Accredited

OCR

GATEWAY SCIENCE SUITE

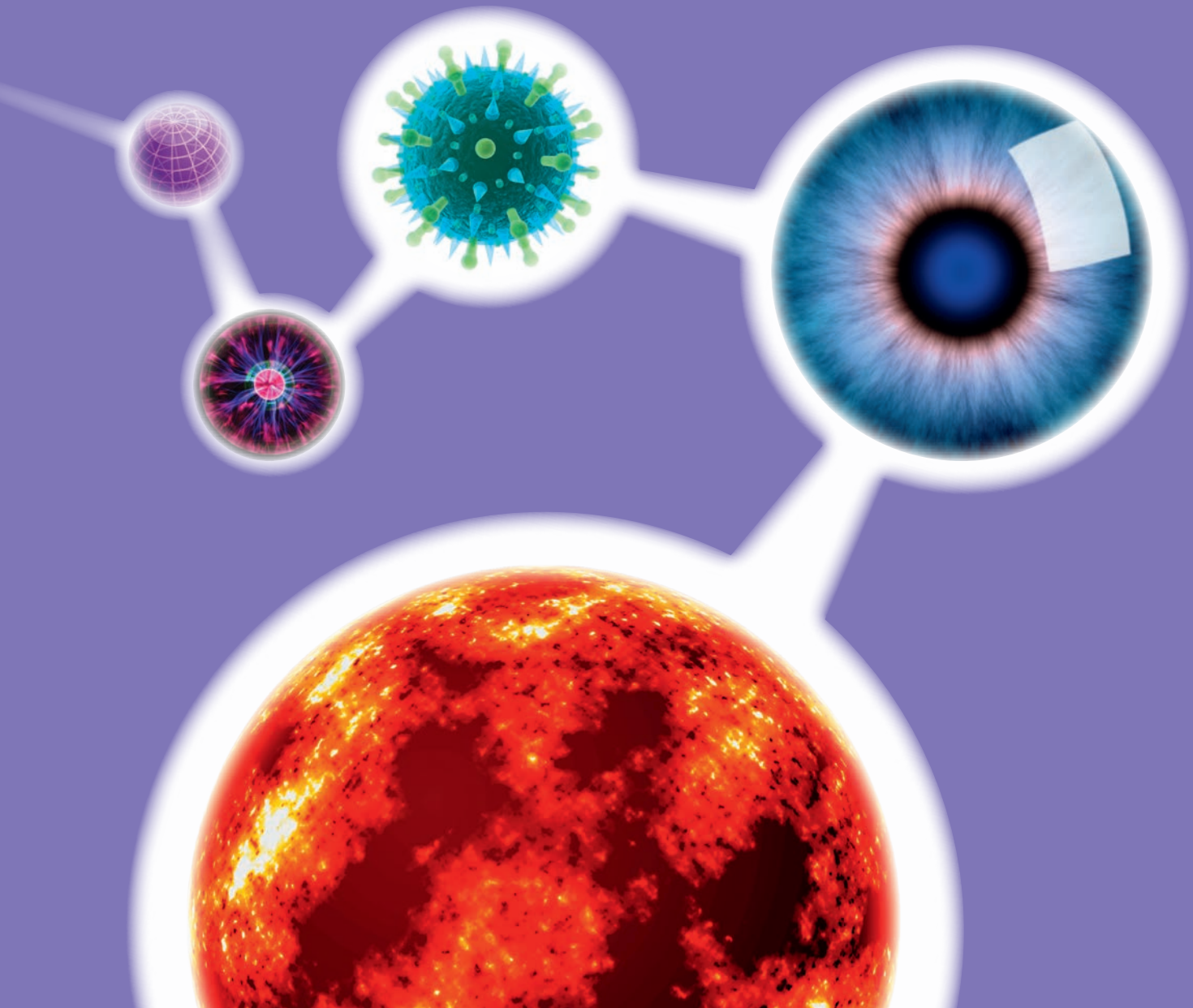
GCSE FURTHER ADDITIONAL SCIENCE B

ACCREDITED SPECIFICATION

J266

VERSION 1

JULY 2013



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

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- 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:

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

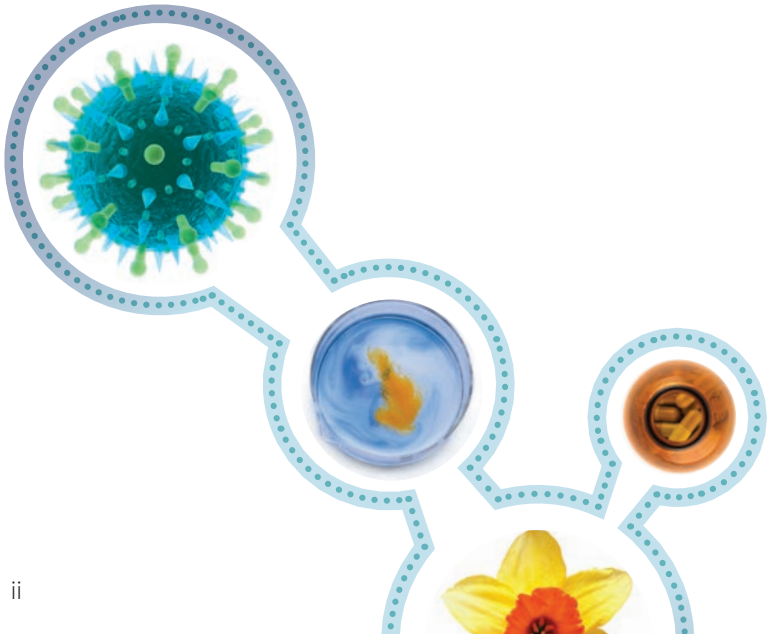
By fax: 01223 552627

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

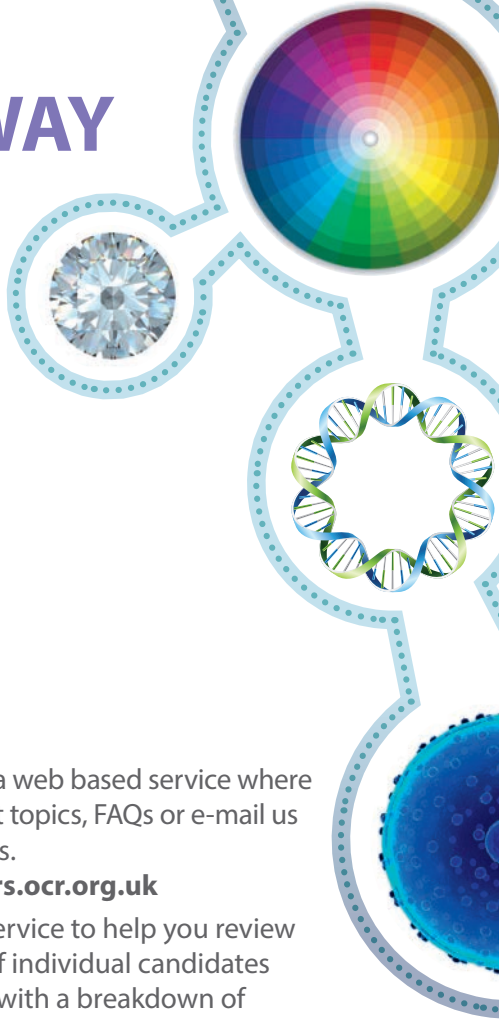
DON'T FORGET

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

ocr.org.uk/science



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:
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Join our social network at **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.
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- **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

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Find out more at:
collinseducation.com/newgcsescience

GATEWAY SCIENCE SUITE

Science in Action

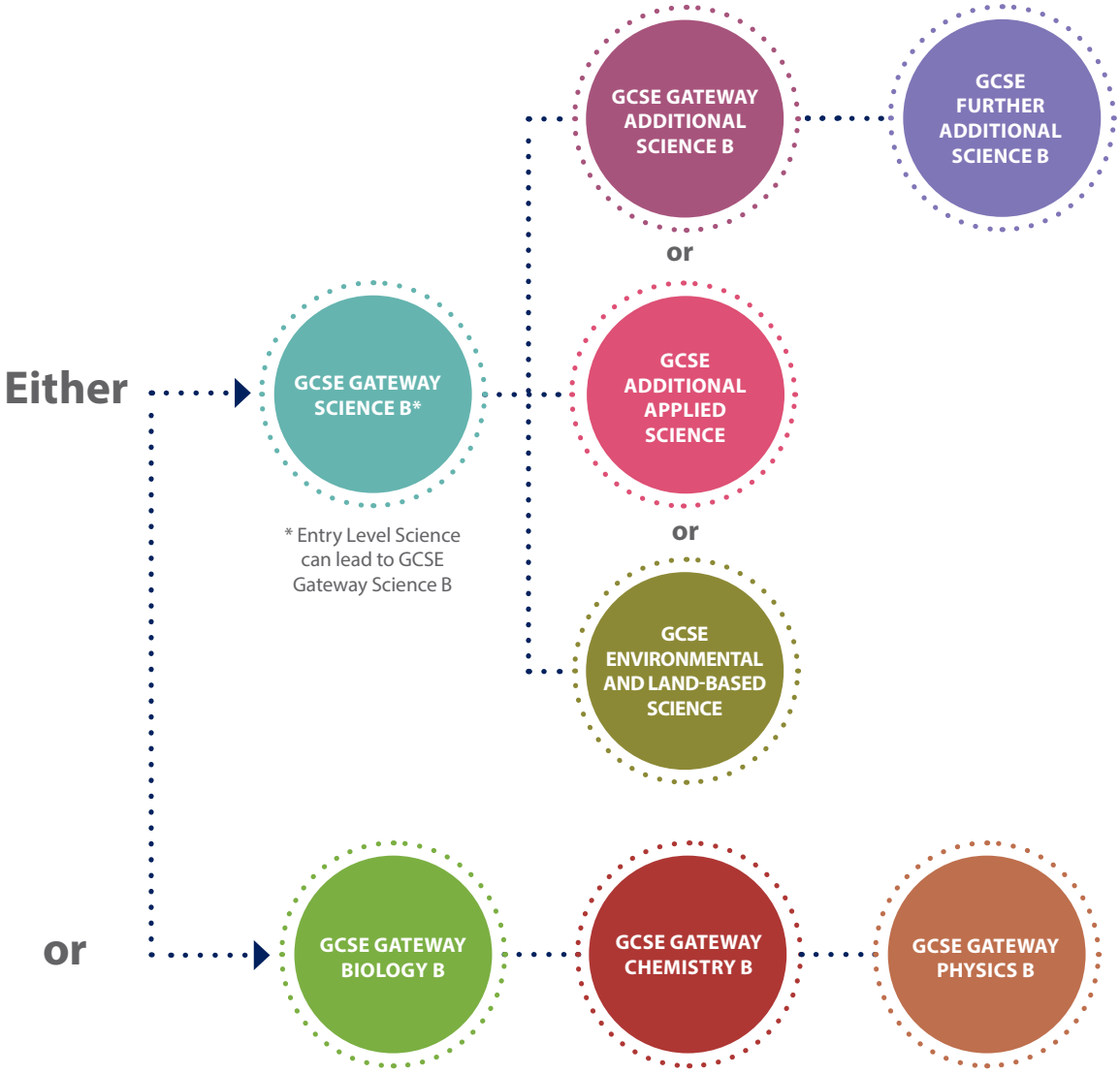
Understand the questions that science can answer. Unpick the scientific concepts and investigate their familiar applications through active learning.

KEY FEATURES

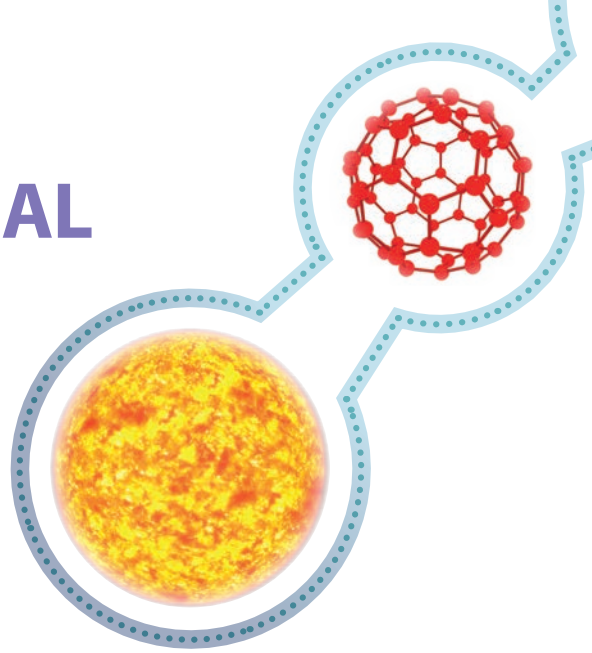
Our Gateway Science Suite gives you and your students:

- 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 FURTHER ADDITIONAL SCIENCE B



KEY FEATURES

GCSE Further Additional Science B:

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

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

COURSE OVERVIEW

ASSESSMENT OVERVIEW

UNIT B761

Module B5: The Living Body
Module C5: How Much?
Module P5: Space For Reflection

75 marks
1 hour 15 minutes
written paper

35% of total GCSE

UNIT B762

Module B6: Beyond The Microscope
Module C6: Chemistry Out There
Module P6: Electricity For Gadgets

85 marks
1 hour 30 minutes
written paper

40% 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 B762 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 B763

Controlled assessment

48 marks
Approx 7 hours

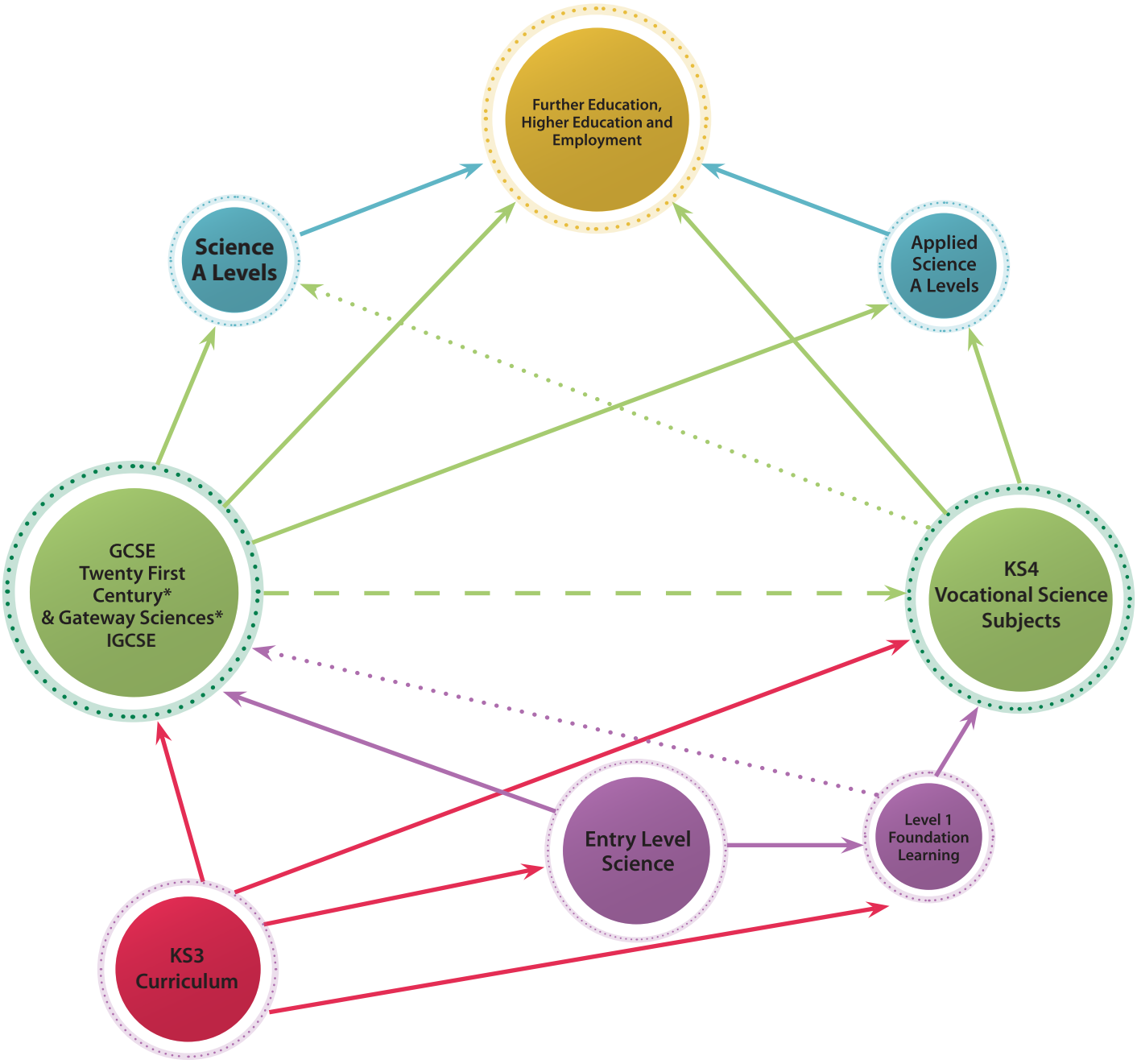
25% of total GCSE

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, Further Additional Science, Biology, Chemistry and Physics.

OCR GCSE in Further Additional Science B J266

Contents

Contents

Contents

Introduction to the Gateway Suite

1

The Gateway Science Suite comprises six 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 Further 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.

2 Introduction to GCSE Further Additional Science B

2.1 Overview of GCSE Further Additional Science B

Unit B761 *Further Additional Science modules B5, C5, P5*

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 B762 *Further Additional Science modules B6, C6, P6*

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 B763 *Further Additional Science controlled assessment*

This unit is not tiered.

Controlled assessment
48 marks
25% of the qualification

2.2 Guided learning hours

GCSE Further Additional Science B requires 120–140 guided learning hours in total.

2.3 Aims and learning outcomes

A GCSE in Further Additional Science enables learners to further develop their interest in science and encourages progression to AS and A level, and other level 3 qualifications in science. Learners will engage with science thus enabling them 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 further:

- 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.

2.4 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 Further Additional Science B

3

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 B5: The Living Body	Module C5: How Much? (Quantitative Analysis)	Module P5: Space For Reflection
a Skeletons	a Moles and molar mass	a Satellites, gravity and circular motion
b Circulatory systems and the cardiac cycle	b Percentage composition and empirical formula	b Vectors and equations of motion
c Running repairs	c Quantitative analysis	c Projectile motion
d Respiratory systems	d Titrations	d Action and reaction
e Digestion	e Gas volumes	e Satellite communication
f Waste disposal	f Equilibria	f Nature of waves
g Life goes on	g Strong and weak acids	g Refraction of waves
h Growth and repair	h Ionic equations and precipitation	h Optics
Module B6: Beyond The Microscope	**Module C6: Chemistry Out There**	**Module P6: Electricity For Gadgets**
a Understanding microbes	a Electrolysis	a Resisting
b Harmful microorganisms	b Energy transfers – fuel cells	b Sharing
c Useful microorganisms	c Redox reactions	c It's logical
d Biofuels	d Alcohols	d Even more logical
e Life in soil	e Depletion of the ozone layer	e Motoring
f Microscopic life in water	f Hardness of water	f Generating
g Enzymes in action	g Natural fats and oils	g Transforming
h Gene technology	h Detergents	h Charging

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
B5b, C5g, C5h, C6a, C6c, C6h, P5c, P5d, P5f, P5g, P5h, P6a, P6b, P6e, P6g, P6h	Describe a simple scientific idea using a simple model.
B5b	Identify two different scientific views or explanations of scientific data.
B6b, C6e, P5f	Recall that scientific explanations (hypotheses) are: • used to explain observations • tested by collecting data/evidence.
B5b, B6e, P5a, P5f	Describe examples of how scientists use a scientific idea to explain experimental observations or results.
B6b, C6e, P5f	Recognise that scientific explanations are provisional but more convincing when there is more evidence to support them.
B5h, B6d, C6b, C6d, C6h	Identify different views that might be held regarding a given scientific or technological development.
B5g, B5h, B6d, B6f, B6h, C5c, C6b, C6e, P5a, P5e, P5g, P5h, P6c, P6d, P6f, P6g	Identify how a scientific or technological development could affect different groups of people or the environment.
B5g, B5h, B6h, C6e, P6g	Describe risks from new scientific or technological advances.
B6b, C6b	Distinguish between claims/opinions and scientific evidence in sources.
B6b	Recognise the importance of the peer review process in which scientists check each other's work.
B5d, B5h, B6f, B6g, C5a, C5b, C5d, C5e, C5f, C6a, C6h, P5b, P5h, P6a, P6b, P6h	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.
B6g, C5e, C6f, C6h	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 B5: The Living Body

Module B5: The Living Body

Item B5a: Skeletons

Summary: Movement is part of our daily lives. Efficient movement relies on a functioning skeletal and muscular system. Accidents do happen and bones can be broken. This item aims to provide the necessary science to understand the structure of bones and joints, and how damage can be detected, using contemporary technological developments.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Examine X-rays of skeletons: • child and adult • arthritic joint • with rickets • with fractures. Examine human and animal skeletons and identify some of the bones.	Recall that: • some animals, including worms, do not have a skeleton made of hard material • some animals, including insects, have an external skeleton • some animals, including humans, have an internal skeleton. Recall that an insect's external skeleton is made of chitin. Describe the different forms of internal skeleton: • made only of cartilage (limited to sharks) • made mainly of bone with some cartilage (outer ear, nose, end of long bones) (to include humans).
Research technologies which assess the health of bones e.g. bone density scans.	Describe the different types of fractures of bones: • simple • compound • green stick. Recall that X-rays are used to detect fractures.
Carry out an experiment to compare the strengths of solid and hollow structures.	Describe a joint as the place where two or more bones meet (joined by ligaments) and recognise that the bones are moved by muscles (attached by tendons). Identify the locations in the human body of a fixed joint (skull), hinge joint (elbow, knee), and ball and socket joint (shoulder, hip).
	Identify the main bones (humerus, ulna, radius) and muscles (biceps, triceps) in a human arm.

Module B5: The Living Body

Item B5a: Skeletons

Links to other items: B1a: Fitness and health

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain why an internal skeleton is advantageous compared with an external skeleton: • framework of body • can grow with body • easy to attach muscles • flexibility. Understand that cartilage and bone are living tissues. Describe the structure of a long bone: • head with covering of cartilage • shaft containing bone marrow with blood vessels. Explain why long bones that are hollow are advantageous, in terms of weight and strength.	Understand that cartilage and bone are susceptible to infection but can grow and repair themselves. Describe how, in humans, the skeleton starts off as cartilage but is ossified: cartilage is slowly replaced by the addition of calcium and phosphorus (ossification); and that whether a person is still growing can be determined by the amount of cartilage present.
Recall that, despite being very strong, bones can easily be broken by a sharp knock. Explain why elderly people are more prone to fractures, limited to osteoporosis.	Explain why it can be dangerous to move a person with a suspected fracture.
Describe the structure of synovial joints: synovial fluid, synovial membrane, ligaments, cartilage. Describe the types and range of movement in: • a ball and socket • hinge joint.	Explain the functions in a synovial joint of: • synovial fluid • synovial membrane • cartilage • ligaments.
Describe how the biceps and triceps muscles operate (by contraction and relaxation) as antagonistic muscles to bend or straighten the arm.	Explain how the arm bending and straightening is an example of a lever.

Module B5: The Living Body

Item B5b: Circulatory systems and the cardiac cycle

Summary: Our heart beats automatically from before birth until we die; it also adjusts itself to varying levels of activity. The history of discoveries about blood circulation is an interesting story culminating in our increasing use of modern technology. Using video clips to show heart action is an example of using ICT in teaching and learning while ECG traces illustrate the use of ICT in science.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Listen/watch Tony Hancock's classic 'The Blood Donor'. Construct a time-line of discoveries about blood circulation using various sources. Research heart disease in the world and display the information using charts and graphs.	Recall that: • some animals, including amoeba, do not have a blood circulatory system • some animals, including insects, have an open circulatory system • some animals, including humans, have a closed circulatory system. Understand the difference between open and closed circulatory systems. Recall that in a closed circulatory system, blood will flow in arteries, veins and capillaries.
Watch video/flash clips on heart action.	Understand how heart muscle causes blood to move.
Interpret an electrocardiograph (ECG) trace of a normal beat (PQRS wave).	Describe the heart as made of powerful muscles which are supplied with food substances, including glucose, and oxygen by the coronary artery. Understand why the heart needs a constant supply of glucose and oxygen. Describe the pulse as a measure of the heart beat (muscle contraction) to put the blood under pressure and recognise that it can be detected at various places (wrist, ear, temple).

Module B5: The Living Body

Item B5b: Circulatory systems and the cardiac cycle

Links to other items: B3e: The circulatory system, B5c: Running repairs

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain why many animals need a blood circulatory system. Describe a single circulatory system as being one circuit from the heart. Describe a double circulatory system as being two circuits from the heart. Compare the circulatory systems of fish and mammals.	Describe the contribution of Galen (2nd century) (importance of the pulse, the difference between blood in arteries and veins) and William Harvey (17th century) (circulation) towards the understanding of blood circulation. Explain why a single circulatory system links to a two-chambered heart. Explain why a double circulatory system links to a four-chambered heart. Understand that the blood is under a higher pressure in a double circulatory system compared with a single circulatory system and how this allows materials to be transported more quickly around the body.
Interpret data on pressure changes in arteries, veins and capillaries.	Describe the cardiac cycle and interpret associated graphs and charts. Explain the sequence of contraction of the atria and ventricles and the sequence of opening of the semilunar and atrio-ventricular valves.
Describe how heart rate is linked to activity. Understand how heart muscle contraction is controlled: by groups of cells called the pacemakers which produce a small electric current that stimulates muscle contraction. Recognise that artificial pacemakers are now commonly used to control heart beat. Recognise that techniques such as ECG and echocardiograms are used to investigate heart action. Recall that heart rate can be increased by the hormone adrenaline.	Describe how the pacemaker cells (SAN and AVN) coordinate heart muscle contraction: • impulses from the SAN cause the atria to contract and stimulate the AVN • impulses from the AVN cause the ventricles to contract. Interpret data from ECG and echocardiograms.

Module B5: The Living Body

Item B5c: Running repairs

Summary: Our heart and circulation can go wrong. We need to understand how our lifestyle can cause this. We also need to know how these faults can be detected and how they can be put right using modern surgical techniques. This item allows discussion on some of the decisions and ethical issues around blood donation.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Examine models of the heart and heart valves. Watch videos/flash clips to show action of valves. Research types of heart valves. Research causes of heart disease.	Recognise that there are many heart conditions and diseases, to include: • irregular heart beat • hole in the heart • damaged or weak valves • coronary heart disease and heart attacks.
Research the incidence of haemophilia in Europe's royal families. Visit or listen to a presentation from the National Blood Service.	Describe reasons for blood donation. Recall that there are different blood groups called A, B, AB and O, which are further subdivided into Rhesus positive and negative. Describe the function of blood clots at cuts and appreciate that they sometimes occur abnormally inside blood vessels. Recall that anti-coagulant drugs can be used to reduce clotting.

Module B5: The Living Body

Item B5c: Running repairs

Links to other items: B1a: Fitness and health, B3e: The circulatory system, B5b: Circulatory systems and the cardiac cycle, B5h: Growth and repair

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain the consequences of a 'hole in the heart': • blood can move directly from one side of the heart to the other side of the heart • less oxygen in the blood • can require correction by surgery. Explain the consequences of damaged or weak valves in the heart: • reduce effective blood circulation • can require replacement by artificial valves. Explain the consequences of a blocked coronary artery: • reduces blood flow to the heart muscle • can require treatment by bypass surgery. Recognise that there are 'heart assist' devices as well as heart transplants.	Explain how a 'hole in the heart' results in less oxygen in the blood. Understand why unborn babies can all have a 'hole in the heart' and do not need a double circulatory system and why the hole closes soon after birth. Explain the advantages and disadvantages of a heart pacemaker or artificial heart valves over a heart transplant.
Describe the processes of: • blood donation • blood transfusion. Recall that haemophilia is an inherited condition in which the blood does not easily clot. Recall that drugs such as warfarin, heparin and aspirin are used to control clotting. Describe the process of blood clotting, limited to: • platelets in contact with damaged blood vessels, causing a series of chemical reactions leading to the formation of a mesh of fibrin fibres (clot).	Recall that unsuccessful blood transfusions cause agglutination (blood clumping). Explain how the presence of antigens and antibodies in red blood cells and blood serum determines how blood groups react and therefore whether a blood transfusion is successful. Describe which blood groups (A, B, AB and O) have: • antigens A and B • antibodies anti-A and anti-B. Explain which blood groups can be used to donate blood to which other blood groups.

Module B5: The Living Body

Item B5d: Respiratory systems

Summary: With today's polluted atmosphere, many people suffer from respiratory diseases. This unit looks at how respiratory systems work and at respiratory problems, their causes and possible treatments. The experimental work on measuring lung capacities, respiration and peak flow develop the ability to present and analyse information using technical and mathematical language.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Carry out an experiment to show the different amounts of carbon dioxide in inhaled and exhaled air.	Understand why most living things need oxygen to release energy from food. Understand that small simple organisms, including amoeba and earthworms, take in oxygen through their moist and permeable external surfaces. Recognise that larger, more complex animals have special organs for exchange of gases, such as gills and lungs. Understand how surface area affects the exchange of gases.
Examine a model of a bell jar and rubber sheet to explain breathing. Measure lung capacities.	Describe the functions of the main parts of the human respiratory system (trachea, bronchus, bronchioles, lungs, alveoli, pleural membranes, ribs, intercostal muscles and diaphragm). Explain the terms breathing, respiration, inspiration (inhalation) and expiration (exhalation). Describe the direction of exchange of carbon dioxide and oxygen at the lungs and in tissues.
Carry out an experiment to test peak flow of individuals. Research one or more industrial respiratory diseases and present the information in a poster or leaflet.	Recall that there are many conditions and diseases of the respiratory system, to include: • asthma, bronchitis, pneumonia and lung cancer.

Module B5: The Living Body

Item B5d: Respiratory systems

Links to other items: B1b: Human health and diet, B1e: Drugs and you, B3c: Respiration, B4d: Diffusion and osmosis

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Recognise that the methods of gaseous exchange of amphibians and fish restrict them to their habitats: • amphibians need moist habitats • fish gills only work in water.	Explain why the methods of gaseous exchange of amphibians and fish restrict them to their habitats: • the permeable skin of amphibians makes them susceptible to excessive water loss • fish gills work by forcing water across the filaments.
Understand the process of ventilation in terms of changing volume and pressure to include breathing in humans. Explain the terms tidal air, vital capacity air and residual air as part of the total lung capacity. Explain how gaseous exchange occurs within alveoli by diffusion between air and blood.	Explain how gaseous exchange surfaces are adapted for efficient gaseous exchange (permeable, moist surface, large surface area, good blood supply and thin lining (one cell thick)). Interpret data on lung capacities (from a spirometer).
Describe how the respiratory system protects itself from disease by mucus and ciliated cells in the trachea and bronchi. Recognise that there are lung diseases: • with industrial causes (such as asbestosis) • with genetic causes (such as cystic fibrosis) • caused by life style (such as lung cancer); and briefly describe each disease: • asbestosis – inflammation and scarring limiting gas exchange • cystic fibrosis – too much mucus in the bronchioles • lung cancer – cells grow rapidly, reducing surface area in lungs. Describe the symptoms of asthma (difficulty breathing, wheezing, tight chest) and its treatment (inhalers).	Explain why the respiratory system is prone to diseases. Describe what happens during an asthma attack: • lining of airways becomes inflamed • fluid builds up in airways • muscles around bronchioles contract constricting airways.

Module B5: The Living Body

Item B5e: Digestion

Summary: Food provides the raw materials for growth as well as being the source of the energy we release through respiration. The different parts of the digestive system are each adapted for their own roles in digesting and absorbing food.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Investigate the digestion of starch, protein and fat using simple food tests.	Describe the position and function of the parts of the human digestive system: • salivary glands • stomach • pancreas • liver and gall bladder • small intestine • large intestine. Describe the process of physical digestion as breaking food into smaller pieces by: • chewing in the mouth • squeezing in the stomach. Understand that in chemical digestion the digestive enzymes breakdown large food molecules into smaller ones so they can be absorbed into the blood.
Investigate the movement of food molecules across partially permeable membranes.	Recognise that food enters the blood in the small intestine and leaves in body tissues.

Module B5: The Living Body

Item B5e: Digestion

Links to other items: B1b: Human health and diet, B3b: Proteins and mutations, B4d: Diffusion and osmosis

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain the importance of physical digestion: • to pass more easily through the digestive system • to provide a larger surface area. Explain how carbohydrates, proteins and fats are digested by specific enzymes in the mouth, stomach and small intestine respectively, limited to: • carbohydrase breaks down starch to sugar • protease breaks down protein to amino acids • lipase breaks down fat to fatty acids and glycerol. Recall that stomach acid aids protease function.	Explain how bile, from the gall bladder, improves fat digestion. Explain why the pH in the stomach is maintained at acidic levels, whereas the pH in the mouth and small intestine is alkaline or neutral. Understand that the breakdown of starch is a two step process involving the breakdown of starch into maltose and maltose into glucose.
Understand why large molecules need to be broken down into small molecules. Describe how small digested food molecules are absorbed into the blood plasma or lymph in the small intestine by diffusion.	Explain how the small intestine is adapted for the efficient absorption of food.

Module B5: The Living Body

Item B5f: Waste disposal

Summary: Our bodies produce waste, which is often toxic. To avoid poisoning ourselves, we must get rid of this waste. What role do our kidneys, skin and lungs play in this process? Researching methods of respiratory and kidney failure can be used to illustrate contemporary scientific and technological developments.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Carry out experiments to test mock urine samples. Research kidney failure and its treatment.	Explain the difference between egestion and excretion. Name and locate the positions of the main organs of excretion: • lungs • kidneys • skin. Recall that the kidneys excrete urea, water and salt in urine. Understand that the amount and concentration of urine produced is affected by water intake, temperature and exercise.
Investigate the effect of exercise on rate of breathing.	Recall that carbon dioxide produced by respiration, is removed from the body through the lungs.

Module B5: The Living Body

Item B5f: Waste disposal

Links to other items: B1e: Drugs and you, B1f: Staying in balance, B4d: Diffusion and osmosis

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Understand the importance of maintaining a constant concentration of water molecules in blood plasma. Describe the gross structure of a kidney and associated blood vessels (cortex, medulla, ureter, renal artery, renal vein). Explain how kidneys work: • filter blood at high pressure • re-absorb water and useful substances. Recall that urea, produced in the liver (from excess amino acids), is removed from the blood by the kidneys. Explain why the amount and concentration of urine produced is affected by water intake, heat and exercise.	Explain how the structure of the kidney tubule (nephron) is related to filtration of the blood and formation of urine: • a filter unit of glomerulus and capsule • a region for selective reabsorption • a region for salt and water regulation. Explain the principle of a dialysis machine and how it removes urea and maintains levels of sodium and glucose in the blood of a patient with kidney failure. Explain how the concentration of urine is controlled by the antidiuretic hormone (ADH), released by the pituitary gland: • ADH increases permeability of kidney tubules so more water is reabsorbed back into the blood • ADH production is controlled by a negative feedback mechanism.
Explain why carbon dioxide must be removed from the body, limited to the toxic effect of high levels.	Explain how the body responds to increased carbon dioxide levels in the blood: • detected by the brain • increased rate of breathing results.

Module B5: The Living Body

Item B5g: Life goes on

Summary: Humans, like all other animals, have basic needs for survival and reproduction to carry on our species. When things do not work as they should we expect modern techniques to solve our problem. Sometimes solutions raise other issues.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Examine microscope slides of testes and ovaries. Examine models of a developing foetus.	Describe the function of the scrotum: • keeps the testes outside the body where the temperature is better for sperm development. Describe the main stages of the menstrual cycle: • menstruation – uterus lining breaks down (period) • thickening of uterus lining • ovulation – egg released by ovary.
Role play or debate about using infertility treatments.	Understand that fertilisation and pregnancy are not guaranteed for all couples. Understand the causes of infertility, limited to: • blockage of fallopian tubes or sperm ducts • eggs not developed or released from ovaries • insufficient fertile sperm produced by testes. Recognise that in some, but not all, cases pregnancy can be achieved with the help of fertility treatment.
	Understand reasons for checking foetal development.
	Name and locate human endocrine glands and name the hormones produced: • ovaries – oestrogen, progesterone • testes – testosterone.

Module B5: The Living Body

Item B5g: Life goes on

Links to other items: B1h: Variation and inheritance, B5h: Growth and repair

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe the role of hormones in the menstrual cycle: • oestrogen causes the repair of the uterus wall • progesterone maintains the uterus wall • FSH (follicle-stimulating hormone) stimulates an egg to develop • LH (luteinising hormone) controls ovulation. Recall that FSH and LH are released by the pituitary gland in the brain.	Explain how negative feedback mechanisms affect hormone production in the menstrual cycle.
Explain treatments for infertility, to include: • artificial insemination • use of FSH • 'in vitro' fertilisation (IVF) • egg donation • surrogacy • ovary transplants. Explain the arguments for and against such infertility treatments.	Evaluate infertility treatments in terms of moral issues, risks and benefits.
Describe how foetal development can be checked to identify conditions such as Down's syndrome using amniocentesis and chromosomal analysis. Explain why foetal screening raises ethical issues.	
Recall that fertility in humans can be controlled by the artificial use of sex hormones: contraceptive pill and fertility drugs.	Explain how fertility can be reduced by the use of female hormones (contraception) which prevent ovulation by mimicking pregnancy – inhibiting FSH release.

Module B5: The Living Body

Item B5h: Growth and repair

Summary: We start life as a microscopic fertilised egg and grow at different rates at different times of our lives and are sometimes surprised to find we have reached a height of nearly two metres. However, as people live longer, parts of their bodies wear out or go wrong. This item encourages discussion about possible treatments and ethical issues involved. It also provides the opportunity to debate the issues.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Measure heights of candidates in your class/year and display as normal distributions for boys and girls. Collect data from another year group and compare distributions. Use websites/visit museums/use reference books to find out average heights during history (look at suits of armour, door heights in old buildings, height requirements for the Armed Forces).	Recall that growth can be measured as an increase in height or mass. Understand that a person's final height and mass is determined by a number of factors, including: • their genes • diet and exercise • hormones • health/disease. Describe the main stages of human growth and identify them on a human growth curve: • infancy (up to 2 years) • childhood (from 2 to 11 years) • adolescence (puberty) (from 11 to 13/15 years) • maturity (adulthood) (the longest stage) • old age (above 60/65 years).
Research donor cards and other donor organisations such as the Anthony Nolan Trust.	Recall that, due to disease or trauma, it is sometimes necessary to replace body parts with biological or mechanical parts. Recall that some mechanical replacements such as the heart and lung machine, kidney dialysis and mechanical ventilators are used outside the body.
Research the history of one organ transplant.	Understand that organs can be donated by living or dead donors.

Module B5: The Living Body

Item B5h: Growth and repair

Links to other items: B3f: Growth and development, B5c: Running repairs

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Recall that extremes of height are usually caused by genes or hormone imbalance. Describe how diet and exercise can influence growth. Recognise that different parts of a foetus and a baby grow at different rates. Understand why a baby's length, mass and head size are regularly monitored during their first months: to provide early warning of growth problems. Understand the use of average growth charts. Explain possible causes of the increase in life expectancy during recent times, to include: less industrial disease, healthier diet and life style, modern treatments and cures for disease and better housing.	Recall that the human growth hormone is produced by the pituitary gland and that it stimulates general growth, especially in long bones. Describe possible consequences of more people living longer, on a personal and national level.
Explain problems in supply of donor organs, limited to: • shortage of donors • tissue match • size and age. Explain problems of using mechanical replacements, limited to: • size • power supply • materials used • body reactions. Describe the ethical issues concerning organ donation.	Describe problems with transplants, limited to: • rejection • immuno-suppressive drug treatment.
Explain why donors can be living and what makes a suitable living donor. Describe the criteria needed for a dead person to be a suitable donor.	Describe the advantages and disadvantages of a register of donors. Interpret data on transplants and success rates.

3.5 Module C5: How Much? (Quantitative Analysis)

Module C5: How Much? (Quantitative Analysis)

Item C5: Fundamental Chemical Concepts

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

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

Module C5: How Much? (Quantitative Analysis)

Item C5: Fundamental Chemical Concepts

Links to other modules: C1 to C6

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Construct word equations (not all reactants and products given).	
Construct balanced symbol equations given the formulae (no brackets) of the reactants and products. Explain why a symbol equation is balanced.	Construct balanced symbol equations given the formulae (some or all with brackets) of the reactants and products. Construct balanced symbol equations given the names of the reactants and products (limited to the learning outcomes in C5).
Deduce the number of atoms in a formula with brackets. Deduce the number of each type of different atom in a formula with brackets. Recall the formula of the following substances: • hydrochloric acid and ethanoic acid • carbon dioxide, hydrogen and water • sodium chloride and potassium chloride • ammonia and calcium carbonate.	Recall the formula of the following substances: • sulfuric acid and nitric acid • sodium hydroxide, potassium hydroxide and magnesium carbonate • sodium sulfate, potassium sulfate, magnesium sulfate and barium sulfate • lead(II) nitrate and lead iodide • potassium iodide and potassium nitrate.
Understand that a displayed formula shows both the atoms and the bonds in a molecule. Write the molecular formula of a compound given its displayed formula.	Construct balanced equations using displayed formulae.
Understand that positive ions are formed when electrons are lost from atoms. Understand that negative ions are formed when electrons are gained by atoms.	
Understand that an ionic bond is the attraction between a positive ion and a negative ion. Understand that a covalent bond is a shared pair of electrons.	Explain how an ionic bond is formed. Explain how a covalent bond is formed.

Module C5: How Much? (Quantitative Analysis)

Item C5a: Moles and molar mass

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

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

Module C5: How Much? (Quantitative Analysis)

Item C5a: Moles and molar mass

Links to other items: C3d: Reacting masses, C5c: Quantitative analysis, C5e: Gas volumes

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

Module C5: How Much? (Quantitative Analysis)

Item C5b: Percentage composition and empirical formula

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

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

Module C5: How Much? (Quantitative Analysis)

Item C5b: Percentage composition and empirical formula

Links to other items: C3d: Reacting masses, C3e: Percentage yield and atom economy, C5c: Quantitative analysis

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

Module C5: How Much? (Quantitative Analysis)

Item C5c: Quantitative analysis

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

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

Module C5: How Much? (Quantitative Analysis)

Item C5c: Quantitative analysis

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

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Understand that the more concentrated a solution the more solute particles there are in a given volume (the more crowded the solute particles). Convert volume in cm^3 into dm^3 or vice versa.	Recall and use the relationship between the amount in moles, concentration in mol/dm^3 and volume in dm^3: • amount in moles = concentration × volume • concentration = amount in moles ÷ volume • volume = amount in moles ÷ concentration.
Perform calculations involving concentration for simple dilutions of solutions e.g. how to dilute a 1.0 mol/dm^3 solution into a 0.1 mol/dm^3 solution or how to perform a 1 in 10 dilution.	
Interpret information on food packaging about guideline daily amounts (GDA), for example: • percentage of GDA in a portion.	Interpret more complex food packaging information and its limitations, for example: • convert amounts of sodium to amounts of salt. Explain why the above conversion may be inaccurate, to include sodium ions coming from other sources.

Module C5: How Much? (Quantitative Analysis)

Item C5d: Titrations

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

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Demonstrate or carry out an investigation to find out how pH changes during the neutralisation of an alkali with an acid (pH titration curve) using a strong acid and using a pH meter.	Interpret a simple pH curve, to include: • determine the pH at a particular volume added or vice versa (major grid lines). Explain how universal indicator can be used to estimate the pH value of a solution.
Carry out a simple acid-alkali titration using an indicator such as litmus or phenolphthalein. Microscale titrations details from RSC website www.practicalchemistry.org.	Identify the apparatus used in an acid-base titration: • burette and conical flask • pipette and pipette filler. Describe the procedure for carrying out a simple acid-base titration: • acid in burette, alkali in conical flask (or vice versa) • acid slowly added to alkali (or vice versa) until end point is reached • end point detected by the sudden change in colour of an indicator. Explain why it is important to use a pipette filler when using a pipette in an acid-base titration. Calculate the titre given appropriate information from tables or diagrams. Understand that the titre depends on the concentration of the acid or alkali.
Simple investigation of the colour changes of indicators limited to universal indicator, phenolphthalein and litmus during neutralisation. Universal indicator rainbow, see details from RSC website www.practicalchemistry.org.	Describe the colours of the following indicators in acids and alkalis: • universal indicator, litmus and phenolphthalein.

Module C5: How Much? (Quantitative Analysis)

Item C5d: Titrations

Links to other items: C2f: Acids and bases, C5c: Quantitative analysis, C5g: Strong and weak acids

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Interpret a simple pH curve, to include: • determine the volume of acid or alkali at neutralisation • determine the pH at a particular volume added or vice versa (not major grid lines).	Sketch a pH titration curve for the titration of an acid or an alkali.
Explain the need for several consistent titre readings in titrations.	Calculate the concentration of an acid or alkali from titration results, limited to examples involving a one to one molar ratio (acid:alkali). Recall and use the relationship between the amount in moles, concentration in mol/dm^3 and volume in dm^3: • amount in moles = concentration × volume • concentration = amount in moles ÷ volume • volume = amount in moles ÷ concentration.
Describe the difference in colour change during a titration using a single indicator, such as litmus or phenolphthalein, compared to a mixed indicator, such as universal.	Explain why an acid-base titration should use a single indicator rather than a mixed indicator.

Module C5: How Much? (Quantitative Analysis)

Item C5e: Gas volumes

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

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

Module C5: How Much? (Quantitative Analysis)

Item C5e: Gas volumes

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

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe an experimental method to measure the volume of gas produced in a reaction given appropriate details about the reaction.	
Describe an experimental method to measure the mass of gas produced in a reaction given appropriate details about the reaction.	
Understand how the amount of product formed varies with the amount of limiting reactant used. Recall that the limiting reactant is the reactant not in excess that is all used up at the end of the reaction. Explain why a reaction stops in terms of the limiting reactant present given appropriate qualitative information about the reaction.	Explain in terms of reacting particles why the amount of product formed is directly proportional to the amount of limiting reactant used. Calculate the volume of a known number of moles of gas given the molar gas volume of 24 dm^3 at room temperature and pressure (rtp). Calculate the amount in moles of a volume of gas at rtp given the molar gas volume at rtp.
Interpret data in table, graphical and written form about the volume of gas produced during the course of a reaction (not major grid lines), for example: • deduce total volume of gas produced • deduce when the reaction has stopped • deduce volume of gas at a particular time and vice versa • deduce the volume of gas produced with different amounts of limiting reactant.	Sketch a graph to show how the volume of gas produced during the course of a reaction changes, given appropriate details about the reaction.

Module C5: How Much? (Quantitative Analysis)

Item C5f: Equilibria

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

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

Module C5: How Much? (Quantitative Analysis)

Item C5f: Equilibria

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

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Recall that in a reversible reaction at equilibrium: • the rate of the forward reaction equals the rate of the backward reaction • the concentrations of the reactants and the products do not change. Understand how the position of equilibrium is related to the ratio of the concentration of the products to the concentration of the reactants.	Explain why a reversible reaction may reach an equilibrium: • importance of a closed system • initially rate of forward reaction decreases • initially rate of backward reaction increases • eventually rate of forward equals rate of backward reaction.
Recall that a change in temperature, pressure or concentration of reactant or product may change the position of equilibrium. Interpret data in the form of tables or graphs about the equilibrium composition, for example: • composition at particular temperatures • composition at particular pressures • effect of temperature and pressure on composition.	Understand in simple qualitative terms factors that affect the position of equilibrium: • removing a product moves the position of equilibrium to the right or vice versa • adding extra reactant moves the position of equilibrium to the right or vice versa • increasing the temperature moves the position of equilibrium in the direction of the endothermic reaction or vice versa • increasing the pressure moves the position of equilibrium to the side with the least number of moles of gas molecules or vice versa. Explain the effect of changing product concentration, reactant concentration, temperature or pressure on the position of equilibrium given appropriate details about a reaction.
Understand that the reaction between sulfur dioxide and oxygen is reversible: • sulfur dioxide + oxygen $\rightleftharpoons$ sulfur trioxide • $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ Describe the conditions used in the Contact Process: • V_2O_5 catalyst • around 450°C • atmospheric pressure.	Explain the conditions used in the Contact Process: • increasing the temperature moves the position of equilibrium to the left and increases rate of reaction so a compromise temperature is used • addition of catalyst increases rate but does not change position of equilibrium • even at low pressure, the position of equilibrium is already on right so expensive high pressure is not needed.

Module C5: How Much? (Quantitative Analysis)

Item C5g: Strong and weak acids

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

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

Module C5: How Much? (Quantitative Analysis)

Item C5g: Strong and weak acids

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

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Understand that an acid ionises in water to produce H^+ ions. Understand that a strong acid completely ionises in water and a weak acid does not fully ionise and forms an equilibrium mixture.	Explain why the pH of a weak acid is much higher than the pH of a strong acid of the same concentration. Explain the difference between acid strength and acid concentration: • acid strength (strong or weak) is a measure of the degree of ionisation of the acid • acid concentration is a measure of the number of moles of acid in one dm^3. Construct equations for the ionisation of weak and strong acids given the formula of the mono-basic acid.
Explain why ethanoic acid reacts slower than hydrochloric acid of the same concentration: • there are fewer hydrogen ions in ethanoic acid • in ethanoic acid there are fewer collisions between hydrogen ions and reactant particles.	Explain why ethanoic acid reacts slower than hydrochloric acid of the same concentration: • ethanoic acid has a lower concentration of hydrogen ions • in ethanoic acid the hydrogen ions have a lower collision frequency with reactant particles.
Explain why the volume of gaseous products of the reactions of acids is determined by the amounts of reactants present not the acid strength.	
Explain why ethanoic acid is less conductive than hydrochloric acid of the same concentration: • there are fewer hydrogen ions available to move. Explain why hydrogen is produced during the electrolysis of ethanoic acid and of hydrochloric acid.	Explain why ethanoic acid is less conductive than hydrochloric acid of the same concentration: • lower concentration of hydrogen ions to carry the charge in ethanoic acid.

Module C5: How Much? (Quantitative Analysis)

Item C5h: Ionic equations and precipitation

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

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

Module C5: How Much? (Quantitative Analysis)

Item C5h: Ionic equations and precipitation

Links to other items: C4e: The Group 7 elements, C4f: Transition elements, C4h: Purifying and testing water, C6a: Electrolysis

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Understand that ionic substances contain ions which are in fixed positions in the solid but can move in solution. Understand that in a precipitation reaction ions must collide with other ions to react to form a precipitate.	Explain, in terms of collisions between ions, why most precipitation reactions are extremely fast.
Interpret experimental data about the testing of solutions using aqueous barium chloride and aqueous lead nitrate.	
Construct word equations for simple precipitation reactions e.g. for the reaction between solutions of barium chloride and sodium sulfate (products not given).	Construct ionic equations, with state symbols, for simple precipitation reactions, given the formulae of the ions that react. Explain the concept of 'spectator ions'.
Describe the stages involved in the preparation of a dry sample of an insoluble compound by precipitation given the names of the reactants: • mix solutions of reactants • filtration • wash and dry residue.	

3.6 Module P5: Space For Reflection

Module P5: Space For Reflection

Item P5a: Satellites, gravity and circular motion

Summary: Satellites have played a major part in the global communications revolution. We can call someone on the other side of the world using a mobile phone or watch events around the world, as they happen, in the comfort of our own homes. This item looks at what satellites are, their uses, including communications and satellite TV, and the physics behind what keeps them in the correct orbit. Newton's experiment illustrates how uncertainties about science ideas change over time, and the use of models to explain phenomena.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Observe the International Space Station moving across the sky. Use the internet (e.g. NASA website) for information on the International Space Station and Space Shuttle.	Recall that gravity is the universal force of attraction between masses. Recognise that a satellite is an object that orbits a larger object in space. Describe the difference between artificial and natural satellites.
Use the internet to find images of the Earth taken by satellites. (Use images recorded in other wavelengths as well as visible light.) Demonstration of circular motion by swinging a bung around with masses pulling it down. A glass tube is needed to thread the wire through and to hold as you rotate the bung. Demonstration of unbalanced force using a record player to show objects 'flying off' when the speed is high enough.	Describe how the height above the Earth's surface affects the orbit of an artificial satellite. Recall how the height of orbit of an artificial satellite determines its use.
Describe Newton's thought experiment regarding a cannonball fired from a high mountain which, at a high enough speed, will orbit the Earth.	Recall some of the applications of artificial satellites, to include: • communications • weather forecasting • military uses • scientific research • GPS • imaging the Earth.

Module P5: Space For Reflection

Item P5a: Satellites, gravity and circular motion

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
Explain why the Moon remains in orbit around the Earth and the Earth and other planets in orbit around the Sun.	Describe the variation of gravitational force with distance (idea of inverse square law). Explain the variation in speed of a periodic comet during its orbit around the Sun, to include: • influence of highly elliptical orbit • variation in gravitational force of attraction. Explain how the orbital period of a planet depends upon its distance from the Sun.
Describe the orbit of a geostationary artificial satellite: • orbits the Earth once in 24 hours around the equator • remains in a fixed position above the Earth's surface • orbits above the Earth's equator. Understand that circular motion requires: • a centripetal force • gravity provides the centripetal force for orbital motion.	Understand that artificial satellites are continually accelerating towards the Earth due to the Earth's gravitational pull, but that their tangential motion keeps them moving in an approximately circular orbit.
Explain why different satellite applications require different orbits, to include the orbit's: • height • period • trajectory (including polar orbit).	Explain why artificial satellites in lower orbits travel faster than those in higher orbits.

Module P5: Space For Reflection

Item P5b: Vectors and equations of motion

Summary: When analysing the motion of objects, knowing how fast they are travelling is only half the information. We also need to know the direction that they are travelling in. Two cars travelling towards each other at high speed is entirely different from the same cars travelling at the same speed in the same direction.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
	Recall that direction is important when describing the motion of an object. Understand how relative speed depends on the direction of movement (in context of two cars travelling on a straight road).
Measure the average speed of an object moving in a straight line, horizontally or falling under gravity. Use electronic equipment (light gates interfaced with a PC) to measure speed and acceleration. Use an electronic or electrical method together with an equation of motion to calculate the acceleration due to gravity.	Recall that: • direction is not important when measuring speed • speed is a scalar quantity. Recognise that for any journey: • distance travelled can be calculated using the equation: distance = average speed × time $s = \frac{(u + v)}{2} \times t$ Use the equation: $v = u + at$ to calculate final speed only.

Module P5: Space For Reflection

Item P5b: Vectors and equations of motion

Links to other items: P3a: Speed, P3b: Changing speed

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe the difference between scalar and vector quantities: • some quantities, (e.g. mass, time), direction is not relevant (scalar) • some quantities, (e.g. force, velocity, acceleration) direction is important (vector). Calculate the vector sum from vector diagrams of parallel vectors (limited to force and velocity in the same or opposite directions).	Calculate the resultant of two vectors that are at right angles to each other. (Answers can be by calculation or scale diagram.)
Use the equation: $v = u + at$ to calculate v or u. Use the equation, including a change of subject: $s = \frac{(u + v)}{2} \times t$	Use the equations, including a change of subject: $v^2 = u^2 + 2as$ $s = ut + \frac{1}{2} at^2$

Module P5: Space For Reflection

Item P5c: Projectile motion

Summary: Many sports involve throwing, striking or kicking a ball. We are more than familiar with the path taken by a ball that is thrown to us, yet to have our hands in the right position to catch it, requires our brain to analyse the situation very quickly. The shape of the path or 'trajectory' together with the calculations behind this are considered here. Trajectories taken by golf balls and cricket balls can be illustrated by using ICT for teaching and learning. The 'pearls in the air' demonstration provides experience of scientific models.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Use TV images of golfers or footballers to show that the trajectories taken by golf balls and footballs are parabolic (many broadcasts now show the trajectory of the ball). Show "pearls in air" demonstration to show parabolic trajectory.	Recall and identify that the path of an object projected horizontally in the Earth's gravitational field is curved. Recall that the path of a projectile is called the trajectory.
Use 'horizontal and vertical' projectile apparatus to show the independence of the two. Show video clips of stroboscopic motion of falling objects and bouncing balls.	Recognise examples of projectile motion in a range of contexts.
Collect information from the internet and make a PowerPoint presentation about how the launch angle can affect the range of a ball.	Recall that the range of a ball struck in sport depends on the launch angle, with an optimum angle of 45°.

Module P5: Space For Reflection

Item P5c: Projectile motion

Links to other items: P3g: Falling safely

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe the trajectory of an object projected in the Earth's gravitational field as parabolic. Recall that the horizontal and vertical velocities of a projectile are vectors.	Understand that the resultant velocity of a projectile is the vector sum of the horizontal and vertical velocities.
Recall that for a projectile in Earth's gravitational field, ignoring air resistance: • there is no acceleration in the horizontal direction (a constant horizontal velocity) • the acceleration due to gravity acts in the vertical direction (steadily increasing vertical velocity).	Use the equations of motion (in Item P5b) for an object projected horizontally above the Earth's surface where the gravitational field is still uniform.
Recall that, other than air resistance, the only force acting on a ball during flight is gravity. Understand that projectiles have a downward acceleration and that this only affects the vertical velocity. Interpret data on the range of projectiles at different launch angles.	Explain how for an object projected horizontally: • the horizontal velocity is unaffected by gravity • therefore the horizontal velocity is constant • gravity causes the vertical velocity to change.

Module P5: Space For Reflection

Item P5d: Action and reaction

Summary: Coming to a sudden stop is far more painful and dangerous than stopping gently. Seatbelts and crumple zones in cars are designed to bring people and moving objects to rest slowly and safely. People falling from a burning building are caught in a 'Fireman's Blanket' for the same reasons. Even objects with a small mass can have a lot of momentum when struck hard and given a high velocity, and even individual atoms can contribute momentum to launch a powerful rocket, if there are a large enough number of atoms involved.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Use skateboards, chairs on wheels, dynamics trolleys or magnets to show the effect of equal and opposite forces. Carry out a demonstration using air tracks or trolleys to illustrate the conservation of momentum.	Describe and recognise that every action has an equal and opposite reaction.
Discuss examples of collisions in sport (e.g. striking a ball with a bat).	Describe and recognise the opposite reactions in a parallel collision (i.e. velocities parallel). Recall everyday examples of collisions; to include sporting examples and car collisions.
	Explain, using a particle model, how a gas exerts a pressure on the walls of its container.
Launch a water rocket to demonstrate that the explosion propels the water down with the same momentum as the rocket shoots up. Compare mass of fuel and mass of rockets for commercial rocket systems. Research the use of ion motors for deep space probes.	Recall that in a rocket, the force pushing the particles backwards equals the force pushing the rocket forwards.

Module P5: Space For Reflection

Item P5d: Action and reaction

Links to other items: P3f: Crumple zones

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Understand that when an object collides with another object or two bodies interact, the two objects exert an equal and opposite force on each other. (Newton's third law of motion.)	
Describe the opposite reactions in a number of static situations, including examples involving gravity. Understand that equal but opposite forces act in a collision and use this to explain the change in motion of the objects, to include recoil.	Understand that momentum is a property that is always conserved and use that to explain: • explosions • recoil • rocket propulsion. Apply the principle of conservation of momentum to collisions of two objects moving in the same direction (including calculation of mass, speed or momentum only) for collisions when the colliding objects coalesce using the equation: $m_1 u_1 + m_2 u_2 = (m_1 + m_2)v$
Explain, using a particle model, how a change in volume or temperature produces a change in pressure.	Explain pressure in terms of: • the change of momentum of the particles striking the walls creating a force • the frequency of collisions.
Explain, using kinetic theory, rocket propulsion in terms of fast moving particles colliding with rocket walls creating a force.	Explain how, for large scale rockets used to lift satellites into the Earth's orbit, sufficient force is created to lift the rocket: • a large number of particles of exhaust gas are needed • the particles must be moving at high speeds.

Module P5: Space For Reflection

Item P5e: Satellite communication

Summary: Using microwave and satellite technology, you can call anyone from anywhere on the planet, or receive a TV signal via a satellite dish. This technology has moved at a rapid pace. But how does the signal from our mobile phones get to the person receiving the call and how do TV and radio broadcasts reach the viewer and listener? This item looks at why we use microwaves to transmit information and the physics behind the communications industry.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Use the internet to research the parts of the Earth's atmosphere and their effects on absorbing or transmitting electromagnetic radiation. Predict the location of a satellite sending digital TV signals to Earth by looking at which direction the satellite dishes are all pointing in a street of houses.	Recall that different frequencies are used for low orbit satellites (relatively lower frequency) and geostationary satellites (relatively higher frequency).
Show that mobile phones give off electromagnetic waves by placing them near loudspeakers and listening for the crackle. Examine pictures of waves coming into harbours.	Recall that some radio waves (e.g. long wavelength) are reflected by part of the Earth's upper atmosphere. Recall that some radio waves (e.g. short wavelength) and microwaves pass through the Earth's atmosphere.
Use ripple tanks or microwave kits to show that waves spread out from a gap. Demonstration of single edge diffraction using a laser beam.	Recall that radio waves have a very long wavelength. Recognise that radio waves can 'spread' around large objects. Describe a practical example of waves spreading out from a gap.

Module P5: Space For Reflection

Item P5e: Satellite communication

Links to other items: P1c: A spectrum of waves, P1g: Wireless signals

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe how information can be transmitted using microwaves to orbiting artificial satellites and then retransmitted back to Earth or to other satellites. Explain why satellite communication uses digital signals.	Explain why satellite transmitting and receiving dishes need very careful alignment: • the size of a satellite communication dish is many times the microwave wavelength • this produces little diffraction hence a narrow beam that does not spread out • this means the receiving dish and satellite dish need exact alignment.
Describe how electromagnetic waves with different frequencies behave in the atmosphere: • below 30 MHz are reflected by the ionosphere • above 30 GHz, rain, dust and other atmospheric effects reduce the strength of the signal due to absorption and scattering • between 30 MHz and 30 GHz can pass through the Earth's atmosphere.	
Recall the wave patterns produced by a plane wave passing through different sized gaps. Explain why long wave radio waves have a very long range.	Describe how the amount of diffraction depends upon the size of the gap and the wavelength of the wave, including the conditions for maximum diffraction.

Module P5: Space For Reflection

Item P5f: Nature of waves

Summary: Particles can behave like waves. At other times waves behave like particles. The nature of waves and the interaction of particles is fundamental to our understanding of the world around us. This item looks at the most important of all wave properties – interference. When people talk about interference they usually mean 'noise' in an electronic system or 'crackle' in a radio receiver. In the topic of waves, interference means the effect produced when two waves meet and interact with each other.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Carry out a demonstration to show the interference of waves using a ripple tank. Listen to interference by placing two speakers 1m apart and playing the same note. Pupils will notice the loud and quiet spots. Look at waves down a slinky and see what happens when two waves travelling in opposite directions interfere with each other.	Describe interference as an effect resulting from two waves that overlap. Recognise that when waves overlap there are: • areas where the waves add together • areas where the waves subtract from each other. Describe the effect of interference on waves in different contexts, to include: • sound • light • water.
Examine the pattern of light made by a laser passing through two slits. Use OHP wave plates to show interference patterns. Use Polaroid lenses or filters to block out rays of light. Use Polaroid lenses or filters to show that light reflected off water is polarised.	Recall that light travels in straight lines, to include recall of evidence to support this theory (e.g. shadows and eclipses). Recognise that under certain circumstances light can 'bend'. Recall that all electromagnetic waves are transverse.
Compare the conflicting light theories of Huygens (waves) and Newton (particles) and how acceptance of the theories changed over time.	Recall that explanations of the nature of light have changed over time, with some scientists describing light as waves, and some scientists describing light as particles. Describe reflection of light in terms of a particle model.

Module P5: Space For Reflection

Item P5f: Nature of waves

Links to other items: P1c: A spectrum of waves, P1e: Cooking and communicating using waves, P1g: Wireless signals, P5g: Refraction of waves

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe the interference of two waves in terms of reinforcement and cancellation of the waves. Apply understanding of interference to describe practical examples of interference effects using sound waves, surface water waves or microwaves. Recall that coherent wave sources are needed to produce a stable interference pattern. Recall that for light the coherent sources are monochromatic light.	Explain interference patterns in terms of constructive and destructive interference. Explain how the number of half wavelengths in the path difference for two waves from the same source relates to the type of interference used. Describe the properties of coherent wave sources: • same frequency • in phase • same amplitude.
Describe diffraction of light for: • a single slit • double slits and that the interference patterns produced are evidence for the wave nature of light. Explain what is meant by plane polarised light. Understand that all electromagnetic waves are transverse waves and so can be plane polarised.	Explain a diffraction pattern for light to include: • the size of the gap must be of the order of the wavelength of light • how the diffracted waves interfere to produce the pattern. Explain how polarisation is used in the application of Polaroid filters and sunglasses, including: • light from some substances (e.g. water) is partly plane polarised • what the Polaroid filter does to this plane polarised light.
Explain why the particle theory of light is not universally accepted.	Explain how the wave theory of light has supplanted the particle theory, as the evidence base has changed over time.

Module P5: Space For Reflection

Item P5g: Refraction of waves

Summary: Drive along a road on a hot day and you may see water appear to be on the surface of the road. Even more strangely, however, is that this puddle is not actually there when you get there. Such optical illusions are common place and involve the passage of light as it enters and leaves different mediums. This item illustrates how phenomena can be explained by using scientific theories, models and ideas.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Carry out an experiment to compare the refractive indices of glass and perspex. Survey effects due to refraction such as mirages and apparent depth.	Describe and recognise that refraction involves a change in direction of a wave due to the wave passing from one medium into another. Explain why a ray of light travelling from air into glass has an angle of incidence usually greater than the angle of refraction.
Carry out experiments: • to produce a visible spectrum using a prism • recombine the spectral colours using two prisms • use two prisms and a slit to show that there is no further dispersion of a spectral colour.	Describe and recognise that dispersion happens when light is refracted. Recall the order of the spectral colours and relate this to the order of the wavelengths.
Look in detail at bicycle reflectors and cat's eyes to show that they are prisms. Use prisms to investigate total internal reflection (TIR). Show fibre optic cables in action. Fibre optic Christmas tree lights are a good source of these. Make a wall chart, leaflet or PowerPoint presentation of the many uses of TIR, including optical fibres, to illustrate the development of useful products from scientific ideas. Carry out an experiment to compare the critical incident angle of glass or perspex.	Describe and recognise that some, or all, of a light ray can be reflected when travelling from glass, or water, to air. Recall the many uses of TIR, including: • optical fibres • binoculars • reflectors and cat's eyes on the road and road signs.

Module P5: Space For Reflection

Item P5g: Refraction of waves

Links to other items: P1c: A spectrum of waves, P1e: Cooking and communicating using waves, P1g: Wireless signals, P5f: Nature of waves, P5h: Optics

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain why refraction occurs at the boundary between two media: • when the wave speed decreases the wave bends towards the normal • when the wave speed increases the wave bends away from the normal. Describe refractive index as a measure of the amount of bending after a boundary. Use the equation: $\text{refractive index} = \frac{\text{speed of light in vacuum}}{\text{speed of light in medium}}$	Interpret data on refractive indices and speed of light to predict the direction of refraction (Snell's law not required). Use the equation, including a change of subject: $\text{refractive index} = \frac{\text{speed of light in vacuum}}{\text{speed of light in medium}}$ This will require the use of standard form notation and/or a scientific notation calculator.
Recall that the amount of bending increases with greater change of wave speed and refractive index. Explain dispersion in terms of spectral colours having different wave speeds in different media but the same speeds in a vacuum.	Explain dispersion in terms of spectral colours having: • a different speed in glass • different refractive indices • blue light having a greater refractive index than red light.
Describe what happens to light incident on a glass/air surface when the angle of incidence is less than, equal to or above the critical angle. Describe the optical path in devices using TIR, including: • optical fibres • binoculars • reflectors and cat's eyes on the road and road signs. Recognise that different media have different critical angles.	Explain the conditions under which TIR can occur. Explain how the refractive index of a medium relates to its critical angle.

Module P5: Space For Reflection

Item P5h: Optics

Summary: Projecting an image onto a screen is a large industry and involves big money; especially if it's you they are projecting. The cameras used to film the movies use a complex arrangement of lenses to zoom in and focus on the actors, and the images they form are real but inverted.

On a more modest theme many people would struggle with day-to-day life or be unable to read clearly without spectacles. This item takes a look at the many uses of optical devices.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Carry out an experiment with a convex lens to focus the image of a distant object on the lab wall, e.g. window of lab or inside of lab window. Observe how the distance between the lens and screen varies with focal length. (Focusing image of a distant object on a screen.) Construct a simple telescope with one short focal length lens and one long focal length lens.	Recall and identify the shape of a convex lens. Recall that convex lenses are also called converging lenses. Describe what happens to light incident on a convex lens parallel to the axis. Describe the focal length of a convex lens as being measured from the centre of the lens to focal point (focus). Recognise and recall that 'fat' lenses have short focal lengths and 'thin' lenses have long focal lengths.
Carry out an experiment with convex lenses to see how the image of a light bulb varies with the distance of the bulb from the lens.	Recognise and recall that convex lenses produce real images on a screen.
Use pin hole cameras to explore how the size of the aperture (opening) affects both the sharpness and brightness of the image and how focusing is achieved with a lens. Examine different lenses from old spectacles to see the different shapes and thicknesses. Carry out an experiment with a convex lens to measure magnification. Examine an optical instrument. It may be a telescope, microscope or a camera. Look at the arrangement and number of lenses. Look in particular at their differing size and focal lengths.	Recall that convex lenses are used: • in cameras • in projectors • in some spectacles • as a magnifying glass.

Module P5: Space For Reflection

Item P5h: Optics

Links to other items: P5g: Refraction of waves

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe the effect of a convex lens on: • a diverging beam of light • a parallel beam of light. For a convex lens recall and recognise: • principal axis • focal length • focal point • optical centre of lens.	Explain the refraction by a convex lens of: • a ray travelling parallel to the principal axis before it is incident on the lens • a ray travelling through the focal point of the lens before it is incident on the lens • a ray incident on the centre of the lens.
Describe how a convex lens produces a real image on film and screen respectively. (A suitable diagram may be required or given.)	Explain how to find the position and size of the real image formed by a convex lens by drawing suitable ray diagrams.
Describe the use of a convex lens: • in a camera • in a projector • as a magnifying glass. Explain how the images produced by cameras and projectors are focused. Use the equation: $\text{magnification} = \frac{\text{image size}}{\text{object size}}$	Describe the properties of real and virtual images. Use the equation, including a change of subject: $\text{magnification} = \frac{\text{image size}}{\text{object size}}$

3.7 Module B6: Beyond The Microscope

Module B6: Beyond The Microscope

Item B6a: Understanding microbes

Summary: We are used to talking about plants and animals that can be seen and touched. Microscopic organisms such as bacteria, viruses and fungi tend to be either ignored or cause fear. This unit considers the characteristics of these organisms and gives some appreciation of the importance of scale in biology. Practical work with microorganisms develops the skills of working safely and accurately.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Examine greatly magnified images of bacteria and calculate magnification. 'How big would a cat be if we magnified it by the same factor?' is a useful problem to solve. Prepare a culture of bacteria on an agar plate using aseptic technique.	Recall that the size of a typical bacterial cell is just a few microns (thousandths of a mm). Identify and label parts of a flagellate bacillus as shown by *E. coli*, to include: • flagellum • cell wall • bacterial DNA. Recognise that bacteria can be classified by their shape. Describe how bacteria reproduce by splitting into two. Understand that bacteria can reproduce very rapidly in suitable conditions. Recognise that bacteria can be grown in large fermenters.
Make a slide of yeast and stain it with methylene blue and examine it under a microscope.	Recall that yeast is a fungus. Identify and label parts of a yeast cell, to include: • nucleus • cytoplasm • cell wall • bud. Describe how yeast reproduces asexually by budding.
	Understand that viruses are: • not living cells • much smaller than bacteria and fungi.

Module B6: Beyond The Microscope

Item B6a: Understanding microbes

Links to other items: B1c: Staying healthy, B2a: Classification, B3d: Cell division, B4g: Decay, B6b: Harmful microorganisms

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe how the parts of bacterial cells relate to their function, to include: • flagellum for movement • cell wall to maintain shape, and to stop it from bursting • DNA to control the cell's activities and replication of the cell. Describe the main shapes of bacteria as: • spherical • rod • spiral • curved rods. Recall that bacteria reproduce by a type of asexual reproduction called binary fission. Describe aseptic techniques for culturing bacteria on an agar plate.	Explain how bacteria: • can survive on an enormous range of energy sources • can exploit a very wide range of habitats because some bacteria can consume organic nutrients and others can make their own. Explain the consequences of very rapid bacterial reproduction in terms of food spoilage and disease. Explain reasons for the safe handling of bacteria.
Describe how yeast growth rate can be increased, its optimum growth rate being controlled by: • food availability • temperature • pH • removal of waste products.	Describe how yeast growth rate doubles for every 10°C rise in temperature until the optimum is reached.
Describe the structure of viruses as: • a protein coat • surrounding a strand of genetic material. Understand that viruses: • can only reproduce in other living cells • only attack specific cells • may attack plant, bacterial or animal cells.	Explain how a virus reproduces, to include: • attaching itself to a specific host cell • injecting its genetic material into the cell • using the cell to make the components of new viruses • causing the host cell to split open to release the viruses.

Module B6: Beyond The Microscope

Item B6b: Harmful microorganisms

Summary: Despite giving a range of useful products, some microorganisms are dangerous to humans. Each year millions of deaths are directly caused by bacteria and viruses. The work of Lister, Pasteur and Fleming illustrates how uncertainties in scientific knowledge change over time and the role of the scientific community in validating these changes.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
	Understand that some microorganisms are pathogens. Describe how pathogens can enter the body, limited to: • nose (airborne microorganisms) • mouth (contaminated food and water) • skin (insect bites, cuts, infected needles) • reproductive organs (contact). Relate different types of microorganisms to the disease they can cause, limited to: • cholera and food poisoning, caused by bacteria • influenza and chickenpox, caused by viruses • athlete's foot caused by a fungus.
Research how aid agencies such as the Red Cross respond rapidly to an emergency. Research incidence of disease following a recent natural disaster.	Recall that diseases such as cholera and food poisoning can be a major problem following a natural disaster such as earthquakes and erupting volcanoes.
Compare the effectiveness of different antiseptics/ antibiotics using a culture of bacteria on an agar plate (by measuring and comparing the diameters of the halos).	Recognise that harmful bacteria can be controlled by antibiotics. Understand that bacteria can develop resistance to antibiotics.

Module B6: Beyond The Microscope

Item B6b: Harmful microorganisms

Links to other items: B1c: Staying healthy, B6a: Understanding microbes

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Understand how the transmission of diseases can be prevented, limited to disease transmitted by: • food • water • contact • airborne droplets. Describe the stages of an infectious disease, to include: • entry into the body • rapid growth, the incubation period • production of many toxins • appearance of symptoms such as fever.	Interpret data on the incidence of influenza, food poisoning and cholera.
Explain why natural disasters cause a rapid spread of diseases, to include: • damage to sewage systems and water supplies • damage to electrical supplies causing rapid food decay • displacement of people • disruption to health services.	
Describe the pioneering work of the following scientists in the treatment of disease, limited to: • Pasteur and the germ theory of disease • Lister and the development of antiseptics • Fleming and the discovery of penicillin. Describe how antiseptics and antibiotics are used in the control of disease. Recall that viruses are unaffected by antibiotics. Explain how some strains of bacteria are developing resistance to antibiotics by natural selection.	Explain the importance of various procedures in the prevention of antibiotic resistance, to include: • only prescribing antibiotics when necessary • completion of the dose.

Module B6: Beyond The Microscope

Item B6c: Useful microorganisms

Summary: As we begin to understand how microorganisms work, we can develop new ways of using them as well as making existing processes more efficient.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Make yoghurt using freshly pasteurised milk and a starter culture of live yoghurt. Measure and record the pH of milk as it is converted to yoghurt using pH paper/pH meter/data logger. Consider adverts for 'pro-biotic' yoghurts.	Recall that some bacteria are useful in: • yoghurt making • cheese production • vinegar production • silage production • composting.
Brewing beer, cider or wine. A 'home brew' beer or wine kit can be used to demonstrate the principles of fermentation. Collect gas from fermenting sugar and test it for carbon dioxide. Carry out experiments to show how yeast activity is affected by temperature.	Describe fermentation as the production of alcohol, including wine and beer, by the breakdown of sugars by yeast in the absence of oxygen. Recall that a gas, carbon dioxide, is also produced during fermentation.
	Recall that some products of fermentation can be further treated to increase the alcohol concentration to produce spirits.

Module B6: Beyond The Microscope

Item B6c: Useful microorganisms

Links to other items: B3c: Respiration, B6a: Understanding microbes

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe the main stages in making yoghurt, to include: • sterilisation of equipment • pasteurisation of milk • incubation of culture • sampling • addition of flavours, colours and packaging.	Describe the action of *Lactobacillus* bacteria in yoghurt making, to include: • the breakdown of lactose in milk • the production of lactic acid.
Recall and use the word equation for fermentation (anaerobic respiration in yeast): glucose (sugar) → ethanol (alcohol) + carbon dioxide Describe the main stages in brewing beer or wine, to include: • extracting sugar from source material • adding yeast, keeping it warm • preventing entry of air and other microorganisms • clarifying/clearing, drawing off the wine/beer • pasteurising, casking or bottling.	Recall and use the balanced chemical equation for fermentation (anaerobic respiration): $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$ Explain the implications for the fermentation process of yeast being able to undergo aerobic or anaerobic respiration. Interpret data on the breakdown of sugar by yeast in different conditions such as changing temperature and the presence or absence of oxygen. Describe what is meant by the term pasteurisation and explain why this needs to be done in the case of bottled beers.
Describe the process of distillation to increase the alcohol concentration, and understand that this commercial process needs licensed premises.	Understand how fermentation is limited by the effects of increasing levels of alcohol. Understand that different strains of yeast can tolerate different levels of alcohol.

Module B6: Beyond The Microscope

Item B6d: Biofuels

Summary: With problems of declining stocks of fossil fuels and long term problems of nuclear energy, many countries are developing cleaner fuels which need only simple technology. Many of these processes involve the use of microorganisms.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
	Explain how plants produce biomass. Recognise examples of fuels from biomass, to include: • alcohol • biogas • wood.
Research the use of biogas in Nepal. Design a biogas digester and display the plans as a chart. Research use of biogas in cities such as Newcastle and Leeds.	Understand why biogas (mainly methane) is an important energy resource in certain remote parts of the world lacking a mains electricity supply or mains sewage system. Recall that the rotting of organic material such as dead plants and animal waste: • occurs in marshes, septic tanks and animal digestive systems • produces a mixture of gases including methane • is caused by the action of bacteria. Recall that biogas can be produced on a large scale using a digester. Explain why methane being released from landfill sites is dangerous: it can burn or explode preventing use of the site for many years.
	Recall that alcohol: • can be made from yeast • can be used as a biofuel by mixing with petrol.

Module B6: Beyond The Microscope

Item B6d: Biofuels

Links to other items: B2g: Population and pollution, B4h: Farming

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe different methods of transferring energy from biomass, to include: • burning fast growing trees • fermenting biomass using bacteria or yeast. Given data, evaluate different methods of transferring energy from biomass. Describe the advantages of using biofuels, to include: • alternative sources to fossil fuels • no increase in greenhouse gas levels • no particulates produced.	Explain why the burning of biofuels does not cause a net increase in greenhouse gas levels if: • they are burnt at the same rate as the biomass is being produced • areas of land are not cleared of other vegetation in order to grow crops for biofuels. Explain how, in some areas, the use of large areas of land to produce biofuels is resulting in: • habitat loss • extinction of species.
Recall that biogas contains: • mainly methane • some carbon dioxide • traces of hydrogen, nitrogen and hydrogen sulfide. Describe how methane can be produced on a large scale using a continuous flow method of providing organic waste and removing the gas and remaining solids. Describe the uses of biogas, to include: • burning to generate electricity • burning to produce hot water and steam for heating systems • used as a fuel for vehicles. Describe how biogas production is affected by temperature.	Recall that biogas containing more than 50% methane can be burnt in a controlled way but a lower percentage of about 10% is explosive. Understand that biogas is a 'cleaner' fuel than diesel and petrol but does not contain as much energy as natural gas. Explain why biogas production is affected by temperature.
Recall that a mixture of petrol and alcohol: • is called gasohol • is used for cars in countries such as Brazil.	Understand why gasohol is more economically viable in countries that have ample sugar cane and small oil reserves.

Module B6: Beyond The Microscope

Item B6e: Life in soil

Summary: Life above ground is obvious. Life below ground is just as diverse and essential in maintaining the recycling of important elements and providing the correct conditions for plant growth. Without the action of soil life we would have to climb over dead dinosaur bodies to get to school and many important elements would be unavailable.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Carry out an experiment to show that life is present in a soil sample (using lime water or bicarbonate indicator). Investigate the humus, air and water content of soil.	Describe the main components of soil as being: • different sized mineral particles • dead material • living organisms • air • water.
Identify soil fauna and flora using identification keys. Examine microscopic soil life using light and binocular microscopes.	Describe a typical food web in a soil, to include: • herbivores such as slugs, snails and wire worms • detritivores such as earthworms, millipedes and springtails • carnivores such as centipedes, spiders and ground beetles. Describe the role of bacteria and fungi as decomposers.
Compare the composition of different soils.	Explain why soil is important for the majority of plants.
Set up a wormery.	Recognise that earthworms can improve soil structure and fertility.

Module B6: Beyond The Microscope

Item B6e: Life in soil

Links to other items: B2b: Energy flow, B2c: Recycling, B4a: Ecology in the local environment, B4g: Decay

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe the difference between a sandy soil and a clay soil in terms of particle size. Recall that loam is a soil that contains a mixture of clay and sand. Recall that if the dead material in soil is largely decomposed, it is called humus. Describe simple experiments to compare the humus, air and water content of different soils.	Explain how particle size affects the air content and permeability of soils. Explain the results of soil experiments in terms of mineral particle size and organic matter content.
Interpret data on soil food webs.	
Explain why some life in soil depends on a supply of oxygen and water. Explain the importance of humus in the soil, limited to: • decomposition to release minerals • increasing the air content.	Explain why aerating and draining will improve soils. Explain why neutralising acidic soils and mixing up soil layers is important.
Explain why earthworms are important to soil structure and fertility, to include: • burying organic material for decomposition by bacteria and fungi • aerating and draining the soil • mixing up soil layers • neutralising acidic soil.	Recognise the part played by Charles Darwin in highlighting the importance of earthworms in agriculture.

Module B6: Beyond The Microscope

Item B6f: Microscopic life in water

Summary: More than two thirds of the Earth's surface is covered by water, mostly sea water. Life in water is different from life on land yet it shows the same incredible variation. Some of this life is obvious, due to its size, but it all depends on microscopic plankton for a source of food. Since there seems to be so much water, we have unfortunately used it to dispose of waste causing extensive damage to aquatic life.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Examine microscopic life in pond water.	Recognise that there are a wide variety of microorganisms living in water.
Examine living *Daphnia* to observe internal structures such as its heart and digestive system.	Recognise that plankton are microscopic plants (phytoplankton) and microscopic animals (zooplankton). Recall that phytoplankton are capable of photosynthesis and are producers in aquatic food chains and webs. Understand that plankton: • have limited movement and so rely on water currents • show seasonal variations in numbers due to variations in light, temperature and minerals.
Research the effect of marine pollution on whale species and other marine organisms.	Recall that the variety and numbers of aquatic microorganisms can be affected by pollution and acid rain. Recognise various pollutants of water, to include: oil, sewage, PCBs, fertilisers, pesticides and detergents. Analyse data on water pollution to determine the pollution source.

Module B6: Beyond The Microscope

Item B6f: Microscopic life in water

Links to other items: B2b: Energy flow, B4a: Ecology in the local environment

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain the advantages of life in water, limited to: • no problem of water shortage and dehydration • less variation in temperature • more support • easy disposal of waste products. Explain the disadvantages of life in water, limited to: • regulating water content • resistance to movement.	Explain the problems of water balance caused by osmosis. Describe the action of contractile vacuoles in microscopic animals such as amoeba.
Describe how factors affecting photosynthesis vary at different depths and in different seasons in water, to include: • light • temperature • minerals. Interpret data on seasonal fluctuations in phytoplankton and zooplankton.	Interpret data on marine food webs. Understand that 'grazing food webs' are most common in the oceans but some food chains rely on: • 'marine snow' • bacteria, deep in the ocean, acting as producers.
Explain how sewage and fertiliser run-off can cause eutrophication, to include: • rapid growth of algae • resulting death and decay • using up oxygen • causing the death of animals unable to respire. Describe how certain species of organisms are used as biological indicators for pH and oxygen levels.	Explain the accumulative, long term effect of PCBs and DDT on animals such as whales.

Module B6: Beyond The Microscope

Item B6g: Enzymes in action

Summary: Many effects of microorganisms are based on the enzymes they contain. Enzymes are specific and catalyse many reactions which are useful to humans. They enable reactions which normally take place at much higher temperatures to work at low temperatures (thus saving energy).

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Investigate the effectiveness of a biological washing powder in removing food stains. Plan or perform an investigation to find the effects of temperature, soaking time or concentration of washing powder solution on the efficiency of stain removal.	Describe everyday uses of enzymes, limited to: • biological washing powders and stain removers • cheese making and juice extraction • the preparation of medical products such as reagent sticks • altering the flavour of food products. Recall that biological washing powders do not work at high temperature and extremes of pH.
Demonstrate the use of 'clinistix' or 'dextrostix' to determine the glucose concentration of a series of 'spoof urines'. (Glucose dissolved in a solution of water, a trace of marmite and 1 drop of washing up liquid so it looks like urine.)	Describe how people with diabetes test their urine (using either Benedict's test or reagent strip sticks) for the presence of glucose.
Immobilise enzymes in alginate beads and investigate the effect on a substrate.	Recall how some enzymes can be immobilised: • in gel beads • on reagent sticks. Recall that immobilised enzymes on reagent sticks can be used to measure glucose levels in the blood.

Module B6: Beyond The Microscope

Item B6g: Enzymes in action

Links to other items: B3b: Proteins and mutations

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe the enzymes in biological washing powders, to include: • amylases – to digest the carbohydrate starch • lipases – to digest fat and remove fatty stains • proteases – to digest protein and remove protein stains. Explain why biological washing powders work best at moderate temperatures.	Explain why the products of digestion will easily wash out of clothes, in terms of their solubility. Explain why biological washing powders may not work in acidic or alkaline tap water.
Describe how sucrose can be broken down by the use of an enzyme called sucrase (invertase). Recognise that, when sucrose is broken down by enzymes, the product is much sweeter, making it useful to the food industry.	Explain how foods are sweetened using invertase: • invertase converts sucrose into glucose and fructose • these sugars are much sweeter than the sucrose • foods can therefore be sweetened without adding so much sugar (e.g. in low calorie foods).
Describe how enzymes can be immobilised in gel beads by: • mixing the enzyme with alginate • dropping the mixture into calcium chloride solution. Explain the advantages of immobilising enzymes, to include: • the mixture not becoming contaminated with the enzyme • immobilised enzymes in alginate beads can be used in continuous flow processing.	Explain the condition of lactose intolerance: • they cannot produce the enzyme lactase • so bacteria in the gut ferment lactose • fermentation produces diarrhoea and wind. Explain the principles behind the production of lactose-free milk for people with lactose intolerance, to include: • immobilised lactase converting lactose in milk into glucose and galactose • these simple sugars can then be absorbed.

Module B6: Beyond The Microscope

Item B6h: Gene technology

Summary: Biotechnology is “using life to make things”. Genetic engineering has the potential to alter life on Earth in a very short time span by transferring genes from one organism to another. Genetic engineering is possible due to the availability of enzymes that can be used to manipulate DNA. The same enzymes can be used to produce DNA ‘fingerprints’.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Extract DNA from onions, kiwi fruit or wheat germ.	Define genetic engineering as altering the genetic code of an organism by inserting genes. Understand that genes from one organism can work in another. Describe the process of genetic engineering: • removing a gene from one organism • inserting it into another organism • the gene works in the new organism.
Use gene splicing kits (using a luminous gene from jelly fish).	Recall that bacteria can be genetically engineered to produce useful human proteins, to include: • insulin • human growth hormone. Describe how these bacteria can be grown in large fermenters to produce large quantities of proteins.
Examine DNA ‘fingerprinting’ results. Use DNA ‘fingerprinting kits’ (using lambda phage DNA).	Recall that a person’s DNA can be used to produce a DNA ‘fingerprint’. Understand that this can be used to identify a person because a person’s DNA is unique.

Module B6: Beyond The Microscope

Item B6h: Gene technology

Links to other items: B3a: Molecules of life, B3g: New genes for old

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Recall that the new type of organism produced by genetic engineering is called a transgenic organism. Describe the main stages in genetic engineering: • identification of a desired gene in one organism • removal of gene from DNA • cutting open the DNA in another organism • inserting the new gene into the DNA • gene works in transgenic organism • transgenic organism can be cloned to produce identical copies. Recall that the cutting and inserting of DNA is achieved using enzymes.	Explain why genes from one organism can work in another, making genetic engineering possible. Explain how: • restriction enzymes cut open DNA to leave 'sticky ends' • the 'sticky ends' allow ligase enzymes to rejoin DNA strands.
Describe how bacteria can be used in genetic engineering to produce human insulin, to include: • the gene for producing human insulin is cut out of human DNA • a loop of bacterial DNA is cut open • the insulin gene is inserted into the loop • the loop is inserted into a bacterium • the bacteria are then able to produce insulin • transgenic bacteria are cultured by cloning • large quantities of insulin are harvested.	Recall that bacteria have loops of DNA called plasmids in their cytoplasm. Explain how, because these plasmids can be taken up by bacteria, they can be used as 'vectors' in genetic engineering. Recall that assaying techniques are used to check that the new gene has been correctly transferred.
Interpret data on DNA 'fingerprinting' for identification. Describe the arguments for and against the storage of DNA 'fingerprints'.	Describe the stages in the production of a DNA 'fingerprint', to include: • extraction of DNA from sample • fragmentation of DNA using restriction enzymes • separation using electrophoresis • visualising pattern using a radioactive probe.

3.8 Module C6: Chemistry Out There

Module C6: Chemistry Out There

Item C6: Fundamental Chemical Concepts

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

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

Module C6: Chemistry Out There

Item C6: Fundamental Chemical Concepts

Links to other modules: C1 to C6

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Construct word equations (not all reactants and products given).	
Construct balanced symbol equations given the formulae (no brackets) of the reactants and products. Explain why a symbol equation is balanced.	Construct balanced symbol equations given the formulae (some or all with brackets) of the reactants and products. Construct balanced symbol equations given the names of the reactants and products (limited to the learning outcomes in C6).
Deduce the number of atoms in a formula with brackets. Deduce the number of each type of different atom in a formula with brackets. Recall the formula of the following substances: • chlorine, hydrogen, oxygen and water • calcium carbonate and carbon dioxide • ethanoic acid.	Recall the formula of the following substances: • sulfates and chlorides of calcium, iron(II), magnesium, tin(II) and zinc • calcium hydrogencarbonate and sodium carbonate • ethanol and glucose.
Understand that a displayed formula shows both the atoms and the bonds in a molecule. Write the molecular formula of a compound given its displayed formula.	Construct balanced equations using displayed formulae.
Understand that positive ions are formed when electrons are lost from atoms. Understand that negative ions are formed when electrons are gained by atoms.	
Understand that an ionic bond is the attraction between a positive ion and a negative ion. Understand that a covalent bond is a shared pair of electrons.	Explain how an ionic bond is formed. Explain how a covalent bond is formed.

Module C6: Chemistry Out There

Item C6a: Electrolysis

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

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

Module C6: Chemistry Out There

Item C6a: Electrolysis

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

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe electrolysis in terms of flow of charge by moving ions and the discharge of ions at the electrodes.	
Recall the products of the electrolysis of: • NaOH(aq) – hydrogen at cathode and oxygen at anode • H_2SO_4(aq) – hydrogen at cathode and oxygen at anode.	Construct the half equations for the electrode processes that happen during the electrolysis of NaOH(aq) or H_2SO_4(aq) given the formula of the ions present in the electrolyte: • cathode – $2H^+ + 2e^- \rightarrow H_2$ • anode – $4OH^- - 4e^- \rightarrow O_2 + 2H_2O$ Explain why the electrolysis of NaOH(aq) makes H_2 rather than Na at the cathode.
Recall the products of the electrolysis of $CuSO_4$(aq) with carbon electrodes: • copper is formed at the cathode and oxygen at the anode. Understand how the amount of substance produced during electrolysis varies with time and current.	Construct the half equations for electrode processes that happen during the electrolysis of $CuSO_4$(aq) using carbon electrodes: • cathode – $Cu^{2+} + 2e^- \rightarrow Cu$ • anode – $4OH^- - 4e^- \rightarrow O_2 + 2H_2O$ Perform calculations based on current, time and the amount of substance produced in electrolysis.
Explain why an ionic solid cannot be electrolysed but the molten liquid can be electrolysed: • ionic solid has ions which are in fixed positions and cannot move • ions in the molten liquid can move.	Construct the half equations for the electrode processes that happen during the electrolysis of molten binary ionic compounds given the formulae of the ions present in the electrolyte.

Module C6: Chemistry Out There

Item C6b: Energy transfers – fuel cells

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

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

Module C6: Chemistry Out There

Item C6b: Energy transfers – fuel cells

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

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Construct the balanced symbol equation for the reaction between hydrogen and oxygen.	Draw and interpret an energy level diagram for the reaction between hydrogen and oxygen. Draw and interpret energy level diagrams for other reactions given appropriate information.
Construct the balanced symbol equation for the overall reaction in a hydrogen-oxygen fuel cell.	Explain the changes that take place at each electrode in a hydrogen-oxygen fuel cell: • construct the equations for the electrode reactions given the formula of the ions present and the products • redox reactions at each electrode.
List some advantages of using a hydrogen-oxygen fuel cell to provide electrical power in a spacecraft: • provides water that can be used by astronauts • lightweight • compact • no moving parts.	Explain the advantages of a hydrogen-oxygen fuel cell over conventional methods of generating electricity.
Explain why the car industry is developing fuel cells: • no carbon dioxide emissions from the car • fossil fuels such as petrol are non-renewable • large source of hydrogen available by decomposing water.	Explain why the use of hydrogen-oxygen fuel cells will still produce pollution: • fuel cells often contain poisonous catalysts that have to be disposed of at the end of the lifetime of the fuel cell • production of the hydrogen and oxygen will involve the use of energy which may have come from the burning of fossil fuels.

Module C6: Chemistry Out There

Item C6c: Redox reactions

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

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

Module C6: Chemistry Out There

Item C6c: Redox reactions

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

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

Module C6: Chemistry Out There

Item C6d: Alcohols

Summary: There is a large group of compounds called alcohols. Ethanol is an example of an alcohol. Ethanol, which is renewable, can provide an alternative to crude oil as a source of fuel and organic compounds.

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

Module C6: Chemistry Out There

Item C6d: Alcohols

Links to other items: C1a: Making crude oil useful, C1b: Using carbon fuels, C3g: Batch or continuous?

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

Module C6: Chemistry Out There

Item C6e: Depletion of the ozone layer

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

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

Module C6: Chemistry Out There

Item C6e: Depletion of the ozone layer

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

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain why the use of CFCs has been banned in the UK: • society has agreed with scientists' views that CFCs deplete the ozone layer.	Describe and explain how scientists' attitude to CFCs has changed: • initial enthusiasm for the use of CFCs based upon their inertness • later discovery of ozone depletion and link to presence of CFCs • acceptance by scientists and the rest of the world community that the use of CFCs should be banned.
Describe how CFCs deplete the ozone layer: • CFC molecules are broken down in the stratosphere by ultraviolet light to give highly reactive chlorine atoms • chlorine atoms react with ozone molecules • chlorine atoms are regenerated so can react with more ozone molecules. Construct an equation to show the formation of chlorine atoms from CFCs. Recall that a chlorine radical is a chlorine atom. Explain why CFCs are only removed slowly from the stratosphere.	Explain in terms of electrons how a carbon-chlorine bond can break to form highly reactive chlorine atoms. Explain why only a small number of chlorine atoms will destroy a large number of ozone molecules. Interpret the symbol equations for the reactions that take place when chlorine atoms and ozone react. Explain why CFCs will continue to deplete ozone a long time after their use has been banned.
Describe how depletion of the ozone layer allows more ultraviolet light to reach the surface of the Earth.	Explain how ozone absorbs ultraviolet light in the stratosphere.
Recall that CFCs can be replaced with alkanes or HFCs and that these will not damage the ozone layer.	

Module C6: Chemistry Out There

Item C6f: Hardness of water

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

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

Module C6: Chemistry Out There

Item C6f: Hardness of water

Links to other items: C4h: Purifying and testing water

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

Module C6: Chemistry Out There

Item C6g: Natural fats and oils

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

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

Module C6: Chemistry Out There

Item C6g: Natural fats and oils

Links to other items: C1a: Making crude oil useful, C1f: Cooking and food additives, C1g: Smells, C6h: Detergents

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

Module C6: Chemistry Out There

Item C6h: Detergents

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

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

Module C6: Chemistry Out There

Item C6h: Detergents

Links to other items: C6g: Natural fats and oils

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

3.9 Module P6: Electricity For Gadgets

Module P6: Electricity For Gadgets

Item P6a: Resisting

Summary: Most electrical devices have some form of control built into their circuits. These increase or decrease current according to an input. Simple examples are the volume of a personal CD-player or the speed of a food processor. More sophisticated examples include the ability to program devices such as microwave cookers or DVD players. The latter is covered more in the last two items of this module.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Carry out an experiment using a variable resistor as a dimmer unit to control the brightness of a bulb and measure the current in the circuit.	Recognise and draw the circuit symbols for a resistor, variable resistor (rheostat), bulb, cell, battery, switch and power supply. Describe and recognise that a variable resistor (rheostat) can be used to vary the brightness of a lamp.
Carry out an experiment to investigate the voltage-current characteristics of ohmic conductors.	Recall the units of voltage, current and resistance. Use the equation: $\text{resistance} = \frac{\text{voltage}}{\text{current}}$ Recall and identify that for a given ohmic conductor the current increases as the voltage increases.
Carry out an experiment to investigate the voltage-current characteristics of a non-ohmic device, such as a bulb.	Understand that current in a wire is a flow of charge carriers called electrons. Use models of atomic structure to explain electrical resistance in a metal conductor in terms of charge carriers (electrons) colliding with atoms (ions) in the conductor. Recall and identify how the resistance changes as a wire becomes hot.

Module P6: Electricity For Gadgets

Item P6a: Resisting

Links to other items: P4c: Safe electricals, P6b: Sharing

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain the effect of a variable resistor (rheostat) in a circuit in terms of: • control of the current • varying the brightness of a bulb or speed of a motor.	Explain the effect of changing the length of resistance wire in a variable resistor (rheostat) on the resistance.
Use the equation, including a change of subject: $\text{resistance} = \frac{\text{voltage}}{\text{current}}$ Use a voltage-current graph qualitatively to compare the resistances of ohmic conductors.	Calculate the resistance of an ohmic conductor from a voltage-current graph.
Use kinetic theory to explain that for metallic conductors, the collision of charge carriers with atoms makes the atoms vibrate more. This increased atomic vibration: • causes an increase in collisions (increased resistance) • increases the temperature of the conductor. Describe and recognise how a voltage-current graph shows the changing resistance of a non-ohmic device, such as a bulb.	Explain the shape of a voltage-current graph for a non-ohmic conductor, such as the filament in a lamp, in terms of increasing resistance and temperature.

Module P6: Electricity For Gadgets

Item P6b: Sharing

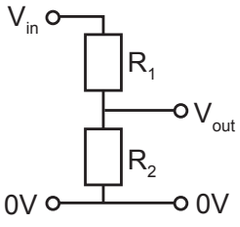
Summary: Electronic circuits rely on supply voltage (pd) being split into two smaller voltages. Sometimes, these output voltages also need to be adjusted to a threshold level to give the required output voltage. This item develops ideas about how both fixed and variable resistors are used, together with LDRs and thermistors, to achieve the desired output voltage.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Examine a potential divider circuit in an electronic device. Use a rheostat as a potential divider to control the brightness of two bulbs in series.	Recall that a potential divider is used to produce a required voltage in a circuit. Understand that two or more resistors in series increase the resistance of the circuit. Calculate the total resistance for resistors in series e.g. $R_T = R_1 + R_2 + R_3$
Use multimeters to show how the resistance of light dependent resistors (LDRs) and thermistors are affected by external conditions. Examine circuits which use LDRs to control output e.g. lights which come on at night. Examine circuits which use thermistors to control output. Investigate how the fixed resistor in a potential divider can affect the output voltage in temperature sensors and light sensors.	Recognise and draw the symbol for an LDR and a thermistor. Recall and identify that an LDR responds to a change in light level. Recall and identify that a thermistor responds to changes in temperature.
Use multimeters to measure the resistance of resistors individually, in series and in parallel.	

Module P6: Electricity For Gadgets

Item P6b: Sharing

Links to other items: P6a: Resisting

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain how two fixed resistors can be used as a potential divider. Understand that the output voltage depends on the relative values of the resistors R_1 and R_2. Explain how one fixed resistor and one variable resistor in a potential divider allows variation of the output voltage.	Calculate the value of V_{out} when R_1 and R_2 are in a simple ratio.  Understand that when R_2 is very much greater than R_1, the value of V_{out} is approximately V_{in}. Understand that when R_2 is very much less than R_1, the value of V_{out} is approximately zero. Explain how two variable resistors can be used in place of the two fixed resistors to provide an output voltage with an adjustable threshold.
Describe how the resistance of an LDR varies with light level. Describe how the resistance of a thermistor (ntc only) varies with temperature.	Explain why an LDR or a thermistor can be used in place of R_2 in a potential divider with a fixed resistor to provide an output signal which depends on light or temperature conditions.
Understand that placing resistors in parallel rather than in series will reduce the total resistance of the circuit.	Calculate the total resistance for resistors in parallel e.g. $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

Module P6: Electricity For Gadgets

Item P6c: It's logical

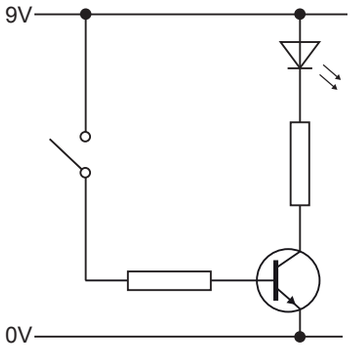
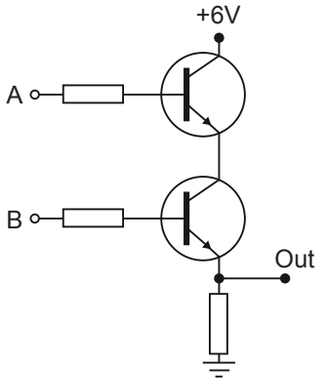
Summary: Many electronic devices rely on some form of logic circuit. The personal computer is probably the best known example, but washing machines and car ignitions also contain the silicon chip. This item develops ideas about logic circuits and the gates which are used.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Examine a simple NPN transistor circuit used as a switch. View a microprocessor chip with casing removed using a microscope.	Recall that the transistor is the basic building block of electronic components and that the average computer may have millions/billions of them within its circuits. Recall that the transistor is an electronic switch. Recognise and draw the symbol for an NPN transistor and label its terminals.
Examine a combination of transistors used as an AND gate.	Recall that transistors can be connected together to make logic gates. Recall that the input signal for a logic gate is either a high voltage (about 5 V) or a low voltage (about 0 V).
Show that setting conditions, such as either driver's door OR passenger's door OR both doors need to be open before the courtesy light in a car switches on, leads to a truth table. Carry out experiments to show the actions of NOT, AND and OR (higher tier NAND and NOR) logic gates. Build logic gate circuits to solve problems.	Describe the truth table for a NOT logic gate in terms of high and low signals.

Module P6: Electricity For Gadgets

Item P6c: It's logical

Links to other items: P6d: Even more logical

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe the benefits and drawbacks of increasing miniaturisation of electronic components to manufacturers and to users of the products. Understand how a small base current (I_b) is needed to switch a greater current flowing through the collector (I_c) and emitter (I_e). Use the equation: $I_e = I_b + I_c$	Explain how increasing availability of computer power requires society to make choices about acceptable uses of new technologies. Complete a labelled circuit diagram to show how an NPN transistor can be used as a switch for a light-emitting diode (LED).  Explain why a high resistor is placed in the base circuit.
Recognise the circuit diagram for an AND gate as two transistors connected together.  Recall that other logic gates can be made from a combination of two transistors.	Complete a labelled diagram to show how two transistors are connected to make an AND gate.
Describe the truth tables for AND and OR logic gates in terms of high and low signals.	Describe the truth table for NAND and NOR logic gates in terms of high and low signals.

Module P6: Electricity For Gadgets

Item P6d: Even more logical

Summary: In practice, most electronic devices require many logic gates combined to give the necessary output under a variety of conditions. This item develops ideas about how truth tables are used to show how logic gates can be combined.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Examine common devices which use more than one logic gate.	Recall and identify the input and output signals in an electronic system with a combination of logic gates.
Carry out investigations to solve problems using two or more logic gates combined together. Investigate the operation of a relay.	Recognise that the output current from a logic gate is able to light an LED. Recognise and draw the symbols for an LED and a relay. Recall that a relay can be used as a switch.

Module P6: Electricity For Gadgets

Item P6d: Even more logical

Links to other items: P6c: It's logical

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Complete a truth table of a logic system with up to three inputs made from logic gates.	Complete a truth table of a logic system with up to four inputs made from logic gates.
Describe how to use switches, LDRs and thermistors in series with fixed resistors to provide input signals for logic gates.	Explain how a thermistor or an LDR can be used with a fixed resistor to generate a signal for a logic gate which depends on temperature or light conditions. Explain how a thermistor or an LDR can be used with a variable resistor to provide a signal with an adjustable threshold voltage for a logic gate.
Explain how an LED and series resistor can be used to indicate the output of a logic gate. Describe how a relay uses a small current in the relay coil to switch on a circuit in which a larger current flows.	Explain why a relay is needed for a logic gate to switch a current in a mains circuit: • a logic gate is a low power device that would be damaged if exposed directly to mains power • the relay isolates the low voltage in the sensing circuit from the high voltage mains.

Module P6: Electricity For Gadgets

Item P6e: Motoring

Summary: Many of the electrical devices we use every day contain electric motors. They can be very small such as in a CD player or much larger in devices such as washing machines. This item develops ideas about the magnetic effect of an electric current and how magnetic fields interact to produce the movement needed for a motor.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Examine the magnetic field around a current-carrying wire and a coil. Show that a current-carrying wire placed in a magnetic field has a force acting on it.	Recall that a current-carrying wire has a circular magnetic field around it. Describe and recognise that this field is made up of concentric circles. Explain why a current-carrying straight wire placed in a magnetic field can move.
Examine the construction of both simple and practical motors. Research electric motors. Build a DC motor.	Recall that motors are found in a variety of everyday applications e.g. washing machine, CD player, food processor, electric drill, fan, windscreen wiper. Recall that electric motors transfer energy to the load (as useful work) and to the surroundings (as waste heat).

Module P6: Electricity For Gadgets

Item P6e: Motoring

Links to other items: P6f: Generating

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe the shape of the magnetic field around a straight wire, a rectangular coil and a solenoid. Understand that a current-carrying wire at right angles to a magnetic field experiences a force. Describe the effect of reversing the current and/or the direction of the magnetic field.	Explain how Fleming's Left Hand Rule is used to predict the direction of the force on a current-carrying wire.
Explain how the forces on a current-carrying coil in a magnetic field produce a turning effect on the coil. Explain how this effect is used in a simple DC electric motor. Describe the effect of changing: • the size of the electric current • the number of turns on the coil • the strength of the magnetic field.	Explain how the direction of the force on the coil in a DC electric motor is maintained in terms of the change of current direction every half-turn. Describe how this is achieved using a split-ring commutator in a simple DC electric motor. Explain why practical motors have a radial field produced by curved pole pieces.

Module P6: Electricity For Gadgets

Item P6f: Generating

Summary: Electricity is a very convenient energy source which allows us to use the everyday appliances at home, school and work. As well as being convenient it is readily available, easy to use, versatile and clean at the point of use. This item develops ideas about how electricity is generated.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Demonstrate the induction effect using a strong magnet and a wire. Using a coil and a strong magnet, show the effect of increasing the number of turns and changing the relative motion of the magnet and coil. Build a model generator. Examine and research the differences between a model generator and a generator in a power station.	Describe and recognise the dynamo effect: electricity can be generated by: • moving a wire near a magnet • moving a magnet near a wire. Label a diagram of an AC generator to show the coil, magnets, slip rings and brushes.
Examine ways in which the electrical output from a generator can be increased. Compare the voltage output of AC and DC generators using a cathode-ray oscilloscope (CRO) and investigate how rotation speed affects the output.	Describe a generator as a motor working in reverse. Explain why electricity is useful: • enables energy to be easily transmitted over long distances • enables energy to be stored for future use. Recall that in the UK, mains electricity is supplied at 50 Hz.

Module P6: Electricity For Gadgets

Item P6f: Generating

Links to other items: P2b: Generating electricity, P6e: Motoring

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Understand that a voltage is induced across a wire when the wire moves relative to a magnetic field. Understand that a voltage is induced across a coil when the magnetic field within it changes. Describe the effect of reversing the direction of the changing magnetic field.	Explain how the size of the induced voltage depends on the rate at which the magnetic field changes.
Explain why the rotation of a magnet inside a coil of wire induces an alternating current. Recall that electricity is generated in a power station when an electromagnet rotates inside coils of wire. Describe how changing the speed of rotation of the electromagnet's coil(s) affects the size and frequency of the voltage generated. Describe how changing the number of turns on the electromagnet's coil(s) affects the size of the voltage generated.	When provided with a diagram, explain how an AC generator works, including the action of the slip rings and brushes.

Module P6: Electricity For Gadgets

Item P6g: Transforming

Summary: There are many electrical and electronic devices which work on voltages much lower than mains voltage. Electricity is transmitted around the country at voltages very much higher than mains voltage. This means that the current is lower, therefore, less energy is wasted heating up the power lines. This item develops ideas about transformers as devices which change voltage or isolate a supply. The research on the different voltages in the National Grid allow the use of ICT as a teaching and learning resource.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Examine household devices that contain transformers. Demonstrate step-up and step-down transformers.	Recall that transformers are devices that: • work with AC and do not work with DC • do not change AC into DC. Understand and use the terms step-up transformer and step-down transformer. Recall that step-down transformers are used in a variety of everyday applications e.g. phone chargers, radios, laptops.
	Recognise and draw the symbol for a transformer. Recall that an isolating transformer is used in a bathroom shaver socket.
Research how different voltages are used in the National Grid. Research how real transformers in the National Grid work. Demonstrate model power lines to show power losses.	Recall that step-up transformers are used to increase the voltage from the generator at a power station to supply the National Grid. Recall that step-down transformers are used in sub-stations to reduce the voltage for domestic and commercial use.

Module P6: Electricity For Gadgets

Item P6g: Transforming

Links to other items: P2b: Generating electricity

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe the construction of a transformer as two coils of wire wound on an iron core. Describe the difference in construction of a step-up and a step-down transformer and how this construction changes the size of the output.	Explain why the use of transformers requires the use of alternating current. Describe how the changing field in the primary coil of a transformer induces an output voltage in the secondary coil. Use and manipulate the equation: $\frac{\text{voltage across primary coil}}{\text{voltage across secondary coil}} = \frac{\text{no.primary turns}}{\text{no.secondary turns}}$
Explain why an isolating transformer is used in some mains circuits (e.g. bathroom shaver socket).	Explain why isolating transformers: • have equal numbers of turns in the primary and secondary coils • improve safety in some mains circuits.
Recall and identify that some power is lost through heat in the transmission of electrical power in cables and transformers.	Understand how power loss in the transmission of electrical power is related to the current flowing in the transmission lines. Use the equation: $\text{power loss} = \text{current}^2 \times \text{resistance}$ Use and manipulate the equation: $V_p I_p = V_s I_s$ applied to a (100% efficient) transformer. Use these relationships to explain why power is transmitted at high voltages.

Module P6: Electricity For Gadgets

Item P6h: Charging

Summary: As well as changing the voltage, using a transformer, it is often necessary to change the current from AC to DC. This item develops ideas about the use of diodes and capacitors to obtain a constant DC output. This is because many things, such as micro chips need a DC supply to work. This item provides the opportunity to discuss contemporary scientific and technological developments.

Suggested practical and research activities to select from	Assessable learning outcomes Foundation Tier only: low demand
Examine the current-voltage characteristics of a diode.	Recognise and draw the symbol for a diode. Recall that a diode only allows a current to pass in one direction. Understand the direction of current flow from the diode symbol. Recognise half-wave rectification from a voltage-time graph.
Carry out an experiment to show the difference between half-wave and full-wave rectification.	Recognise full-wave rectification from a voltage-time graph.
Show that a capacitor can store charge. Show students mains voltage-time history from an uninterruptable power supply.	Recognise and draw the symbol for a capacitor. Describe the function of a capacitor. Recall and identify that a capacitor will produce a more constant (smoothed) output. Explain why many devices need a more constant voltage supply.

Module P6: Electricity For Gadgets

Item P6h: Charging

Links to other items: P2b: Generating electricity

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Recognise the current-voltage characteristics for a silicon diode. Use this graph to explain that a diode only allows current to flow in one direction. Recall and identify that a single diode produces half-wave rectification.	Explain the current-voltage graph for a silicon diode in terms of high resistance in reverse direction and low resistance in forward direction. Describe the action of a silicon diode in terms of the movement of holes and electrons.
Recall that four diodes can be used in the construction of a bridge circuit to obtain full-wave rectification.	Explain how four diodes in a bridge circuit can produce full-wave rectification.
Describe the result of a current flowing in a circuit containing an uncharged capacitor: • charge is stored • the voltage across the capacitor increases. Understand how the flow of current changes with time when a conductor is connected across a charged capacitor.	Describe the flow of current and reduction in voltage across a capacitor when a conductor is connected across it. Explain the action of a capacitor in a simple smoothing circuit.

4 Assessment of GCSE Further Additional Science B

4.1 Overview of the assessment in GCSE Further Additional Science B

To claim the qualification GCSE Further Additional Science B (J266) candidates will need to complete all three units B761, B762 and B763.

GCSE Further Additional Science B J266	
Unit B761: *Further Additional Science modules B5, C5, P5*	
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 B5, C5 and P5 • uses structured questions (candidates answer all questions) • assesses the quality of written communication.
Unit B762: *Further Additional Science modules B6, C6, P6*	
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 B6, C6 and P6 • 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 B763: *Further 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 B761 and B762, candidates are entered for an option in either the Foundation Tier or the Higher Tier. Unit B763 (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 B761/F and B762/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 Further 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 B761: *Further Additional Science modules B5, C5, P5*	16	17.5	1.5	35
Unit B762: *Further Additional Science modules B6, C6, P6*	16	17.5	6.5	40
Unit B763: *Further 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	–	–	0

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 judgements 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 Further Additional Science B

5

This section provides general guidance on controlled assessment: what controlled assessment tasks are, when and how they are available; how to plan and manage controlled assessment and what controls must be applied throughout the process. More 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 three 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, three 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 B763

Assessment Task	Task Marks	Weighting
Further 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 Science B suite. 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 Science B suite. 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 judgements 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.

Centres with entries for both unit B763: Further Additional Science B controlled assessment and for unit B723: Additional Science B controlled assessment must ensure internal standardisation takes place across all work for both these units as these units will be moderated together.

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 unit B763: Further Additional Science B controlled assessment, 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 Section 8.4.1 for entry codes.

Where centres have entries for both unit B763: Further Additional Science B controlled assessment and for unit B723: Additional Science B controlled assessment, these units will be moderated together. Centres must use the same submission method and entry option across both units. The sample request will be for a combined sample across these two units.

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 Further Additional Science B unit B763 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.

Where a centre has entries for both unit B763: Further Additional Science B controlled assessment and for unit B723: Additional Science B controlled assessment, these units will be moderated together.

Support for GCSE Further Additional Science B 6

6.1 Free resources available from the OCR website

The following materials will be available on the OCR website:

- GCSE Further 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.

Collins is the publisher partner for OCR GCSE Science B suite.

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.

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 Further 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 Further Additional Science B

7

7.1 Equality Act information relating to GCSE Further 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 Further 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.

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

	Unit B761	Unit B762	Unit B763	Certification availability
June 2014	✓	✓	✓	✓
June 2015	✓	✓	✓	✓

8.2 Certification rules

For GCSE Further 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 B761 and B762 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
B761F	01	Written Paper	*Further Additional Science modules B5, C5, P5* (Foundation Tier)
B761H	02	Written Paper	*Further Additional Science modules B5, C5, P5* (Higher Tier)
B762F	01	Written Paper	*Further Additional Science modules B6, C6, P6* (Foundation Tier)
B762H	02	Written Paper	*Further Additional Science modules B6, C6, P6* (Higher Tier)
B763A	01	Moderated via OCR Repository	Controlled assessment
B763B	02	Moderated via postal moderation	Controlled assessment
B763C	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 Further Additional Science B certification code J266.

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 QA1D.

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.

Other information about GCSE Further Additional Science B

9

9.1 Overlap with other qualifications

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

This specification includes the content of Modules 5 and 6 of GCSE Biology B, GCSE Chemistry B and GCSE Physics B.

Aspects of the controlled assessment of skills are common across GCSE Further Additional Science B, 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.	B6b: Describe the pioneering work of the following scientists in the treatment of disease, limited to Pasteur, Lister, Fleming. C6e: Survey of safer alternatives to CFCs. P5f: Compare the conflicting light theories of Huygens (waves) and Newton (particles) and how acceptance of the theories changed over time.
Ethical issues The ethical implications of selected scientific issues.	B5h: Research the history of one organ transplant. C5c: Survey information on food packaging with particular regard to guideline daily amounts (GDA) values.
Economic issues The range of factors which have to be considered when weighing the costs and benefits of scientific activity.	B6d: Understand why gasohol is more economically viable in countries that have ample sugar cane and small oil reserves. C6h: Critical analysis of advertisements for washing-up liquids and washing powders. P5d: Compare mass of fuel and mass of rockets for commercial rocket systems.
Cultural issues Scientific explanations which give insight into the local and global environment.	B5b: Research heart disease in the world and display the information using charts and graphs. C6b: Explain why the car industry is developing fuel cells. P5a: Recall some of the applications of artificial satellites.

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
B761	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
B762	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
B763	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

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.

A Appendix A: Guidance for the production of electronic controlled assessment

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 B763, 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.

Accepted file formats

A

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)

B 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.

Appendix C: Physical quantities and units

C

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

D 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.

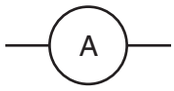
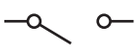
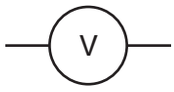
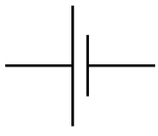
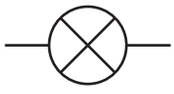
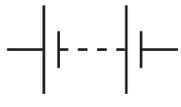
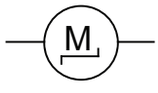
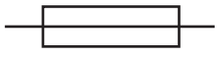
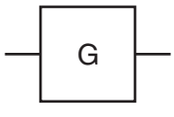
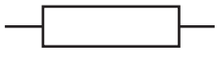
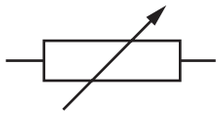
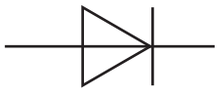
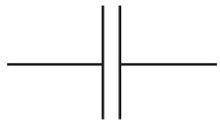
Such adaptations might include a reduced scale of working, deciding that the fume cupboard provision was inadequate or the skills of the candidates were insufficient to attempt particular activities safely. The significant findings of such risk assessment should then be recorded, for example on schemes 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).

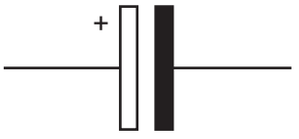
*These, and other CLEAPSS® publications, are on the CLEAPSS® Science Publications CD-ROM issued annually to members. Note that CLEAPSS® publications are only available to members. For more information about CLEAPSS® www.cleapss.org.uk. In Scotland, SSERC www.sserc.org.uk has a similar role to CLEAPSS®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

Appendix E: Electrical symbols

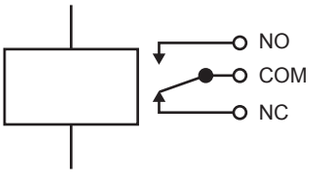
E

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	

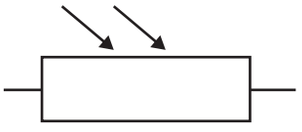
Electrolytic capacitor



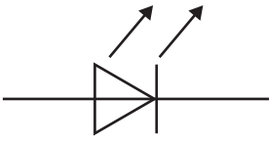
Relay



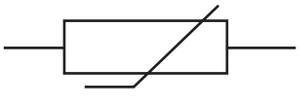
LDR



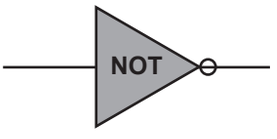
LED



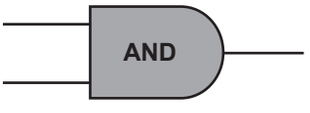
Thermistor



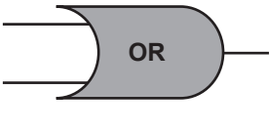
NOT gate



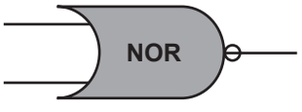
AND gate



OR gate

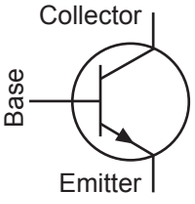


NOR gate



NAND gate

NPN transistor



Appendix F: Periodic Table

F

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						

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

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

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

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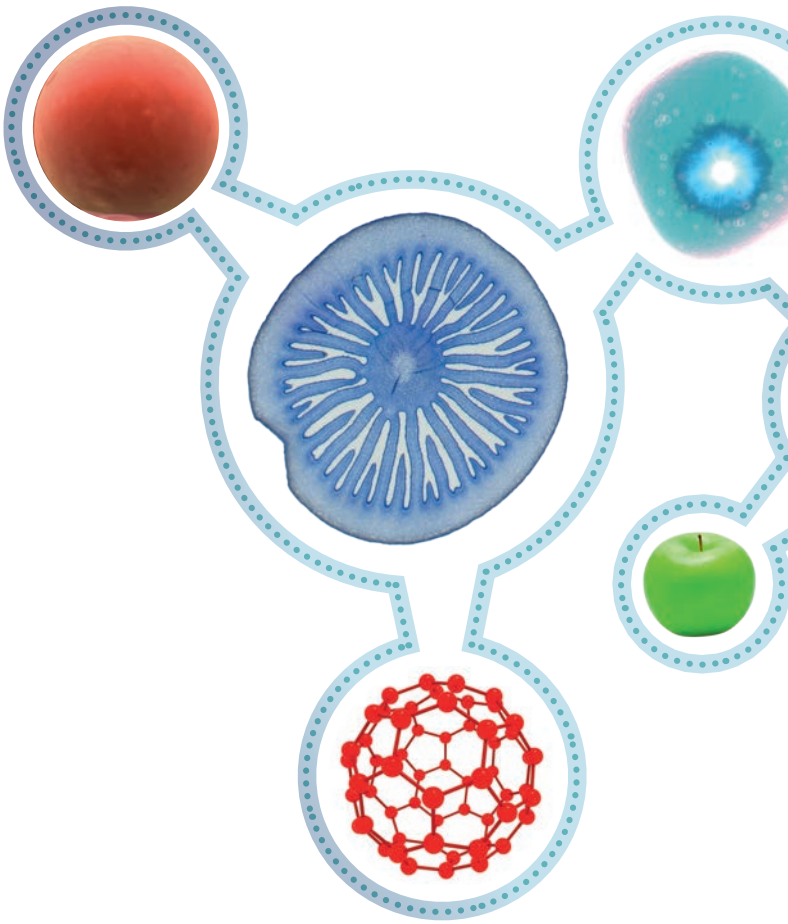

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