclear transfer and that nuclear transfer involves placing the nucleus of a body cell into an egg cell. Describe some possible uses of cloning, limited to: • mass producing animals with desirable characteristics • producing animals that have been genetically engineered to provide human products • producing human embryos to supply stem cells for therapy. Understand the ethical dilemmas concerning human cloning.	Describe in outline the cloning technique used to produce Dolly, to include: • nucleus removed from an egg cell • egg cell nucleus replaced with the nucleus from an udder cell • egg cell given an electric shock to make it divide • embryo implanted into a surrogate mother sheep • embryo grows into a clone of the sheep from which the udder cell came. Describe the benefits and risks of using cloning technology. Explain the possible implications of using genetically modified animals to supply replacement organs for humans.
Describe the advantages and disadvantages associated with the commercial use of cloned plants, to include: • advantage – can be sure of the characteristics of the plant since all plants will be genetically identical • advantage – it is possible to mass produce plants that may be difficult to grow from seed • disadvantage – if plants become susceptible to disease or to change in environmental conditions then all plants will be affected • disadvantage – lack of genetic variation.	Describe plant cloning by tissue culture, to include: • selection for characteristics • large number of small pieces of tissue • aseptic technique • use of suitable growth medium and conditions. Explain why cloning plants is easier than cloning animals: many plant cells retain ability to differentiate, unlike animal cells which usually lose this ability at an early stage.

3.5 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 items: C3 to C4

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 the 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: C3b: Rate of reaction (2), C3c: Rate of reaction (3), C4d: The Group 1 elements

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: C3a: Rate of reaction (1), C3c: Rate of reaction (3), C4d: The Group 1 elements

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: C3a: Rate of reaction (1), C3b: Rate of reaction (2), C4d: The Group 1 elements

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

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

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

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 (4.2J/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?

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.

3.6 Module P3: Forces For Transport

Module P3: Forces for Transport

Item P3a: Speed

Summary: Transport and road safety provide the context for this module. The abilities to describe and measure motion are used in the treatment of issues involving everyday transport. Speed is studied in this item; how it can be measured and calculated and how distance and time can be graphically represented. The activities on vehicle speeds allow the opportunity to collect and analyse scientific data. Using ICT to interpret the data and using creative thought can then lead to the development of theories and models.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Calculating speeds from measurements of time and distance (e.g. pupils running and walking, vehicles, pupil riding a bike, remote controlled toy cars). Practical experiment to investigate the speeds of vehicles near school: • are male drivers faster than female? • have the speed-bumps made any difference? Practical experiment to investigate the speeds of toy cars on ramps: • how does the slope angle or height affect the speed? • which cars are fastest? Find out how different speed cameras work. Exploration of speed records (cars, animals, planes, people etc). Make a wall chart or PowerPoint presentation to show the range of speed for land animals.	Use the equation: $\text{average speed} = \frac{\text{distance}}{\text{time}}$ to include change of units from km to m. Understand why one type of speed camera takes two photographs: • a certain time apart • when the vehicle moves over marked lines a known distance apart on the road. Understand how average speed cameras work.
Looking at data from cars, sport and animals then transferring it to graphical form for analysis (distance-time graphs).	Draw and interpret qualitatively graphs of distance against time.

Module P3: Forces For Transport

Item P3a: Speed

Links to other items: P3b: Changing speed, P3c: Forces and motion

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Interpret the relationship between speed, distance and time including: • increasing the speed, which increases the distance travelled in the same time • increasing the speed reduces the time needed to cover the same distance. Use the equation, including a change of subject: distance = average speed × time $= \frac{(u + v)}{2} \times t$	Interpret the relationship between speed, distance and time to include the effect of changing any one or both of the quantities. Use the equation, including a change of subject and/or units: distance = average speed × time $= \frac{(u + v)}{2} \times t$
Describe and interpret the gradient (steepness) of a distance-time graph as speed (higher speed gives steeper gradient).	Draw and interpret graphs of distance against time: • qualitatively for non-uniform speed • calculations of speed from the gradient of distance-time graph for uniform speed.

Module P3: Forces For Transport

Item P3b: Changing speed

Summary: In this item the idea of acceleration is developed. The concept of velocity is introduced here, and is developed further in P5. Accelerations (involving the change in speed) of cars can be used and graphically illustrated and studied. Practical measurements of bicycles and sprint starts can be done to collect and analyse data. The experiments on acceleration allow the opportunity to collect and analyse science data using ICT tools and the interpretation of the data using creative thought to develop theories.

Suggested practical and research activities to select from	**Assessable learning outcomes Foundation Tier only: low demand**
Practical measurements of bicycles, sprint starts, falling objects can be done (using manual or electronic measurement) to collect and analyse real data for calculating acceleration.	Describe the trends in speed and time from a simple speed-time graph: • horizontal line – constant speed • straight line positive gradient – increasing speed • straight line negative gradient – decreasing speed.
Use of real car data from websites or magazines to illustrate and develop further the concepts of: • speed • acceleration.	Recognise that acceleration involves a change in speed (limited to motion in a straight line): • speeding up involves an acceleration • slowing down involves a deceleration • greater change in speed (in a given time) results in higher acceleration. Recall that acceleration is measured in metres per second squared (m/s^2). Use the equation: $\text{acceleration} = \frac{\text{change in speed}}{\text{time taken}}$ when given the change in speed.
	Recognise that direction is important when describing the motion of an object. Understand that the velocity of an object is its speed combined with its direction.

Module P3: Forces For Transport

Item P3b: Changing speed

Links to other items: P3a: Speed, P3c: Forces and motion

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe, draw and interpret qualitatively, graphs of speed against time for uniform acceleration to include: • greater acceleration shown by a higher gradient • the significance of a positive or negative gradient • calculations of distance travelled from a simple speed-time graph for uniform acceleration.	Describe, draw and interpret graphs of speed against time including: • quantitatively for uniform acceleration • calculations of distance travelled from a speed-time graph for uniform acceleration • calculations of acceleration from a speed-time graph for uniform acceleration • qualitative interpretation of speed-time graphs for non-uniform acceleration.
Describe acceleration as change in speed per unit time and that: • increase in speed results from a positive acceleration • decrease in speed results from a negative acceleration or deceleration. Use the equation including prior calculation of the change in speed: $\text{acceleration} = \dfrac{\text{change in speed}}{\text{time taken}}$	Explain how acceleration can involve either a change: • in speed • in direction • in both speed and direction. Interpret the relationship between acceleration, change of speed and time to include the effect of changing any one or two of the quantities. Use the equation, including a change of subject: $\text{acceleration} = \dfrac{\text{change in speed}}{\text{time taken}}$
Recognise that for two objects moving in opposite directions at the same speed, their velocities will have identical magnitude but opposite signs. Calculate the relative velocity of objects moving in parallel.	

Module P3: Forces For Transport

Item P3c: Forces and motion

Summary: Before taking your driving test you need to pass a theory test. Part of this involves driving safely and knowledge of car stopping distances. Driving fast may be tempting but stopping safely is more important. In this item we start to understand the effects of forces on braking and the factors which affect stopping distances. The experiments using elastics, light gates and trolleys allow the opportunity to collect and analyse scientific data using ICT tools and the interpretation of the data using creative thought to develop theories. Work on stopping distances provides the opportunity to discuss how and why decisions about science and technology are made, including ethical issues and the social, economic and environmental effects of such decisions.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Use of elastics, light gates and trolleys to explore acceleration.	Recognise situations where forces cause things to: • speed up • slow down • stay at the same speed. Use the equation: force = mass × acceleration when given mass and acceleration.
Modelling stopping distances using a bicycle. Use of real car data from the Highway Code and websites or magazines to illustrate the science of stopping distances. Make a wall chart, PowerPoint presentation or a leaflet to show stopping distances for different speeds.	Describe thinking distance as: • the distance travelled between the need for braking occurring and the brakes starting to act. Describe braking distance as: • the distance taken to stop once the brakes have been applied. Describe stopping distance as: • thinking distance + braking distance. Calculate stopping distance given values for thinking distance and braking distance. Explain why thinking, braking and stopping distances are significant for road safety.

Module P3: Forces For Transport

Item P3c: Forces and motion

Links to other items: P3a: Speed, P3b: Changing speed, P3d: Work and power, P3e: Energy on the move, P3f: Crumple zones.

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe and interpret the relationship between force, mass and acceleration in everyday examples. Use the equation, including a change of subject: force = mass × acceleration	Use the equation, including a change of subject and the need to previously calculate the accelerating force: force = mass × acceleration
Explain how certain factors may increase thinking distance: • driver tiredness • influence of alcohol or other drugs • greater speed • distractions or lack of concentration. Explain how certain factors may increase braking distance: • road conditions • car conditions • greater speed. Interpret data about thinking distances and braking distances. Explain the implications of stopping distances in road safety: • driving too close to the car in front (i.e. inside thinking distance) • speed limits • road conditions.	Explain qualitatively everyday situations where braking distance is changed including: • friction • mass • speed • braking force. Draw and interpret the shapes of graphs for thinking and braking distance against speed. Explain the effects of increased speed on: • thinking distance – increases linearly • braking distance – increases as a squared relationship e.g. if speed doubles, braking distance increases by a factor of four, if speed trebles, braking distance increases by a factor of nine.

Module P3: Forces For Transport

Item P3d: Work and power

Summary: Work is done whenever a force moves something. Transport, by its nature, is always moving and energy is being transferred all the time. In this item we will learn about power and the energy we use to provide it. Different power ratings, fuel consumption, engine size costs and associated environmental issues about car use can be used to develop the skills of presenting information, developing an argument and drawing a conclusion using scientific terms. This also provides the opportunity to discuss how scientific knowledge and ideas change over time.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Construct a table of examples when work is, and is not, done.	Recall everyday examples in which work is done and power is developed to include: • lifting weights • climbing stairs • pulling a sledge • pushing a shopping trolley.
Measuring work done by candidates lifting weights, walking up stairs or doing 'step-ups'.	Describe how energy is transferred when work is done. Understand that the amount of work done depends on: • the size of the force in newtons (N) • the distance travelled in metres (m). Recall that the joule is the unit for both work and energy. Use the equation: work done = force × distance
Measuring power developed by candidates lifting known weights or their body weight, up stairs for example. The plenary could focus on how efficient the human body is as a machine.	Describe power as a measurement of how quickly work is being done. Recall that power is measured in watts (W). Recognise that cars: • have different power ratings • have different engine sizes and these relate to fuel consumption.

Module P3: Forces For Transport

Item P3d: Work and power

Links to other items: P3a: Speed, P3c: Forces and motion, P3e: Energy on the move, P3f: Crumple zones.

Assessable learning outcomes both tiers: standard demand	**Assessable learning outcomes Higher Tier only: high demand**
Use the equation: weight = mass × gravitational field strength	Use the equation, including a change of subject: weight = mass × gravitational field strength
Use the equation, including a change of subject: work done = force × distance	Use the equation: work done = force × distance then use the value for work done in the power equation below.
Use the equation: $\text{power} = \frac{\text{work done}}{\text{time}}$ Interpret fuel consumption figures from data on cars to include: • environmental issues • costs.	Use the equation, including a change of subject: $\text{power} = \frac{\text{work done}}{\text{time}}$ when work has been calculated. Use and understand the derivation of the power equation in the form: power = force × speed

Module P3: Forces For Transport

Item P3e: Energy on the move

Summary: Transport is essential to modern life whether it be bus, train, tram, bicycle, walking or car. All these need a source of energy which is transferred to kinetic energy. Some vehicles use more fossil fuels than others and this has implications for cost, pollution in our cities and future energy reserves. Other vehicles may use bio-fuels or solar power which are renewable energy sources.

Suggested practical and research activities to select from	**Assessable learning outcomes Foundation Tier only: low demand**
Exploring the significance of KE in braking distances applied to stopping distance charts.	Understand that kinetic energy (KE) depends on the mass and speed of an object.
Carry out research to find out which energy sources can be used to move motor vehicles, and discover what proportion of vehicles use each source.	Recognise and describe (derivatives of) fossil fuels as the main fuels in road transport: • petrol • diesel. Recall that bio-fuels and solar energy are possible alternatives to fossil fuels. Describe how electricity can be used for road transport, and how its use could affect different groups of people and the environment: • battery driven cars • solar power/cars with solar panels.
Evaluating data from fuel consumption figures for cars. Construct a wall chart, make a PowerPoint presentation or a leaflet that illustrates the problems of large engine cars and the merits of solar power and bio-fuels.	Draw conclusions from basic data about fuel consumption, including emissions (no recall required). Recognise that the shape of a moving object can influence its top speed and fuel consumption: • wedge shape of sports car • deflectors on lorries and caravans • roof boxes on cars • driving with car windows open.

Module P3: Forces For Transport

Item P3e: Energy on the move

Links to other items: P3f: Crumple zones, P3h: The energy of games and theme rides

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Use and apply the equation: $KE = \frac{1}{2}mv^2$	Use and apply the equation: $KE = \frac{1}{2}mv^2$ including a change of subject. Apply the ideas of kinetic energy to: • relationship between braking distances and speed • everyday situations involving objects moving.
Describe arguments for and against the use of battery powered cars. Explain why electrically powered cars do not pollute at the point of use whereas fossil fuel cars do. Recognise that battery driven cars need to have the battery recharged: • this uses electricity produced from a power station • power stations cause pollution. Explain why we may have to rely on bio-fuelled and solar powered vehicles in the future.	Explain how bio-fuelled and solar powered vehicles: • reduce pollution at the point of use • produce pollution in their production • may lead to an overall reduction in CO_2 emissions.
Interpret data about fuel consumption, including emissions.	Explain how car fuel consumption figures depend on: • energy required to increase KE • energy required to do work against friction • driving styles and speeds • road conditions. Evaluate and compare data about fuel consumption and emissions.

Module P3: Forces For Transport

Item P3f: Crumple zones

Summary: When cars stop energy is absorbed. This happens during braking and in collisions. Injuries in collisions can be reduced by clever car design and this unit explores the science behind the safety features of modern vehicles. Collisions are studied here in terms of energy, acceleration, force and momentum.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
	Use the equation: momentum = mass × velocity to calculate momentum.
Show videos on road safety and describe how seatbelts reduce the rate at which momentum changes.	Recall that a sudden change in momentum in a collision, results in a large force that can cause injury.
Design, build and test model crumple zones with trolleys, egg boxes, paper and straws. Use road safety websites and booklets to find out about safety features of cars and how they are tested, compared, and reported to the public. Test seatbelt materials for stretching. Research safety features in modern cars. Draw a time line showing when different safety features became standard on most cars.	Describe the typical safety features of modern cars that require energy to be absorbed when vehicles stop: • heating in brakes, crumple zones, seatbelts, airbags. Explain why seatbelts have to be replaced after a crash. Recognise the risks and benefits arising from the use of seatbelts. Recall and distinguish between typical safety features of cars which: • are intended to prevent accidents, or • are intended to protect occupants in the event of an accident.

Module P3: Forces For Transport

Item P3f: Crumple zones

Links to other items: P3c: Forces and motion

<table>
<tr><th>Assessable learning outcomes
both tiers: standard demand</th><th>Assessable learning outcomes
Higher Tier only: high demand</th></tr>
<tr><td>Use the equation including a change of subject:
momentum = mass × velocity
Describe why the greater the mass of an object and/or the greater the velocity, the more momentum the object has in the direction of motion.
Use the equation:
$\text{force} = \frac{\text{change in momentum}}{\text{time}}$
to calculate force.</td><td>Use and apply the equation including a change of subject:
$\text{force} = \frac{\text{change in momentum}}{\text{time}}$
Use Newton's second law of motion to explain the above points.
F = ma</td></tr>
<tr><td>Explain how spreading the change in momentum over a longer time reduces the likelihood of injury.
Explain, using the ideas about momentum, the use of crumple zones, seatbelts and airbags in cars.</td><td>Explain why forces can be reduced when stopping (e.g. crumple zones, braking distances, escape lanes, crash barriers, seatbelts and airbags) by:
• increasing stopping or collision time
• increasing stopping or collision distance
• decreasing acceleration.</td></tr>
<tr><td>Describe how seatbelts, crumple zones and airbags are useful in a crash because they:
• change shape
• absorb energy
• reduce injuries.
Describe how test data may be gathered and used to identify and develop safety features for cars.</td><td>Evaluate the effectiveness of given safety features in terms of saving lives and reducing injuries.
Describe how ABS brakes:
• make it possible to keep control of the steering of a vehicle in hazardous situations (e.g. when braking hard or going into a skid)
• work by the brakes automatically pumping on and off to avoid skidding
• sometimes reduce braking distances.
Analyse personal and social choices in terms of risk and benefits of wearing seatbelts.</td></tr>
</table>

Module P3: Forces For Transport

Item P3g Falling safely

Summary: Falling objects are usually subject to at least two forces – weight and drag. Some cars have similar engines to others yet have very different top speeds. This is to do with pairs of forces which may or may not balance. These ideas are of vital importance to the parachutist and drag-racer who want to slow down in time – safely! Investigating falling whirligig, parachutes or plasticine shapes provides the opportunity to explain phenomena by developing and using scientific theories. Work on the balance of forces illustrates the use of modelling in developing scientific understanding.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Investigate factors affecting the speed of a falling whirligig or parachute. Investigate factors affecting the speed of plasticine shapes as they fall through wallpaper paste. Use an electronic time device (e.g. light gates linked to a PC) to investigate falling objects. Make a wall chart by drawing a series of pictures of a falling parachutist to show the stages of flight for a sky-diver.	Recognise that frictional forces (drag, friction, air resistance): • act against the movement • lead to energy loss and inefficiency • can be reduced (shape, lubricant). Explain how objects falling through the Earth's atmosphere reach a terminal speed.
	Understand why falling objects do not experience drag when there is no atmosphere.

Module P3: Forces For Transport

Item P3g Falling safely

Links to other items: P3h: The energy of games and theme rides

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain in terms of the balance of forces how moving objects: • increase speed • decrease speed • maintain steady speed.	Explain, in terms of balance of forces, why objects reach a terminal speed: • higher speed = more drag • larger area = more drag • weight (falling object) or driving force (e.g. a car) = drag when travelling at terminal speed.
Recognise that acceleration due to gravity (g) is the same for any object at a given point on the Earth's surface.	Understand that gravitational field strength or acceleration due to gravity: • is unaffected by atmospheric changes • varies slightly at different points on the Earth's surface • will be slightly different on the top of a mountain or down a mineshaft.

Module P3: Forces For Transport

Item P3h The energy of games and theme rides

Summary: Rides at theme parks are designed to thrill and frighten you in a safe way. We pay good money to have our 'gravity' distorted. Theme ride designers are experts on energy and forces. Their simple trick is to use gravity and potential energy as the source of movement. This item will help you understand the science of theme rides and how scientific understanding can be applied by society.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Investigate bouncing balls (or a ball on a curved curtain track) as an energy system whose efficiency can be measured (100% × bounce height (or height raised)/drop (or fall) height).	Recognise that objects have gravitational potential energy (GPE) because of their mass and position in Earth's gravitational field.
Investigate models (toy cars on plastic track) or real roller-coasters as an energy system whose efficiency can be measured (100% × climb height/fall height).	Recognise everyday examples in which objects use gravitational potential energy (GPE).

Module P3: Forces For Transport

Item P3h The energy of games and theme rides

Links to other items: P3e: Energy on the move, P3g: Falling safely

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe everyday examples in which objects have gravitational potential energy (GPE). Use the equation: GPE = mgh Recognise and interpret examples of energy transfer between gravitational potential energy (GPE) and kinetic energy (KE).	Understand that for a body falling through the atmosphere at terminal speed: • kinetic energy (KE) does not increase • gravitational potential energy (GPE) is transferred to increased internal or thermal energy of the surrounding air particles through the mechanism of friction. Use and apply the equation, including a change of subject: GPE = mgh
Interpret a gravity ride (roller-coaster) in terms of: • kinetic energy (KE) • gravitational potential energy (GPE) • energy transfer. Describe the effect of changing mass and speed on kinetic energy (KE): • doubling mass doubles KE • doubling speed quadruples KE.	Use and apply the relationship $mgh = \frac{1}{2}mv^2$ Show that for a given object falling to Earth, this relationship can be expressed as $h = v^2 \div 2g$ and give an example of how this formula could be used.

3.7 Module B4: It's A Green World

Module B4: It's A Green World

Item B4a: Ecology in the local environment

Summary: We are surrounded by a huge variety of living organisms, many of which go unnoticed. This item seeks to help candidates appreciate this variety. Candidates are introduced to methods of sampling and mapping animals and plants. It also provides an appreciation of the biodiversity of some artificial ecosystems.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Use a variety of sampling techniques to include pooters, nets, pitfall traps, quadrats, tullgren funnel, belt transects. Estimate the number of weeds in a field. Examine the variety of life in a one metre quadrat of turf or from a sample of leaf litter.	Describe how to use collecting/counting methods, to include: • pooters • nets • pitfall traps • quadrats. Describe a method to show the variety of plants and animals living in a small area such as a 1m quadrat. Use keys to identify plants and animals.
Compare the communities of two different habitats. Use sensors and data loggers to collect data such as temperature, light intensity and soil pH then link this with the animals and plants found in different places. Map the distribution of plant species at different distances from a pond/tree.	Explain how the distribution of organisms within a habitat is affected by the presence of other living organisms as well as physical factors.
Compare a cultivated area with an uncultivated area.	Define biodiversity as the variety of different species living in a habitat. Identify native woodlands and lakes as natural ecosystems and forestry plantations and fish farms as artificial ecosystems.

Module B4: It's A Green World

Item B4a: Ecology in the local environment

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Use data from collecting/counting methods to calculate an estimate of the population size based on: • scaling up from a small sample area • the use of capture-recapture data, given the formula: population size = $\frac{\text{number in 1st sample} \times \text{number in 2nd sample}}{\text{number in 2nd sample previously marked}}$	Explain the effect of sample size on the accuracy of an estimate of population size. Explain the need to make certain assumptions when using capture-recapture data, to include: • no death, immigration or emigration • identical sampling methods • marking not affecting survival rate.
Explain the differences between: • ecosystem and habitat • community and population. Describe how to map the distribution of organisms in a habitat using a transect line. Interpret data from kite diagrams showing the distribution of organisms.	Explain what it means for an ecosystem to be described as self supporting in all factors other than an energy source. Describe zonation as a gradual change in the distribution of species across a habitat. Explain how a gradual change of an abiotic factor can result in the zonation of organisms in a habitat.
Compare the biodiversity of natural ecosystems and artificial ecosystems to include: • native woodlands and lakes with forestry plantations and fish farms.	Explain reasons for the differences between the biodiversity of native woodlands and lakes compared with forestry plantations and fish farms.

Module B4: It's A Green World

Item B4b: Photosynthesis

Summary: Virtually everything we eat can be traced back to plants. Either we eat food from plants or we eat food from animals, that in turn have eaten plants. This item looks at how plants make food in the first place and what they do with it.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Test leaves for starch: variegated and non-variegated leaves and leaves deprived of light or carbon dioxide. Investigate the release of oxygen by pondweed.	Recall and use the word equation for photosynthesis: $$\text{carbon dioxide} + \text{water} \xrightarrow[\text{(chlorophyll)}]{\text{(light energy)}} \text{glucose} + \text{oxygen}$$ Understand that oxygen is a waste product in this reaction.
Draw a poster to show what happens to the glucose made in photosynthesis.	Recall that the glucose made in photosynthesis is transported as soluble sugars but is stored as insoluble starch. Recall that glucose and starch can be converted to other substances in plants to be used for energy, growth and storage products.
Investigate the effect of changing light intensity, temperature or carbon dioxide concentration on the rate of photosynthesis by measuring the rate of oxygen released from pondweed. Research how commercial glasshouses maximise the growth of crops by maximising the rate of photosynthesis.	Explain why plants grow faster in the summer because of more: • light • warmth.
	Understand that plants carry out respiration as well as photosynthesis.

Module B4: It's A Green World

Item B4b: Photosynthesis

Links to other items: B3c: Respiration, B4c: Leaves and photosynthesis, B4d: Diffusion and osmosis, B4e: Transport in plants

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Recall and use the balanced symbol equation for photosynthesis: $6CO_2 + 6H_2O \xrightarrow[\text{(chlorophyll)}]{\text{(light energy)}} C_6H_{12}O_6 + 6O_2$ Describe the development of the understanding of the process of photosynthesis, to include: • the view of Greek scientists that plants gained mass only by taking in minerals from the soil • Van Helmont's experimental conclusion that plant growth cannot be solely due to nutrients from the soil • Priestley's experiment which showed that oxygen is produced by plants.	Explain how experiments using isotopes have increased our understanding of photosynthesis, to include: that oxygen produced by photosynthesis comes from the water and not the carbon dioxide. Describe photosynthesis as a two stage process: • light energy is used to split water, releasing oxygen gas and hydrogen ions • carbon dioxide gas combines with the hydrogen to make glucose.
Describe the conversion of glucose and starch to other substances in plants and their use: • glucose for energy (respiration) • cellulose for cell walls • proteins for growth and repair • starch, fats and oils for storage.	Explain why insoluble substances such as starch are used for storage: • does not move away in solution from storage areas • does not affect water concentration inside cells.
Describe how photosynthesis can be increased by providing: • more carbon dioxide • more light • higher temperature.	Explain the effects of limiting factors on the rate of photosynthesis: • CO_2 • light • temperature.
Explain why plants carry out respiration all the time.	Explain why plants take in carbon dioxide and give out oxygen during the day and do the reverse at night, in terms of both photosynthesis and respiration.

Module B4: It's A Green World

Item B4c: Leaves and photosynthesis

Summary: To most teenagers, plants are there to be eaten and sometimes admired for their colourful flowers. This item seeks to consolidate understanding of how green plants work. Preparing and examining slides of leaves provides the opportunity to work accurately and safely and present information using scientific and mathematical conventions.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Examine a variety of leaves to look at common features. Design the 'ideal' leaf. Make leaf prints and examine stomata under a microscope. Examine prepared microscope slides showing the internal structure of leaves. Use ICT to examine leaves www.plantscienceimages.org.uk.	Understand why chloroplasts are not found in all plant cells. Recall that chlorophyll pigments in chloroplasts absorb light energy for photosynthesis. Recall the entry points of materials required for photosynthesis: • water through root hairs • carbon dioxide through stomata. Recall the exit point of materials produced in photosynthesis: • oxygen through stomata. Understand that broader leaves enable more sunlight to be absorbed.

Module B4: It's A Green World

Item B4c: Leaves and photosynthesis

Links to other items: B4b: Photosynthesis, B4d: Diffusion and osmosis

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Name and locate the parts of a leaf: • cuticle • upper and lower epidermis • palisade and spongy mesophyll layers • stomata and guard cells • vascular bundle. Explain how leaves are adapted for efficient photosynthesis: • broad, so large surface area • thin, so short distance for gases to diffuse • contain chlorophyll and other pigments to absorb light from different parts of the spectrum • have a network of vascular bundles for support and transport • guard cells which open and close the stomata.	Explain how the cellular structure of a leaf is adapted for efficient photosynthesis: • epidermis is transparent • palisade layer at the top containing most of the chloroplasts • air spaces in the spongy mesophyll allow diffusion between stomata and photosynthesising cells • internal surface area to volume ratio very large. Interpret data on the absorption of light by photosynthetic pigments (chlorophyll a and b, carotene and xanthophyll) to explain how plants maximise the use of energy from the Sun.

Module B4: It's A Green World

Item B4d: Diffusion and osmosis

Summary: The materials used in, and produced by, life processes, move through living organisms in several ways, one of the most important of these being diffusion. One such material is water which is needed for key life processes such as photosynthesis, support and transport of materials. Water enters plants by a type of diffusion called osmosis.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Demonstrate diffusion e.g. spread of perfume across a room, potassium permanganate in water. Investigate the rate of diffusion of food dye through agar jelly.	Recall that substances move in and out of cells by diffusion through the cell membrane. Describe diffusion as the movement of a substance from a region of high to low concentration.
Carry out experiments to demonstrate osmosis using visking tubing and solutions of various concentrations.	Recognise that water moves in and out of plant cells by osmosis through the cell membrane.
Investigate the effects of changing solute concentration on potato discs/strips.	Recall that the plant cell wall provides support. Understand that lack of water can cause plants to droop (wilt).
Make leaf prints of upper and lower surfaces of leaves and examine with a microscope to investigate number/distribution of stomata.	Describe how carbon dioxide and oxygen diffuse in and out of plants through the leaves.
	Recall that water moves in and out of animal cells through the cell membrane.

Module B4: It's A Green World

Item B4d: Diffusion and osmosis

Links to other items: B3d: Cell division, B3e: The circulatory system, B4c: Leaves and photosynthesis

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain the net movement of particles by diffusion from an area of high concentration to an area of low concentration, as a consequence of the random movement of individual particles. Describe how molecules enter and leave cells by diffusion through the cell membrane.	Explain how the rate of diffusion is increased by: • a shorter distance • a greater concentration difference (gradient) • a greater surface area.
Describe osmosis as the movement of water across a partially-permeable membrane from an area of high water concentration (i.e. dilute solution) to an area of low water concentration (i.e. concentrated solution). Recall that osmosis is a type of diffusion. Explain the term partially-permeable.	Explain the net movement of water molecules by osmosis from an area of high water concentration to an area of low water concentration across a partially-permeable membrane, as a consequence of the random movement of individual particles. Predict the direction of water movement in osmosis.
Explain how plants are supported by the turgor pressure within cells: • water pressure acting against inelastic cell wall. Explain wilting in terms of a lack of turgor pressure.	Explain the terms: flaccid, plasmolysed and turgid.
Explain how leaves are adapted to increase the rate of diffusion of carbon dioxide and oxygen.	
Describe the effects of the uptake and loss of water on animal cells.	Explain why there are differences in the effects of water uptake and loss on plant and animal cells. Use the terms: crenation and lysis.

Module B4: It's A Green World

Item B4e: Transport in plants

Summary: The materials used in, and produced by, life processes in plants, move through plants in several ways. The suggested activities each provide the opportunity to plan a test of a scientific idea, analyse and interpret data using qualitative techniques, present information and draw a conclusion using scientific and technical conventions. Investigating factors affecting transpiration rate can include the use of ICT in teaching and learning and illustrates the use of models in explaining scientific phenomena.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Examine stained tissues of some species of plants.	
Carry out experiments to estimate transpiration: • loss of water by plants • plants lose water through their leaves • which surface of a leaf loses most water • weighing potted plants – loss of mass.	Describe how water travels through a plant: • absorption from soil through root hairs • transport through the plant, up the stem to the leaves • evaporation from the leaves (transpiration).
Carry out an experiment to show factors that affect transpiration rate: • light • wind • temperature • humidity. ICT data logging opportunity.	Describe experiments to show that transpiration rate is affected by: • light intensity • temperature • air movement • humidity.
Investigate how quickly detached leaves dry out when different surfaces are covered with petroleum jelly.	Understand that healthy plants must balance water loss with water uptake.

Module B4: It's A Green World

Item B4e: Transport in plants

Links to other items: B4b: Photosynthesis, B4d: Diffusion and osmosis

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe the arrangement of xylem and phloem in a dicotyledonous root, stem and leaf, to include vascular bundles. Relate xylem and phloem to their function: • xylem – transpiration – movement of water and minerals from the roots to the shoot and leaves • phloem – translocation – movement of food substances (sugars) up and down stems to growing and storage tissues. Understand that both xylem and phloem form continuous systems in leaves, stems and roots.	Describe the structure of xylem and phloem: • xylem vessels – thick strengthened cellulose cell wall with a hollow lumen (dead cells) • phloem – columns of living cells.
Recall transpiration as the evaporation and diffusion of water from inside leaves. Describe how transpiration causes waters to be moved up xylem vessels.	Explain how transpiration and water loss from leaves are a consequence of the way in which leaves are adapted for efficient photosynthesis.
Describe the effect on transpiration rate of: • increase in light intensity • increase in temperature • increase in air movement • decrease in humidity. Interpret data from experiments on transpiration rate.	Explain why transpiration rate is increased by: • increase in light intensity • increase in temperature • increase in air movement • decrease in humidity.
Explain how root hairs increase the ability of roots to take up water by osmosis. Recall that transpiration provides plants with water for: • cooling • photosynthesis • support • movement of minerals. Explain how the structure of a leaf is adapted to reduce excessive water loss: • waxy cuticle • small number of stomata on upper surface.	Explain how the cellular structure of a leaf is adapted to reduce water loss: • changes in guard cell turgidity (due to light intensity and availability of water) to regulate stomatal apertures • number, distribution, position and size of stomata.

Module B4: It's A Green World

Item B4f: Plants need minerals

Summary: Candidates should appreciate that a balanced diet contains minerals and vitamins. The actual amounts needed are small but without them our health will suffer. Plants also need minerals and without them their growth will suffer. The survey of the contents of 'plant foods' provides the opportunity to use ICT sources and tools to collect secondary data.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Survey the contents of fertilisers such as 'plant foods'. Practicals available from SAPS (How Science Works practical activities).	Recall that fertilisers contain minerals such as nitrates, phosphates, potassium and magnesium compounds and that these are needed for plant growth. Interpret data on NPK values to show the relative proportions of nitrates, phosphates and potassium in fertilisers.
Carry out an experiment to show the results of mineral deficiencies in plants. Investigate the contents and manufacture of organic and synthetic fertilisers.	Describe experiments to show the effects on plants of mineral deficiencies: • soil-less culture • each trial missing one mineral.
	Describe how minerals are absorbed, to include: • dissolved in solution • by the root hairs • from the soil.

Module B4: It's A Green World

Item B4f: Plants need minerals

Links to other items: B4g: Decay, B4h: Farming

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain why plants require: • nitrates: for proteins which are needed for cell growth • phosphates: for respiration and growth • potassium compounds: for respiration and photosynthesis • magnesium compounds: for photosynthesis.	Describe how elements obtained from soil minerals are used in the production of compounds in plants, limited to: • nitrogen to make amino acids • phosphorus to make DNA and cell membranes • potassium to help enzymes (in photosynthesis and respiration) • magnesium to make chlorophyll.
Relate mineral deficiencies to the resulting poor plant growth: • nitrate – poor growth and yellow leaves • phosphate – poor root growth and discoloured leaves • potassium – poor flower and fruit growth and discoloured leaves • magnesium – yellow leaves.	
Recall that minerals are usually present in soil in quite low concentrations.	Explain how minerals are taken up into root hair cells by active transport. Understand that active transport can move substances from low concentrations to high concentrations (against the concentration gradient), across a cell membrane, using energy and respiration.

Module B4: It's A Green World

Item B4g: Decay

Summary: We try to prevent food going off (decaying) but we want decay to happen when sewage is treated or when compost is made. This item is concerned with the process of decay and some examples. The experiments on decay provide the opportunity to plan a test of a scientific idea, analyse and interpret data using qualitative and quantitative techniques, present information and draw a conclusion using scientific and technical conventions. The survey of preservation techniques provides the opportunity to use ICT sources and tools to collect secondary data.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Examine results (e.g. photographs) of long term decay of compost.	Recall the key factors in the process of decay: • presence of microorganisms • temperature • oxygen • moisture. Explain why decay is important for plant growth.
Carry out an experiment to show decay e.g. bread or fruit. Investigate the effect of temperature on decay.	Describe how to carry out an experiment to show that decay is caused by the decomposers bacteria and fungi.
Make a compost column. Visit a sewage works.	Recall that microorganisms are used to: • break down human waste (sewage) • break down plant waste (compost).
Survey different food preservation methods and explain how each works. Investigate different food preservation methods.	Recognise that food preservation techniques reduce the rate of decay: • canning • cooling • freezing • drying • adding salt/sugar • adding vinegar.

Module B4: It's A Green World

Item B4g: Decay

Links to other items: B3c: Respiration, B4f: Plants need minerals, B4h: Farming

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe the effects on the rate of decay of changing: • temperature • amount of oxygen • amount of water.	Explain why changing temperature, and the amounts of oxygen and water, affect the rate of decay in terms of the: • effect on microbial respiration • effect on growth and reproduction of microorganisms.
Recall that detritivores, including earthworms, maggots and woodlice, feed on dead and decaying material (detritus). Explain how detritivores increase the rate of decay by producing a larger surface area.	Explain the term saprophyte. Explain how saprophytic fungi digest dead material, in terms of extracellular digestion.
Explain how food preservation methods reduce the rate of decay.	

Module B4: It's A Green World

Item B4h: Farming

Summary: Organic farming has become more widespread but intensive farming techniques are more common. This item looks at the issues concerning sustainable food production. Discussing different farming methods provides many opportunities to investigate why decisions about science and technology are made and the ethical issues raised. This can be developed to look at the social, economic and environmental effects of such decisions.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Arrange a visit to a local farm/garden centre/small holding.	Analyse data to show that farmers can produce more food if they use pesticides and understand that these practices can cause harm to the environment and to health. Recall that pesticides kill pests which are any organisms that damage crops. Recall that examples of pesticides include: • insecticides to kill insects • fungicides to kill fungi • herbicides to kill plants (weeds).
Role-play exercise to highlight different view points on intensive farming.	Recall that intensive farming means trying to produce as much food as possible from the land, plants and animals available. Describe how intensive farming methods can increase productivity methods limited to: • fish farming • glasshouses • hydroponics • battery farming.
Survey use of organic food and reasons for choice. Grow lettuce/tomato plants using hydroponics. Investigate websites such as DEFRA, LEAF.	Describe organic farming methods: • no artificial fertilisers • no pesticides.
	Describe how pests can be controlled biologically by introducing predators.

Module B4: It's A Green World

Item B4h: Farming

Links to other items: B4a: Ecology in the local environment, B4f: Plants need minerals, B4g: Decay

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain the disadvantages of using pesticides: • pesticides may enter and accumulate in food chains • pesticides may harm organisms which are not pests • some pesticides are persistent.	
Describe how plants can be grown without soil (hydroponics). Describe possible uses of hydroponics, to include: • glasshouse tomatoes • plant growth in areas of barren soil. Understand that intensive farming methods may be efficient but they raise ethical dilemmas.	Explain the advantages and disadvantages of hydroponics: • better control of mineral levels and disease • lack of support for plant • required addition of fertilisers. Explain how intensive food production improves the efficiency of energy transfer by reducing energy transfer: • to pests, including competing plants (weeds) • as heat from farm animals by keeping them penned indoors (battery farming) so that they are warm and move around less.
Describe organic farming techniques: • use of animal manure and compost • crop rotation including use of nitrogen-fixing crops • weeding • varying seed planting times. Explain the advantages and disadvantages of organic farming techniques.	
Explain the advantages and disadvantages of biological control, to include: • advantages: no need for chemical pesticides, does not need repeated treatment • disadvantages: predator may not eat pest, may eat useful species, may increase out of control, may not stay in the area where it is needed. In the context of biological control, explain how removing one or more organisms from a food chain or web may affect other organisms.	

3.8 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 C3 to C4.

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 items: C3 to C4

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: 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

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: C4b: Ionic bonding, C4d: The Group 1 elements, C4h: Purifying and testing water

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: C4b: Ionic bonding, C4g: Metal structure and properties

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 the 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: 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: C4e: The Group 7 elements

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.

3.9 Module P4: Radiation For Life

Module P4: Radiation For Life

Item P4a: Sparks

Summary: The concept of medical physics runs through this item. Electrostatics plays an important part in our lives. We investigate some of the ideas of electrostatics and look at the problems caused.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Carry out experiments to compare how effective different types of duster are.	Recognise that when some materials are rubbed they attract other objects: • certain types of dusting brushes become charged and attract dust as they pass over it.
Investigate the effect of charged insulators on small uncharged objects. Carry out experiments to demonstrate the forces between charges.	Recognise that insulating materials can become charged when rubbed with another insulating material. State that there are two kinds of charge: • positive • negative.
Carry out experiments to create static charges, and investigate the effects that result.	Describe how you can get an electrostatic shock from charged objects: • synthetic clothing. Describe how you can get an electrostatic shock if you become charged and then become earthed: • touching water pipes after walking on a floor covered with an insulating material e.g. synthetic carpet.

Module P4: Radiation For Life

Item P4a: Sparks

Links to other items: P4b: Uses of electrostatics

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Recognise that like charges repel and unlike charges attract. Understand that electrostatic phenomena are caused by the transfer of electrons, which have a negative charge.	Describe static electricity in terms of the movement of electrons: • a positive charge due to lack of electrons • a negative charge due to an excess of electrons. Recognise that atoms or molecules that have become charged are ions.
Explain how static electricity can be dangerous when: • in atmospheres where explosions could occur e.g. inflammable gases or vapours or with high concentrations of oxygen • in situations where large quantities of charge could flow through the body to earth. Explain how static electricity can be a nuisance: • dirt and dust attracted to insulators (plastic containers, TV monitors etc) • causing clothing to “cling”.	Explain how the chance of receiving an electric shock can be reduced by: • correct earthing • use of insulating mats • using shoes with insulating soles • bonding fuel tanker to aircraft. Explain how anti-static sprays, liquids and cloths help reduce the problems of static electricity.

Module P4: Radiation For Life

Item P4b: Uses of electrostatics

Summary: Electrostatics has many uses. This item looks at some of the uses both in medicine and everyday life and illustrates the use of contemporary scientific and technological developments and their benefits, drawbacks and risks.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Research how electrostatic precipitators work and how effective they are at reducing some pollution.	Recall that electrostatics can be useful for electrostatic precipitators: • remove the dust or soot in smoke • used in chimneys.
	Recall that electrostatics can be useful for spraying: • spray painting • crop spraying.
Research how defibrillators are used by medical staff in emergencies.	Recall that electrostatics can be useful for restarting the heart when it has stopped (defibrillator). Recall that defibrillators work by discharging charge.

Module P4: Radiation For Life

Item P4b: Uses of electrostatics

Links to other items: P4a: Sparks

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain how static electricity can be useful for electrostatic dust precipitators to remove smoke particles etc. from chimneys: • dust passes through charged metal grid or past charged rods • dust particles become charged • plates are earthed or charged opposite to grid • dust particles attracted to plates • plates struck and dust falls to collector.	Explain how static electricity is used in electrostatic dust precipitators to remove smoke particles etc from chimneys: • high voltage metal grids put into chimneys to produce a charge on the dust • dust particles gain or lose electrons • dust particles induce a charge on the earthed metal plate • dust particles are attracted to the plates.
Explain how static electricity can be useful for paint spraying: • spray gun charged • paint particles charged the same so repel giving a fine spray and coat • object charged oppositely to paint so attracts paint into the 'shadows' of the object giving an even coat with less waste.	Explain how static electricity is used in paint spraying, in terms of paint and car gaining and losing electrons and the resulting effects.
Explain how static electricity can be useful for restarting the heart when it has stopped (defibrillator): • paddles charged • good electrical contact with patient's chest • charge passed through patient to make heart contract • care taken not to shock operator.	

Module P4: Radiation For Life

Item P4c: Safe electricals

Summary: This item investigates electricity. Safety is a major requirement when electricity is used in a medical situation. Here the principles of fuses and earthing are studied.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Carry out experiments to investigate circuits and the effects of resistors and variable resistors on current. Also the effects of length and thicknesses of resistance wire on current and resistance can be investigated.	Explain the behaviour of simple circuits in terms of the flow of electric charge. Describe and recognise how resistors can be used to change the current in a circuit. Describe how variable resistors can be used to change the current in a circuit: • longer wires give less current • thinner wires give less current (rheostat configured as a variable resistor only). Recall that resistance is measured in ohms.
Research house wiring features such as plugs and ring mains.	Recall the colour coding for live, neutral and earth wires: • live – brown • neutral – blue • earth – green/yellow. State that an earthed conductor cannot become live.
Investigate fuses and residual-current devices (RCDs) and research how they are used in the home. Compare a range of appliances to identify which are double insulated and what they have in common. Research and compare power and fuse ratings in common household appliances. A circus of appliances with plugs open and comparison of appliance coverings.	Describe reasons for the use of fuses and circuit breakers (as re-settable fuses). Recognise that "double insulated" appliances do not need earthing.

Module P4: Radiation For Life

Item P4c: Safe electricals

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain how variable resistors can be used to change the current in a circuit: • longer wires have more resistance • thinner wires have more resistance (rheostat configured as a variable resistor only). Describe the relationships between current, voltage (pd) and resistance: • for a given resistor, current increases as voltage increases and vice versa • for a fixed voltage, current decreases as resistance increases and vice versa. Use the equation: $\text{resistance} = \dfrac{\text{voltage}}{\text{current}}$	Use and apply the equation, including a change of subject: $\text{resistance} = \dfrac{\text{voltage}}{\text{current}}$
Describe the functions of the live, neutral and earth wires: • live – carries the high voltage • neutral – completes the circuit • earth – a safety wire to stop the appliance becoming live.	
Explain how a wire fuse reduces the risk of fire; if the appliance develops a fault: • too large a current causes the fuse to melt • preventing flow of current • prevents flex overheating and causing fire • prevents further damage to appliance. Use the equation: power = voltage × current Explain why “double insulated” appliances do not need earthing: • the appliance is a non-conductor and cannot become live.	Explain the reasons for the use of fuses and circuit breakers as re-settable fuses (structure and mode of operation not required). Explain how the combination of a wire fuse and earthing protects people. Use the equation, including a change of subject: power = voltage × current to select a suitable fuse for an appliance.

Module P4: Radiation For Life

Item P4d: Ultrasound

Summary: The concept of medical physics runs through this item. Ultrasound is an important medical diagnostic and therapeutic tool. This item looks at the properties of longitudinal waves, and investigates some of the medical uses of ultrasound.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Look at ultrasound pictures and investigate the hearing range of pupils in the class. Investigate the properties of longitudinal waves. Use a slinky and/or rope to demonstrate wave behaviours.	Recall that ultrasound is a longitudinal wave. Recognise features of a longitudinal wave: • wavelength • compression • rarefaction.
Use echoes from hard surfaces to develop the idea of reflection of sound, and calculation of distance to the surface (using the echo time and speed of sound).	Recognise that ultrasound can be used in medicine for diagnostic purposes: • to look inside people by scanning the body • to measure the speed of blood flow in the body (candidates are not expected to describe the Doppler effect).

Module P4: Radiation For Life

Item P4d: Ultrasound

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe features of longitudinal waves: • wavelength • frequency • compression (a region of higher pressure) • rarefaction (a region of lower pressure). Recall that the frequency of ultrasound is higher than the upper threshold of human hearing (20 000 Hz) because the ear cannot detect these very high frequencies.	Describe and compare the motion and arrangement of particles in longitudinal and transverse physical waves: • wavelength • frequency • compression • rarefaction • amplitude.
Recognise that ultrasound can be used in medicine for non-invasive therapeutic purposes such as to break down kidney and other stones.	Explain how ultrasound is used in: • body scans (reflections from different layers returning at different times from different depths) • breaking down accumulations in the body such as kidney stones. Explain the reasons for using ultrasound rather than X-rays for certain scans: • able to produce images of soft tissue • does not damage living cells.

Module P4: Radiation For Life

Item P4e: What is radioactivity?

Summary: Nuclear radiation is often misunderstood and frightening. Many people will come across nuclear radiations in everyday life. This item explores the properties and uses of nuclear radiation.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Investigate the reality of long half-lives and the dangers of nuclear waste. Explore the idea of half-life and how it is used to date artefacts in archaeology and rocks containing radioactive minerals. Model radioactive decay with dice or computer simulations.	Recognise that the radioactivity or activity of an object is measured by the number of nuclear decays emitted per second. Understand that radioactivity decreases with time. Recall that nuclear radiation ionises materials.
Use the Periodic Table to construct a graph of proton number against neutron number to show line of stability.	Recall that radiation comes from the nucleus of the atom.

Module P4: Radiation For Life

Item P4e: What is radioactivity?

Links to other items: P4f: Uses of radioisotopes, P4g: Treatment, P4h: Fission and fusion

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe radioactive substances as decaying naturally and giving out nuclear radiation in the form of alpha, beta and gamma. Explain and use the concept of half-life. Interpret graphical data of radioactive decay to include a qualitative description of half-life. Explain ionisation in terms of: • removal of electrons from particles • gain of electrons by particles.	Interpret graphical or numerical data of radioactive decay to include calculation of half-life. Explain why alpha particles are such good ionisers.
Describe radioactivity as coming from the nucleus of an atom that is unstable. Recall that an alpha particle is a helium nucleus. Recall that a beta particle is a fast moving electron.	Describe what happens to a nucleus when an alpha particle is emitted: • mass number decreases by 4 • nucleus has two fewer neutrons • nucleus has two fewer protons • atomic number decreases by 2 • new element formed. Describe what happens to a nucleus when a beta particle is emitted: • mass number is unchanged • nucleus has one less neutron • nucleus has one more proton • atomic number increases by one • new element formed. Construct and balance nuclear equations in terms of mass numbers and atomic numbers to represent alpha and beta decay.

Module P4: Radiation For Life

Item P4f: Uses of radioisotopes

Summary: The uses of radioisotopes include tracers, smoke alarms, cancer treatment and radioactive dating. This item illustrates the use of contemporary scientific and technological developments and their benefits, drawback and risks. It also provides the opportunity to use ICT in teaching and learning, while work on dating rocks, illustrates how ICT is used by scientists.

Suggested practical and research activities to select from	**Assessable learning outcomes Foundation Tier only: low demand**
Research and debate the issues surrounding the storage and disposal of radioactive waste. Use the internet to research levels of background radiation in different parts of the UK. Investigate the variation of background radiation with location and possible health risks.	Understand why background radiation can vary. Recall that background radiation mainly comes from rocks and cosmic rays.
Research the use of radioisotopes in industry.	Recall industrial examples of the use of tracers: • to track dispersal of waste • to find leaks/blockages in underground pipes • to find the route of underground pipes.
Look inside ionisation based smoke detectors and identify the relevant parts.	Recall that alpha sources are used in some smoke detectors.
	Recall that radioactivity can be used to date rocks.

Module P4: Radiation For Life

Item P4f: Uses of radioisotopes

Links to other items: P4e: What is radioactivity?, P4h: Fission and fusion

Assessable learning outcomes both tiers: standard demand	**Assessable learning outcomes Higher Tier only: high demand**
Recall that some background radiation comes from waste products and man-made sources e.g. waste from: • industry • hospitals.	Evaluate the relative significance of sources of background radiation.
Describe how tracers are used in industry: • radioactive material put into pipe • progress tracked with detector above ground/ outside pipe • leak/blockage shown by reduction/no radioactivity after the point of blockage.	Explain why gamma radiation is used as an industrial tracer.
Explain how a smoke detector with an alpha source works: • smoke particles hit by alpha radiation • less ionisation of air particles • current is reduced causing alarm to sound.	
Explain how the radioactive dating of rocks depends on the calculation of the uranium/lead ratio. Recall that measurements from radioactive carbon can be used to find the date of old materials.	Explain how measurements of the activity of radioactive carbon can lead to an approximate age for different materials: • the amount of Carbon-14 in the air has not changed for thousands of years • when an object dies (e.g. wood) gaseous exchange with the air stops • as the Carbon-14 in the wood decays the activity of the sample decreases • the ratio of current activity from living matter to the activity of the sample is used to calculate the age within known limits.

Module P4: Radiation For Life

Item P4g: Treatment

Summary: The concept of medical physics runs through this item. Radiations are important medicinal tools. This item looks at the use of radiations and the precautions taken to reduce the potential risks.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Look at X-ray images and research how they are produced.	Describe some similarities and differences between X-rays and gamma rays: • both are ionising electromagnetic waves • have similar wavelengths • are produced in different ways.
Research the production of medical radioisotopes.	Recall that medical radioisotopes are produced by placing materials into a nuclear reactor.
Demonstrate and model the tracer idea with a radioactive source (low level sample (e.g. rock) only) hidden in school skeleton and detected outside. Investigate the balance of risks for staff and patients during radiotherapy which kills both healthy and cancerous cells.	Describe uses of nuclear radiation in medicine, to include: • diagnosis • treatment of cancer using gamma rays • sterilisation of equipment. Recall that only beta and gamma radiation can pass through skin. Recall that nuclear radiation can damage cells. Describe the role of a radiographer and the safety precautions they must take.

Module P4: Radiation For Life

Item P4g: Treatment

Links to other items: P4e: What is radioactivity?

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Recall that materials absorb some ionising radiation. Understand how the image produced by the absorption of X-rays depends on the thickness and density of the absorbing materials.	Explain how: • gamma rays are given out: from the nucleus of certain radioactive materials • X-rays are made: by firing high speed electrons at metal targets • X-rays are easier to control than gamma rays.
Describe how materials can become radioactive as a result of absorbing extra neutrons.	
Explain why gamma (and sometimes beta) emitters can be used as tracers in the body. Understand why medical tracers should not remain active in the body for long periods.	Explain how radioactive sources are used in medicine: 1. to treat cancer: • gamma rays focused on tumour • wide beam used • rotated round the patient with tumour at centre • limiting damage to non-cancerous tissue. 2. as a tracer: • beta or gamma emitter with a short half-life • drunk/eaten/ingested/injected into the body • allowed to spread through the body • followed on the outside by a radiation detector.

Module P4: Radiation For Life

Item P4h: Fission and fusion

Summary: This item deals with work on the processes of nuclear fission and fusion. Nuclear fission is a major source of energy and can be used to produce electricity. Oil and gas will become less important as supplies decrease and alternative forms of energy will be needed. This item explains the process of nuclear fission and how the energy produced can be harnessed to produce electricity. The prospect of harnessing nuclear fusion for power generation is also considered.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Use ICT simulations of chain reactions and nuclear reactors.	Recognise that nuclear power stations use uranium as a fuel. Describe the main stages in the production of electricity: • source of energy • used to produce steam • used to produce electricity.
Research nuclear accidents in power plants. Debate the issues surrounding nuclear power as a solution to future UK needs.	Describe the process that gives out energy in a nuclear reactor as nuclear fission, and that it is kept under control. Recall that nuclear fission produces radioactive waste.
Investigate potential benefits and difficulties of developing fusion based nuclear reactors.	Describe the difference between fission and fusion: • fission is the splitting of nuclei • fusion is the joining of nuclei.
Investigate ‘cold fusion’ controversy (*Fleischmann–Pons claims*) as an example of the development of theories and the peer review process.	Recall that one group of scientists have claimed to successfully achieve ‘cold fusion’. Explain why the claims are disputed: other scientists could not repeat their findings.

Module P4: Radiation For Life

Item P4h: Fission and fusion

Links to other items: P4e: What is radioactivity?, P4f: Uses of radioisotopes

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe how domestic electricity is generated at a nuclear power station: • nuclear reaction • producing heat • heating water to produce steam • spinning a turbine • driving a generator.	Describe what happens to allow uranium to release energy: • uranium nucleus hit by neutron • causes nucleus to split • energy released • more neutrons released.
Understand how the decay of uranium starts a chain reaction. Describe a nuclear bomb as a chain reaction that has gone out of control.	Explain what is meant by a chain reaction: • when each uranium nucleus splits more than one neutron is given out • these neutrons can cause further uranium nuclei to split. Explain how scientists stop nuclear reactions going out of control: • rods placed in the reactor • to absorb some of the neutrons • allowing enough neutrons to remain to keep the process operating.
Describe how nuclear fusion releases energy: • fusion happens when two nuclei join together • fusion produces large amounts of heat energy • fusion happens at extremely high temperatures. Describe why fusion for power generation is difficult: • requires extremely high temperatures • high temperatures have to be safely managed. Understand why fusion power research is carried out as an international joint venture.	Explain how different isotopes of hydrogen can undergo fusion to form helium. $^{1}_{1}H + ^{2}_{1}H \rightarrow ^{3}_{2}He$ Understand the conditions needed for fusion to take place, to include: • in stars, fusion happens under extremely high temperatures and pressures • fusion bombs are started with a fission reaction which creates exceptionally high temperatures • for power generation exceptionally high temperatures and/or pressures are required and this combination offers (to date) safety and practical challenges.
Explain why the ‘cold fusion’ experiments and data have been shared between scientists.	Explain why ‘cold fusion’ is still not accepted as a realistic method of energy production.

4 Assessment of GCSE Additional Science B

4.1 Overview of the assessment in GCSE Additional Science B

To claim the qualification GCSE Additional Science B (J262) candidates will need to complete all three units B721, B722 and B723.

GCSE Additional Science B J262	
Unit B721: *Additional Science modules B3, C3, P3*	
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 B3, C3 and P3 • uses structured questions (candidates answer all questions) • assesses the quality of written communication.
Unit B722: *Additional Science modules B4, C4, P4*	
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 B4, C4 and P4 • 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 B723: *Additional Science 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 B721 and B722, candidates are entered for an option in either the Foundation Tier or the Higher Tier. Unit B723 (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 B721/F and B722/H.

4.3 Assessment objectives (AOs)

Candidates are expected to demonstrate their ability to:

AO1	recall, select and communicate their knowledge and understanding of science
AO2	apply skills, knowledge and understanding of science 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 Additional Science 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 B721: *Additional Science modules B3, C3, P3*	16	17.5	1.5	35
Unit B722: *Additional Science modules B4, C4, P4*	16	17.5	6.5	40
Unit B723: *Additional Science 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 their limited knowledge and understanding of science. They have a limited understanding that scientific advances may have ethical implications, benefits and risks. They recognise simple inter-relationships between science 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 and technological skills, knowledge and understanding in practical and some other contexts. They show limited understanding of the nature of science and its applications. They can explain straightforward models of phenomena, events and processes. Using a limited range of skills and techniques, they answer scientific questions, solve straightforward problems and test ideas.

Candidates interpret and evaluate some qualitative and quantitative data and information from a limited 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 science. They demonstrate understanding of the nature of science, its laws, its applications and the influences of society on science and science on society. They understand how 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 and technological skills, knowledge and understanding in a range of practical and other contexts. They recognise, understand and use straightforward links between hypotheses, evidence, theories, and explanations. They use models to explain phenomena, events and processes. Using appropriate methods, sources of information and data, they apply their skills to answer 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 develop arguments with supporting explanations. They draw conclusions consistent with the available evidence.

4.5.3 Grade A

Candidates recall, select and communicate precise knowledge and detailed understanding of science and its applications, and of the effects and risks of scientific developments and its applications on society, industry, the economy and the environment. They demonstrate a clear understanding of why and how scientific applications, technologies and techniques change over time and the need for regulation and monitoring. They use terminology and conventions appropriately and consistently.

They apply appropriate skills, including communication, mathematical and technological skills, knowledge and understanding effectively to a wide range of practical contexts and to explain applications of science. They apply a comprehensive understanding of practical methods, processes and protocols to plan and justify a range of appropriate methods to solve practical problems. They apply appropriate skills, including mathematical, technical and observational skills, knowledge and understanding in a wide range of practical contexts They follow procedures and protocols consistently, evaluating and managing risk and working accurately and safely.

Candidates analyse and interpret critically a broad range of quantitative and qualitative information. They reflect on the limitations of the methods, procedures and protocols they have used and the data they have collected and evaluate information systematically to develop reports and findings. They make reasoned judgments consistent with the evidence to develop substantiated 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 Additional Science B

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 support can be found 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 six 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, six 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 B723

Assessment Task	Task Marks	Weighting
Additional Science 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 Additional Science 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 Additional Science 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 assessment tasks are marked by 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 8.4.1 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 Additional Science B unit B723 can be submitted electronically to the OCR Repository via Interchange: please check Section 8.4.1 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 Additional Science 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 Additional Science 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 Additional Science B specifications.

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.

Equality and Inclusion in GCSE Additional Science B

7.1 Equality Act information relating to GCSE Additional Science 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
Oral language modifiers	Yes	All assessments
BSL signers	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 Additional Science 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 Additional Science B (March 2011) available on the website.

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 Additional Science B certification is available in June 2014 and each June thereafter.

	Unit B721	Unit B722	Unit B723	Certification availability
June 2014	✓	✓	✓	✓
June 2015	✓	✓	✓	✓

8.2 Certification rules

For GCSE Additional Science 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 B721 and B722 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
B721F	01	Written Paper	*Additional Science modules B3, C3, P3* (Foundation Tier)
B721H	02	Written Paper	*Additional Science modules B3, C3, P3* (Higher Tier)
B722F	01	Written Paper	*Additional Science modules B4, C4, P4* (Foundation Tier)
B722H	02	Written Paper	*Additional Science modules B4, C4, P4* (Higher Tier)
B723A	01	Moderated via OCR Repository	Controlled assessment
B723B	02	Moderated via postal moderation	Controlled assessment
B723C	80	Carried forward	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 Additional Science B certification code J262.

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 QA1C.

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 Additional Science B

9.1 Overlap with other qualifications

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

This specification includes the content of Modules 3 and 4 of GCSE Biology B, GCSE Chemistry B and GCSE Physics 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 Science.* 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.	B3a: Explain why new discoveries, such as Watson and Crick's, are not accepted or rewarded immediately, to include the importance of other scientists repeating the work. C4h: Research the pollutants found in water. P4e: Research and debate the issues surrounding the irradiation of food.
Ethical issues The ethical implications of selected scientific issues.	B3f: Research about human stem cells. P4f: Research and debate the issues surrounding the storage and disposal of radioactive waste.
Economic issues The range of factors which have to be considered when weighing the costs and benefits of scientific activity.	B3g: Explain how selective breeding can contribute to improved agricultural yields. C3g: Recall the factors that affect the cost of making and developing a medicine or pharmaceutical drug.
Cultural issues Scientific explanations which give insight into the local and global environment.	B3a: Research the Human Genome Project. C4h: Explain why it is important to conserve water. P3e: Recall that bio-fuels and solar energy are possible alternatives to fossil fuels.

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 farming sustainably, managing waste, 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 car safety, safe use of electricity and radiations, 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
B721	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
B722	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
B723	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Detailed opportunities for generating Key Skills evidence through this specification are posted on the OCR website www.ocr.org.uk. A summary document for Key Skills Coordinators showing ways in which opportunities for Key Skills arise within GCSE courses has been published.

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 B723, 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

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

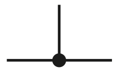
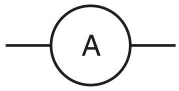
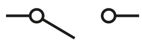
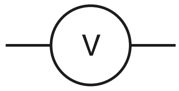
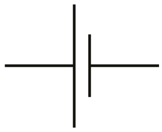
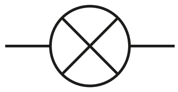
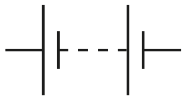
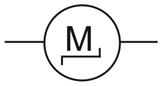
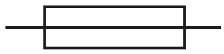
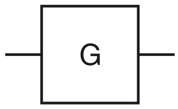
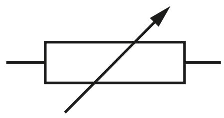
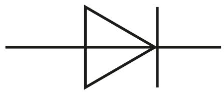
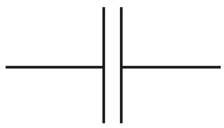
Where an employer has adopted these or other publications as the basis of their model risk assessments, an individual school or college then has to review them, to see if there is a need to modify or adapt them in some way to suit the particular conditions of the establishment.

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.

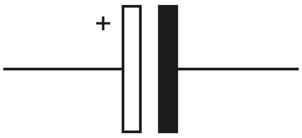
Where project work or individual investigations, sometimes linked to work-related activities, are included in specifications this may well lead to the use of novel procedures, chemicals or micro-organisms, which are not covered by the employer's model risk assessments. The employer should have given 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.

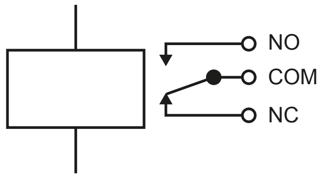
Appendix E: Electrical symbols

Junction of Conductors		Ammeter	
Switch		Voltmeter	
Primary or secondary cell		Indicator or light source	
Battery of cells		or	
Power supply		Motor	
Fuse		Generator	
Fixed resistor		Variable resistor	
Diode		Capacitor	

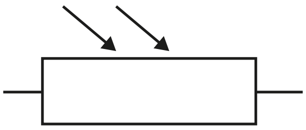
Electrolytic capacitor



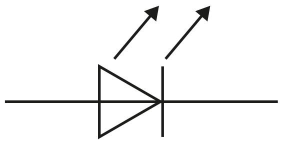
Relay



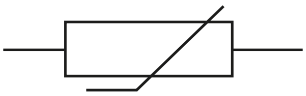
LDR



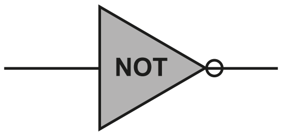
LED



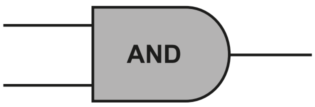
Thermistor



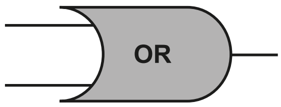
NOT gate



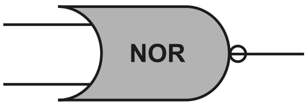
AND gate



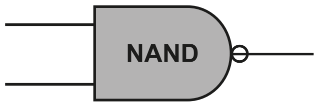
OR gate



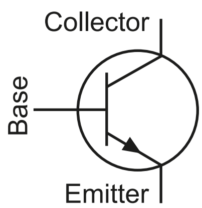
NOR gate



NAND gate



NPN transistor



Appendix F: 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.

YOUR CHECKLIST

OUR AIM IS TO PROVIDE YOU WITH ALL THE INFORMATION AND SUPPORT YOU NEED TO DELIVER OUR SPECIFICATIONS.

- ✓ Bookmark **www.ocr.org.uk/gcse2012**
- ✓ Be among the first to hear about support materials and resources as they become available. Register for email updates at **www.ocr.org.uk/updates**
- ✓ Find out about our training courses at **www.ocreventbooker.org.uk**
- ✓ Find out about controlled assessment support at **www.ocr.org.uk/gcse2012**
- ✓ Learn more about Active Results at **www.ocr.org.uk/activeresults**
- ✓ Join our social network community for teachers at **www.social.ocr.org.uk**

NEED MORE HELP?

Here's how to contact us for specialist advice

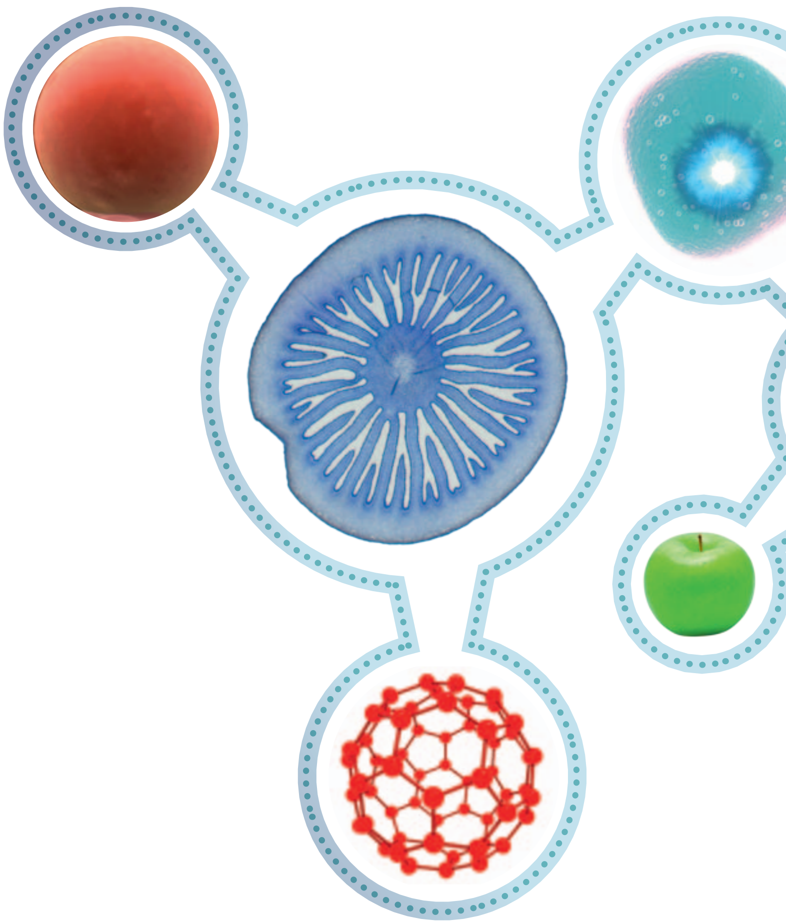
By phone: 01223 553998

By email: science@ocr.org.uk

By online: http://answers.ocr.org.uk

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

www.ocr.org.uk/gcse2012

J262/1205/OC607