GCSE

Additional Science B

Gateway Science Suite

OCR GCSE in Additional Science J641

Foreword to the Second Edition

This Second Edition of the OCR GCSE Additional Science B specification has been produced to correct minor errors found in the original edition (published in Dec 2005). There are no changes to actual content or the scheme of assessment.

Section 6.6 has been updated (amended in Oct 2007).

QAN 100/5633/6

Contents

1 About this Qualification

1.1 About the Gateway Science Suite

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

The qualifications available as part of this suite are:

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

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

The suite is supported by resources published by Collins and Heinemann.

Centres wishing to include GCSE Additional Applied Science in their provision are advised to consider the specification which is part of the Twenty First Century Science Suite A.

1.2 About this Additional Science Specification

This booklet contains OCR's GCSE specification in Additional Science for teaching from September 2006 and first certification in June 2008.

The primary objective of this specification is to interest and engage candidates in science.

This is achieved by:

- identifying activities and experiences which will excite their interest, and linking these to scientific ideas and their implications for society;
- providing opportunities to develop science explanations and theories;
- providing a scheme of assessment which gives regular feedback.

This approach will appeal to candidates of all abilities. The specification emphasises the teaching and learning activities of the course, from which emerge the learning outcomes.

This specification comprises six teaching modules which are assessed through three units. Candidates take all three units.

Unit	Unit Code	Title	Duration	Weighting	Total Mark
1	B623	Additional Science B Unit 1 – modules B3, C3, P3	1 hour	33⅓%	60
2	B624	Additional Science B Unit 2 – modules B4, C4, P4	1 hour	33⅓%	60
3	B626	Additional Science B Unit 3 – Research Study, Data Task and Practical Skills	-	33⅓%	60

1.3 Qualification Titles and Levels

This qualification is shown on a certificate as OCR GCSE in Additional Science.

This qualification is approved by the regulatory authorities (QCA, ACCAC and CEA) as part of the National Qualifications Framework (NQF).

Candidates who gain grades G to D will have achieved an award at Foundation Level (Level 1 of the NQF).

Candidates who gain grades C to A* will have achieved an award at Intermediate Level (Level 2 of the NQF).

1.4 Aims

This specification therefore aims to give candidates opportunities to:

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

OCR has taken great care in the preparation of this specification and assessment material to avoid bias of any kind.

1.5 Prior Learning/Attainment

Candidates who are taking courses leading to this qualification at Key Stage 4 should normally have followed the corresponding Key Stage 3 programme of study within the National Curriculum.

Other candidates taking this course should have achieved a general educational level equivalent to National Curriculum Level 3.

Candidates taking this course will normally have already taken, or be taking at the same time, a course leading to a GCSE in Science.

2 Summary of Content

The specification content is presented as six modules, predominantly Biology, Chemistry and Physics. 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 is approximately 2½ hours teaching time.

Module B3: Living and growing

a Molecules of Life
b Diffusion
c Keep it moving
d Divide and Rule
e Growing Up
f Controlling Plant Growth
g New Genes for Old
h More of the Same

Module B4: It's a Green World

a Who planted that there
b Water, water everywhere
c Transport in plants
d Plants need minerals too
e Energy flow
f Farming
g Decay
h Recycling

Module C3: The Periodic Table

Fundamental Chemical Concepts
a What are atoms like?
b How atoms Combine – Ionic Bonding
c Covalent bonding and the Structure of the Periodic Table
d The Group 1 Elements
e The Group 7 Elements
f Electrolysis
g Transition Elements
h Metal Structure and Properties

Module C4: Chemical Economics

Fundamental Chemical Concepts
a Acids and Bases
b Reacting Masses
c Fertilisers and Crop yield
d Making ammonia – Haber Process and costs
e Detergents
f Batch or Continuous
g Nanochemistry
h How pure is our water?

Module P3: Forces for Transport

a Speed
b Changing Speed
c Forces and Motion
d Work and Power
e Energy on the Move
f Crumple Zones
g Falling Safely
h The Energy of Game and Theme Rides

Module P4: Radiation for Life

a Electrostatics – Sparks
b Electrostatics 2: uses of electrostatics
c Safe Electricals
d Ultrasound
e Treatment
f What is radioactivity
g Uses of radioisotopes
h Fission

3 Content

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 OURSELVES)

Item code and title: e.g. B1a: Fit for life

Summary: A short overview of the item, including the skills, knowledge and understanding of how science works that may be covered within this item.

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Ideas for teaching activities related to the item, which will integrate the skills, knowledge and understanding of how science works into a teaching scheme. Teachers may choose from these suggestions or develop other comparable activities.	Learning outcomes that will only be assessed in the Foundation Tier paper. The use of bullet points provides guidance on: • depth • context • exemplification

Can-Do tasks

Tasks linked to the learning activities in this item which can be used for the practical skill assessment element (Can-Do tasks). The number of points for successful completion of the task are also given.

e.g. I can measure blood pressure 1 point

MODULE CODE AND TITLE

Links to other modules: opportunities for linking ideas across modules within the Gateway suite of sciences.

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Learning outcomes that can be assessed on either the Foundation Tier or Higher Tier question papers. The use of bullet points provides guidance on: • depth • context • exemplification	Learning outcomes that will only be assessed in the Higher Tier paper. The use of bullet points provides guidance on: • depth • context • exemplification

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.

MODULE B3: LIVING AND GROWING

Item B3a: Molecules of Life

Summary: The fundamental processes of life occur inside cells. This item examines the role of DNA in the production of proteins, the building blocks of living things, and the role of an essential group of proteins, enzymes. This item provides the opportunity to collect and analyse scientific data from primary or secondary sources to test a scientific idea and explain phenomena using scientific theories, models and ideas.

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Make a cheek cell slide and examine using a microscope.	Relate a cheek cell slide to the structure and function of the cell: • nucleus carries genetic information; • cell membrane controls the movement of substances in and out of cells; • cytoplasm is where many chemical reactions happen.
Use of 'Cake Workshop'. • 'Recipe for Life' – an activity to demonstrate use of a recipe (code); • 'DNA a chemical recipe' – role play activity to illustrate pairing up of bases. See www.bbsrc.ac.uk	State that chromosomes in the nucleus carry coded information in the form of genes which are made of a chemical called DNA. Recall that proteins are needed for the growth and repair of cells.
Examine DNA 'fingerprinting' results.	State that a person's DNA is unique.
Build plasticine models to illustrate 'lock and key' mechanism. Investigate the effects of changing temperature or pH on enzyme activity.	State that an enzyme will speed up a chemical reaction.

MODULE B3: LIVING AND GROWING

Links to other modules: B1a Fit for Life, B1b What's for Lunch?, B1g Gene Control, B2c The Food Factory, B3b Diffusion, B3d Divide and Rule, B3e Growing Up, B4d Plants need minerals too B6a Understanding Bacteria

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Identify the mitochondria in an animal cell. State that respiration occurs in the mitochondria providing energy for life processes.	
Describe the structure of DNA as a double helix with cross links formed by 2 bases. State that before cells divide the DNA copies itself (DNA replication). State that DNA controls the production of different proteins (protein synthesis). State that each gene codes for a particular protein. State that proteins are made of chains of amino acids. State that we use amino acids from our diet to make proteins.	Describe the complementary base pairings: A -T and G – C. Describe DNA replication: • 'unzipping' to form single strands; • new double strands forming by complementary base pairing. Explain that protein structure is determined by the DNA base code: • base sequence determines amino acid sequence; • each amino acid is coded for by a sequence of 3 bases. State that the body can change some amino acids into others (transamination) in the liver.
Interpret data on DNA 'fingerprinting' for identification.	State the stages in the production of a DNA 'fingerprint' (isolation, fragmentation, separation and comparison with a reference).
State that enzymes are proteins. State that enzymes are biological catalysts. Describe how changing temperature and pH will change the rate of reaction of an enzyme-catalysed reaction: • optimum pH; • optimum temperature. State that enzymes have a high specificity for their substrate. State that enzymes catalyse the chemical reactions occurring in living cells: respiration, photosynthesis, protein synthesis.	State that each protein has its own number and sequence of amino acids, resulting in different shaped molecules which have different functions. Explain the specificity of enzymes in terms of the 'lock and key' mechanism. Explain how enzyme activity is affected by pH and temperature: • optimum pH; • optimum temperature; • denaturing at extremes of pH and high temperatures; • denaturing is an irreversible change inhibiting enzyme function; • denaturing changes the shape of the active site.

MODULE B3: LIVING AND GROWING

Item B3b: Diffusion

Summary: The materials used in, and produced by, life processes, move through living organisms in several ways, one of the most important of these being diffusion. This item examines the process itself and a variety of situations where it occurs. Making a model cell provides the opportunity to work accurately and safely when collecting data and to consider the reliability and validity, present the results and draw a conclusion using scientific and technical language. This also provides experience of developing and using a scientific model.

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Demonstrate diffusion e.g. spread of perfume across a room, potassium permanganate in water. Investigate the rate of diffusion of food dye through agar jelly.	State that substances move in and out of cells through the cell membrane.
Make a model cell using visking tubing and investigate which of sugar and starch can pass through; this could be extended to investigate the effect of changing temperature on the rate of diffusion of sugar.	State that oxygen enters the blood in the lungs and leaves the blood in body tissues. State that carbon dioxide enters the blood in body tissues and leaves in the lungs. State that food enters the blood in the small intestine and leaves in body tissues.
Research the role of the placenta both to allow the movement of some substances and to act as a barrier to prevent the movement of other substances.	Apply research on role of placenta to show that: • developing foetus requires food and oxygen from its mother; • the developing foetus passes carbon dioxide and waste to its mother.
	State that carbon dioxide and oxygen move in and out of plants through the leaves.
	State that water is lost from plants by evaporation from the leaves.

MODULE B3: LIVING AND GROWING

Links to other modules: B1a Fit for Life, B1b What's for Lunch?, B1d Keeping in Touch, B3a Molecules of life, B3c Keep it Moving, B4a Who planted that there?, B4b Water, water everywhere, B5d Breath of Life

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe diffusion as the movement of a substance from a region of high to low concentration. Describe how molecules enter and leave cells by diffusion through the cell membrane.	Explain that diffusion is the net movement of particles from an area of high concentration to an area of low concentration and is a consequence of the random movement of individual particles. Explain that the rate of diffusion is increased by: • a shorter distance; • a greater concentration difference (gradient); • a greater surface area.
Describe how small digested food molecules are absorbed into the blood in the small intestine by diffusion. Describe gaseous exchange within alveoli by diffusion between air and blood.	Explain how the alveoli are adapted for efficient gaseous exchange: permeable, moist, large surface area, good blood supply, wall one cell thick. Explain how the small intestine is adapted for the absorption of food: long, large surface area (villi and microvilli); permeable surface, good blood supply.
Describe how food and oxygen reach the foetus, and carbon dioxide and other wastes are removed, by diffusion through the placenta.	Explain how the placenta is adapted to increase the rate of diffusion.
	Explain how transmitter substances diffuse across synapses to carry signals from one neurone to the next.
Describe how carbon dioxide and oxygen diffuse in and out of plants through the leaves.	Explain how leaves are adapted to increase the rate of diffusion of carbon dioxide and oxygen.
Explain the loss of water from leaves in terms of the diffusion of water molecules.	

MODULE B3: LIVING AND GROWING

Item B3c: Keep it Moving

Summary: If we lose blood in an accident it can be very serious, even fatal. This item explains why blood is vital for life as it transports materials around the body to and from different cells. Research and presentation of a report on disorders of the blood allows the opportunity to use ICT in teaching and learning to present information using scientific language and conventions. Investigating the effect of exercise on heart/pulse rate illustrates the use of ICT phenomena.

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Survey of family / friends to find out who has given blood and their reasons for giving or not giving. Design a leaflet or web-page encouraging people to give blood.	State the functions of cells in the blood: • red blood cells transport oxygen; • white blood cells defend against disease; • platelets help blood clotting.
Research and present a report on disorders of the blood e.g. haemophilia, sickle cell anaemia, leukaemia. Research what to do if someone has a cut and is bleeding badly.	State that the blood moves around the body in: • arteries; • veins; • capillaries.
Examine an animal heart (or model). Measure heart / pulse rate. Investigate effect of exercise on heart/ pulse rate. (ICT opportunity for data-logging).	Describe the functions of the heart: • pumps blood to the lungs; • The right side of the heart punps blood to the lungs; • The left side of the heart pumps blood to the rest of the body. State that blood in arteries is under higher pressure that in the veins.
Use websites to plan for a lower cholesterol intake.	State that cholesterol can build up in arteries and restrict or block blood flow.
Research causes of heart disease.	Describe one way the heart and parts of the heart can be replaced: • mechanically; • biologically.

MODULE B3: LIVING AND GROWING

Links to other modules: B1a Fit for Life, B1b What's for Lunch?, B1c Keeping Healthy, B1f Staying in Balance, B3b Diffusion, B5b The vital pump, B5c Running Repairs

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain how the structure of a red blood cell is adapted to its function: size, shape, contains haemoglobin, lack of nucleus. Describe how the structure of a white blood cell is adapted to its function: • flexible shape to engulf disease organisms. State the function of plasma in transporting foods, hormones, antibodies, water, waste products around the body.	Explain how the structure of a red blood cell is adapted to its function: • small size provides large surface area to volume ratio. Explain that haemoglobin in red blood cells reacts with oxygen in the lungs forming oxyhaemoglobin and the reverse of this reaction happens in the tissues.
Describe how the parts of the circulatory system work together to bring about the transport of substances around the body: • arteries transport blood away from the heart; • veins transport blood to the heart; • capillaries are involved in exchange of materials with tissues.	Explain the adaptations of arteries, veins and capillaries to their functions: • thick muscular and elastic wall in arteries; • large lumen and presence of valves in veins; • permeability in capillaries.
State the names and positions of the parts of the heart and describe their functions: • left and right ventricles to pump blood; • left and right atria to receive blood; • semilunar, tricuspid and bicuspid valves to prevent backflow. four main blood vessels of the heart;. Explain why the left ventricle has a thicker muscle wall than the right ventricle.	Explain the advantage of the double circulatory system in mammals. • higher pressures and therefore greater rate of flow to the tissues.
Explain that the amount of cholesterol in arteries is linked to diet.	Describe how cholesterol can build up to form a plaque which can restrict or block blood flow in arteries.
State problems in supply of donor hearts: shortage of donors, tissue match, size, age. State other problems with transplants: • rejection and necessary drug regime. Describe problems of using mechanical replacements: • size; • power supply; • body reactions.	Describe the advantages and disadvantages of a heart pacemaker and heart valves, over a heart transplant.

MODULE B3: LIVING AND GROWING

Item B3d: Divide and Rule

Rationale: As living things grow, the number of cells in them increases. This item looks at the two ways cells divide, mitosis and meiosis, and the differences between them. Software simulations and video clips which show cell division are uses of ICT in teaching and learning. Using models to illustrate cell division provides experiences of explaining phenomena.

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Watch a video, examine photographs, use software simulations on cell division. Use models to illustrate cell division, using e.g. wool or plasticine. Examine prepared microscope slides to show cell division. Prepare a stained microscope slide of a root tip squash to show mitosis (e.g. garlic or hyacinth). Use bacterial or yeast growing kits.	Explain that cells dividing during: • growth; • replacement of worn out cells; • repair to damaged tissue.
Examination of bull's sperm using a microscope. Examine a hen's egg to show the large amount of stored food.	State that in sexual reproduction sex cells (gametes) join (fertilisation). Explain how the structure of a sperm cell is adapted to its function: • small size and tail for swimming; • nucleus carries genes; • produced in large numbers to increase chance of fertilisation. Explain how the structure of an egg cell is adapted to its function: • large size as contains food source; • nucleus carries genes.

MODULE B3: LIVING AND GROWING

Links to other modules: B1a Fit for Life, B1g Gene Control, B3a Molecules of Life, B3e Growing Up, B3h More of the Same B5h Size Matters

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain the advantages of being multi-cellular: • allows organism to be larger; • allows for cell differentiation; • allows organism to be more complex. State that new cells for growth are produced by mitosis. State that in mammals, body cells are diploid (two of each chromosome).	Explain the advantages of being multi-cellular: • a single large cell has a smaller surface area / volume ratio reducing movement of materials in and out of cell. Explain that in mitosis the chromosomes: • are copied to produce genetically identical cells; • divide to opposite poles of the cell.
State that, at fertilisation, gametes combine to form a diploid zygote. State that gametes are produced by meiosis. State that gametes are haploid (one of each chromosome). State that meiosis introduces variation. Explain how the structure of a sperm cell is adapted to its function: • many mitochondria provide energy; • acrosome releases enzyme to digest egg membrane.	Explain that in meiosis the: • chromosome number is halved and each cell is different; • pairs of chromosomes separate to opposite poles of the cell in the first division; • chromosomes divide to opposite poles of the cell in the second division.

MODULE B3: LIVING AND GROWING

Item B3e: Growing Up

Summary: The growth of children is closely monitored and follows a recognisable pattern. Animals and plants grow in different ways. This item explores some of these differences. Research about human stem cells and cancer provides opportunities to discuss how and why decisions about science are made and the related ethical issues. These discussions can also provide the opportunity to show that there are some questions that science cannot currently answer.

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Make an onion cell slide and examine it using a microscope.	Identify the chloroplasts, vacuole and cell wall in a plant cell. State that the vacuole contains cell sap and helps provide support. State that the cell wall provides support. Describe how to make a stained slide of an onion cell.
Research about human stem cells. Research cancer (uncontrolled growth of undifferentiated cells).	State that growth involves both cell division and cell differentiation. State that cell differentiation involves producing different types of cells.
Plot data on weight gain of baby using a case study or collected data. See Personal Child Health Record from Local Health Authority.	State the main phases of human growth: • infancy; • childhood; • adolescence (puberty); • maturity (adulthood); • old age.

MODULE B3: LIVING AND GROWING

Links to other modules: B1g Gene Control, B2c The Food Factory, B3a Molecules of Life, B3d Divide and Rule, B4a Who planted that there?, B4b Water, water everywhere B3f Controlling Plant Growth, B5h Size Matters, B6a Understanding Bacteria.

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe the similarities and differences between plant and animal cells: • nucleus, membrane, cytoplasm in plant and animal cells; • chloroplasts, cell wall, large vacuole in plant cells only. Describe how animal and plant growth is different: • animals tend to grow to a finite size but many plants can grow continuously.	Describe how plant cell growth differs from animal cell growth: • cell enlargement is the main method by which plants gain height; • cell division is mainly restricted to the tips of shoots and roots; • many plant cells retain the ability to differentiate but most animal cells lose it at an early stage.
State that undifferentiated cells called stem cells can develop into different cells, tissues and organs.	Discuss issues arising from stem cell research.
Explain why gestation periods differ in different animals. State that different parts of a foetus and a baby grow at different rates. Plot data on babies' overall weight and head size. Describe the main phases of human growth: • infancy; • childhood; • adolescence (puberty); • maturity (adulthood); • old age. Interpret data on human growth.	Explain how data on babies' weight and head size can provide early warning of growth problems.

MODULE B3: LIVING AND GROWING

Item B3f: Controlling Plant Growth

Summary: Growth and development in plants are controlled by plant growth regulators (hormones). This item examines some examples of this, as well as how humans can use plant hormones to aid the efficient production of food. Experiments on seed growth allow the development of safe and accurate working, the presenting of results, evaluation of data collection and the validity and reliability of the data.

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
	State that plant hormones are chemicals that control: • growth of shoots and roots; • flowering; • ripening of fruits.
Carry out an experiment to test whether cress seedlings grow towards light. Carry out an experiment to test whether bean roots always grow downwards.	Describe an experiment to show that shoots grow towards light. State that roots grow downwards in response to gravity.
Take cuttings using rooting powder to encourage root growth. Research how seedless grapes are produced. Investigate whether bananas ripen more quickly if already-ripened bananas are close by; research why this happens.	State that plant hormones can be used in agriculture to speed up or slow down plant growth.

MODULE B3: LIVING AND GROWING

Links to other modules: B3e Growing Up

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
State that shoots are positively phototropic but negatively geotropic. State that roots are negatively phototropic but positively geotropic. State that plant hormones (auxins): • move through the plant in solution; • are involved in the response to light (phototropism); • are involved in the response to gravity (geotropism).	Interpret data from phototropism experiments in terms of auxin action: • auxin made in tip; • unequally distributed in response to light. Explain how auxin brings about shoot curvature in terms of cell elongation.
Relate the action of plant hormones to their commercial uses: • selective weedkillers; • rooting powder; • fruit ripening (delay or acceleration); • control of dormancy.	

MODULE B3: LIVING AND GROWING

Item B3g: New Genes For Old

Summary: Genetic engineering and genetic modification are relatively recent terms but humans have been genetically modifying animals and plants using selective breeding for thousands of years. Genes can also change without human intervention. This is known as mutation. Debating the arguments for and against GM ingredients provides opportunities to discuss how and why decisions about science are made and the related ethical issues. These discussions can also provide the opportunity to show that there are some questions that science cannot currently answer.

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
	State that gene mutations are changes to genes.
Research examples of different animal and plant breeds that have been produced by selective breeding.	Recognise features of plants and animals that might be selected for enhancement in a breeding programme.
Survey foods that contain GM ingredients. Debate the arguments for and against GM ingredients. Research the differences between gene therapy and germ line treatment as possible treatments for genetic disorders.	State that genes can be transferred from one living organism to another and that this is called genetic engineering or genetic modification. Recognise features of plants and animals that might be selected for in a genetic engineering programme.

MODULE B3: LIVING AND GROWING

Links to other modules: B1g Gene Control, B6h Genetic Engineering

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain that mutations are usually harmful but may be beneficial. Mutations can be caused by radiation, chemicals, or occur spontaneously.	Explain that mutations change the DNA base sequence, changing or preventing the production of the protein, that the gene normally codes for.
Describe the process of selective breeding involving the: • selection characteristics; • cross breeding; • selection of suitable offspring over many generations. Explain how selective breeding can contribute to improved agricultural yields.	Explain that a selective breeding programme may reduce the gene pool leading to problems of inbreeding: • accumulation of harmful recessive characteristics; • reduction in variation.
Explain some potential advantages and risks of genetic engineering and selective breeding: • advantage – production of organisms with new features; • disadvantage – inserted genes may have unexpected harmful effects. Describe, in outline only, some examples of genetic engineering: • taking the genes from carrots that control beta-carotene production and putting them into rice. Humans can then convert the beta-carotene from rice into Vitamin A (solving the problem of parts of the world relying on rice but lacking in Vitamin A); • the production of human insulin by genetically engineered bacteria; • transferring resistance to herbicides, frost damage or disease to crop plants.	Describe the principles of genetic engineering: • selection of characteristics; • isolation of genes; • insertion; • replication. Discuss the moral and ethical issues involved in genetic modification weighed against the potential benefits.

MODULE B3: LIVING AND GROWING

Item B3h: More of the same

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

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Research information on the techniques used to produce Dolly, the first cloned mammal.	Interpret information on cloning techniques to show that: • cloning is an example of asexual reproduction; • cloning produces genetically identical copies (clones). State that Dolly the sheep was the first mammal cloned from an adult. State that identical twins are naturally occurring clones.
Carry out a meristem tissue culture using cauliflower.	Describe how, in asexual reproduction, cell division produces new individuals. Describe how spider plants, potatoes and strawberries reproduce asexually. Describe how to take a cutting.

MODULE B3: LIVING AND GROWING

Links to other modules: B1g Gene Control, B3d Divide and Rule

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe in outline the cloning technique used with embryo transplants in cows: • sperm collected from selected bulls; • selected cows artificially inseminated; • embryos collected; • embryos split, forming clones; • embryo clones implanted into surrogate cows. Recall that suitable organs for transplant could be produced by cloning animals. Recognise that there are ethical dilemmas concerning human cloning.	Describe in outline the cloning technique used to produce Dolly: • nucleus removed from an egg cell; • egg cell nucleus replaced with the nucleus from an udder cell; • cell implanted into another sheep; • cell grows into a clone of the sheep from which the udder cell came. Discuss the benefits and risks of using cloning technology. Discuss the possible implications of using genetically modified animals to supply replacement organs for humans. Discuss the ethical dilemmas concerning human cloning.
Describe the advantages and disadvantages associated with the commercial use of cloned plants: • advantage: can be sure of the characteristics of the plant since all plants will be genetically identical; • advantage: it is possible to mass produce plants that may be difficult to grow from seed; • disadvantage: if plants become susceptible to disease or to change in environmental conditions then all plants will be affected; • disadvantage: lack of genetic variation.	Describe plant cloning by tissue culture: • selection for characteristics; • large number of small pieces of tissue; • aseptic technique; • use of suitable growth medium and conditions. Explain why cloning plants is easier than cloning animals: • many plant cells retain ability to differentiate unlike animal cells which usually lose this ability at an early stage.

MODULE C3: THE PERIODIC TABLE

Item C3: Fundamental Chemical Concepts

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

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
These learning outcomes are intended to be taught throughout this specification.	Describe that in a chemical reaction reactants are changed into products. Recognise the reactants and products in a word or symbol equation. Recognise that in a chemical change no atoms are lost or made.
These learning outcomes are intended to be taught throughout this specification.	State the number of elements in a compound given its formula. State the number of atoms in a formula with no brackets. State 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.
These learning outcomes are intended to be taught throughout this specification.	Recognise that a molecule is made up of more than one atom joined together. Recognise that a molecular formula shows the numbers and types of atom in a molecule. State the number of atoms in a displayed formula. State the names of the different elements in a compound given its displayed formula. State the number of each different type of atom in a displayed formula.
These learning outcomes are intended to be taught throughout this specification.	State that all atoms are made up of a nucleus and electrons. State that a chemical bond holds atoms together in a compound.

MODULE C3: THE PERIODIC TABLE

Links with other modules: C1 to C6

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Construct word equations given the reactants and products. Construct balanced symbol equations given the formulae (no brackets) of the reactants and products. Explain that a symbol equation is balanced when the number of each type of atom is the same on both sides of an equation.	Construct balanced symbol equations given the formulae (some or all with brackets) of the reactants and products. Construct balanced symbol equations given the names of the reactants and products (limited to the learning outcomes in this specification).
State the number of atoms in a formula with brackets. State the number of each type of different atom in a formula with brackets.	Recall the formula of the following substances: • the oxides of sodium, magnesium, aluminium, zinc, copper, iron(II) and manganese; • the chlorides of magnesium, barium, sodium and potassium; • the carbonates of copper(II), iron(II), zinc and manganese; • the hydroxides of sodium, potassium, lithium, copper(II), iron(II) and iron(III); • water, carbon dioxide, methane, silver nitrate.
Recognise that a displayed formula shows both the atoms and the covalent bonds in a molecule. Write the molecular formula of a compound given its displayed formula.	Balance equations that use displayed formulae.
State that the nucleus of an atom is positive and the electrons negative. State there are two types of chemical bonds: • ionic between a positive ion and a negative ion; • covalent involving a shared pair of electrons.	

MODULE C3: THE PERIODIC TABLE

Item C3a: What are atoms like?

Summary: Atomic structure is fundamental to the study of chemistry. This item considers the sub-atomic particles and electronic structures. This item provides the opportunity to develop and use scientific theories, models and ideas.

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Teacher exposition. Research activity.	Describe an atom as a nucleus surrounded by electrons. State that a nucleus is positively charged, an electron is negatively charged and an atom is neutral.
Deduce the numbers of protons, electrons and neutrons from atomic numbers and mass numbers.	Identify the atomic number of an element by using a periodic table. Identify the name or symbol of an element given its atomic number using a periodic table.
Identify elements and numbers of atoms of each element from formulae.	State that there are just over 100 elements. Describe an element as a substance which: • cannot be broken down chemically; • contains the same type of atom. Identify the elements in a compound from its formula, using a periodic table. Describe a compound as a substance that contains at least two elements chemically combined.
Draw electronic structures given atomic numbers.	

MODULE C3: THE PERIODIC TABLE

Links with other modules: C3b How atoms combine – Ionic Bonding, C3c Convalent bonding and the structure of the Periodic Table, C3d The Group 1 Element, C3e The Group 7 Element, C4b Reacting Masses, P4f What is radioactivity?

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
State that the nucleus is made up of protons and neutrons. State the relative charge and relative mass of an electron, a proton and a neutron: • electron charge -1 and mass 0.0005 (zero); • proton charge +1 and mass 1; • neutron charge 0 and mass 1.	Explain that an atom is neutral because it has the same number of electrons as protons.
Describe atomic (proton) number as the number of protons in an atom. Describe mass (nucleon) number as the total number of protons and neutrons in an atom. Describe isotopes as varieties of an element that have the same atomic number but different mass numbers.	Deduce the number of protons, electrons and neutrons in a particle given its atomic number, mass number and the charge on the particle: • using data in a table; • using the conventional symbolism e.g. carbon-12 or $^{12}_{6}C$ Identify isotopes from data about the number of electrons, protons and neutrons in particles.
State that the elements in the periodic table are arranged in ascending atomic number.	
Describe that electrons occupy the space around the nucleus. State that electrons occupy shells.	Deduce the electronic structure of the first 20 elements in the periodic table e.g. calcium is 2.8.8.2.

MODULE C3: THE PERIODIC TABLE

Item C3b: How Atoms Combine – Ionic Bonding

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

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

MODULE C3: THE PERIODIC TABLE

Links with other modules: C3a What are atoms like, C3c Covalent bonding and the structure of the Periodic Table, C3d The Group 1 Element, C3e The Group 7 Element, P4f What is radioactivity?

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

MODULE C3: THE PERIODIC TABLE

Item C3c: Covalent bonding and the Structure of the Periodic Table

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

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

MODULE C3: THE PERIODIC TABLE

Links with other modules:C3a What are atoms like?, C3b How atoms combine – Ionic Bonding, C3e The Group 7 Element, C3g Transition Elements

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

MODULE C3: THE PERIODIC TABLE

Item C3d: The Group 1 Elements

Summary: This item studies the properties of the Group 1 elements. The item links the similarity of their properties to the position of the elements in the Periodic Table. Video clips of the reactions of rubidium and caesium are examples of the use of ICT in teaching and learning.

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Research properties of alkali metals e.g. using the internet. Demonstrate reactions of sodium, lithium and potassium with water. Show video of reactions of rubidium and caesium with water.	State that Group 1 metals are known as the alkali metals. Recognise sodium, lithium and potassium as Group 1 metals. State that alkali metals react vigorously with water. Explain that alkali metals are stored under oil because they react with air and water. Describe the order of reactivity with water of the alkali metals: • potassium is more reactive than sodium; • sodium is more reactive than lithium.
Candidates carry out flame tests on alkali metal chlorides.	State the flame test colours for lithium, sodium and potassium compounds. Interpret information about flame tests e.g. deduce the alkali metal present from flame colour.

MODULE C3: THE PERIODIC TABLE

Links with other modules: C3a What are atoms like? C3b How atoms combine – Ionic Bonding, C3c Covalent bonding and the structure of the Periodic Table, and C6b Redox Reactions

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe the reaction of lithium, sodium and potassium with water. • hydrogen is formed; • an alkali is formed which is the hydroxide of the metal; • the reactivity with water increases down Group 1; • potassium gives a lilac flame. State the word equation for the reaction of an alkali metal with water.	State the balanced symbol equation for the reaction of an alkali metal with water e.g: $2Na + 2H_2O \rightarrow 2NaOH + H_2$ Predict the properties of alkali metal e.g. • reactivity of rubidium with water; • the physical properties of caesium given information about the other alkali metals.
State that the Group 1 metals have one electron in the outer shell Explain that Group 1 metals have similar properties because they have one electron in their outer shell	Explain that alkali metals have similar properties because when they react, an atom loses one electron to form a positive ion with a stable electronic structure. Write an equation to show the formation of an ion of a Group 1 metal from its atom. Explain that the more reactive the alkali metal the easier it for an atom to lose one electron. Describe the loss of electrons as oxidation. Explain why a process is oxidation from its ionic equation.
Describe how to carry out a flame test to test for the presence of lithium, sodium and potassium compounds: • use of moistened flame test wire; • flame test wire dipped into solid sample; • flame test wire put into blue Bunsen flame.	

MODULE C3: THE PERIODIC TABLE

Item C3e: The Group 7 Elements

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

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
	State that Group 7 elements are known as the halogens. Recognise fluorine, chlorine, bromine and iodine as halogens.
Research properties e.g. melting point and boiling point of the halogens.	State the uses of some halogens: • chlorine to sterilise water; • chlorine to make pesticides and plastics; • iodine is used to sterilise wounds. State that sodium chloride is used: • as a preservative; • as a flavouring; • to manufacture chlorine.
Demonstrate or show video of reaction of sodium with chlorine.	State that halogens react vigorously with alkali metals.
Demonstrate or class practical of displacement reactions of the halogens.	Describe the order of reactivity of the halogens: • fluorine is more reactive than chlorine; • chlorine is more reactive than bromine; • bromine is more reactive than iodine.

MODULE C3: THE PERIODIC TABLE

Links with other modules: C3a What are atoms like? C3b How atoms combine – Ionic Bonding, C3c Convalent bonding and the structure of the periodic table, C3b How atoms combine – Ionic Bonding and C6b Redox Reactions.

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe the physical appearance of the halogens at room temperature: • chlorine is a green gas; • bromine is an orange liquid; • iodine is a grey solid.	

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Describe the reaction between alkali metals and halogens to give metal halides. Identify the metal halide formed when a halogen reacts with an alkali metal. Construct the word equation for the reaction between an alkali metal and a halogen.	Construct the balanced symbol equation for the reaction of an alkali metal with a halogen.
State that the reactivity of the halogens decreases down the group. Describe the displacement reactions of halogens with solutions of metal halides: • chlorine displaces bromides and iodides; • bromine displaces iodides. Construct the word equation for the reaction between a halogen and a metal halide.	Predict the properties of fluorine or astatine given the properties of the other halogens e.g: • physical properties; • melting point; • boiling point; • displacement reactions. Construct the balanced symbol equation for the reaction between halogens and metal halides.
Explain that Group 7 elements have similar properties because they have seven electrons in their outer shell.	Explain that halogens have similar properties because when they react, an atom gains one electron to form a negative ion with a stable electronic structure. Write an equation to show the formation of a halide ion from a halogen molecule. Explain that the more reactive the halogen the easier it is for an atom to gain one electron. Describe the gain of electrons as reduction. Explain why a process is reduction from its ionic equation.

MODULE C3: THE PERIODIC TABLE

Item C3f: Electrolysis

Summary: Electrolysis is an important type of reaction This item describes the electrolysis of some solutions and describes the use of electrolysis to provide useful substances.

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Demonstrate the electrolysis of sodium chloride solution including testing for hydrogen and chlorine. Research different ways of doing it industrially.	State that during electrolysis: • the anode is the positive electrode; • the cathode is the negative electrode; • anions are negative ions and are attracted to the anode; • cations are positive ions and are attracted to the cathode; • an electrolyte is the liquid which conducts electricity; • recognise anions and cations from given formulae. Describe that sulfuric acid solution can be broken down by electrolysis into hydrogen and oxygen. State the tests for hydrogen and oxygen: • hydrogen burns with a 'pop' when lit using a lighted splint; • oxygen relights a glowing splint.
Guided research on industrial extraction of aluminium.	State that aluminium is extracted from its mineral using electricity. Describe electrolysis as the decomposition of a liquid using electricity. State that bauxite is a mineral containing aluminium.

MODULE C3: THE PERIODIC TABLE

Links with other modules: C2d Metals and Alloys, C5b Electrolysis and C6d Chemistry of Sodium Chloride (NaCl)

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe the key features of the electrolysis of dilute sulfuric acid: • hydrogen made at the cathode; • oxygen made at the anode.	State the electrode reactions in the electrolysis of sulfuric acid: • cathode $2H^+ + 2e^- \rightarrow H_2$ • anode $4OH^- - 4e^- \rightarrow 2H_2O + O_2$
Describe the key features of the electrolytic decomposition involved in the production of aluminium: • use of molten aluminium oxide; • oxygen is formed at the graphite anode; • the anodes are gradually worn away by oxidation; • aluminium is formed at the graphite cathode • process has a high electrical energy requirement. Write the word equation for the decomposition of aluminium oxide.	State the electrode reactions in the electrolytic extraction of aluminium: • cathode $Al^{3+} + 3e^- \rightarrow Al$ • anode $2O^{2-} \rightarrow O_2 + 4e^-$ Explain that cryolite is used to lower the melting point of the aluminium oxide. Explain that aluminium is expensive because its extraction uses large amounts of electricity.

MODULE C3: THE PERIODIC TABLE

Item C3g: Transition Elements

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

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

MODULE C3: THE PERIODIC TABLE

Links with other modules:C3c Covalent bonding and the structure of the Periodic Table, C4h How pure is our water?, C5h Ionic Equations

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

MODULE C3: THE PERIODIC TABLE

Item C3h: Metal Structure and Properties

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

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

MODULE C3: THE PERIODIC TABLE

Links with other modules: C2d Metals and Alloys, C2e Cars for Scrap and C4g Nanochemistry

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

MODULE P3: FORCES FOR TRANSPORT

Item P3a: Speed

Summary: Transport and road safety provide the context for this module. The abilities to describe and measure motion are used in the treatment of issues involving everyday transport, including potentially hazardous situations. The safe design and operation of cars (including braking) are also covered. A number of key ideas in this unit underpin later work for those taking P5 and P6. The experiments on vehicle speeds allows the opportunity to collect and analyse science data using ICT tools and the interpretation of the data using creative thought to develop theories.

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Calculating speeds from measurements of time and distance. Practical experiment to investigate the speeds of vehicles near school: • Are male drivers faster than female? • Have the speed-bumps made any difference? Practical experiment to investigate the speeds of toy cars on ramps: • How does the slope angle or height affect the speed? • Which cars are fastest? Find out how different speed cameras work. Exploration of speed records (cars, animals, planes, people etc).	Describe faster objects as covering more distance in a given time. State that speed is measured in metres per second, m/s. State that the measurements needed to determine speed are: • distance; • time. Describe appropriate means of measuring distance and time in everyday situations using a: • stopwatch/stop clock; • measuring tape or trundle wheel. Describe why speed cameras generally take two photographs: • a certain time apart; • near marked lines on the road.
Looking at data from cars, sport and animals then transferring it to graphical form for analysis (distance - time graphs).	Interpret simple graphs of distance against time: • straight line gradient - steady speed; • horizontal line - stationary (zero speed).

MODULE P3: FORCES FOR TRANSPORT

Links with other modules: P3b Changing Speed, P3c Forces and Motion, P5b Vectors and Equations of motions

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Interpret the relationship between speed, distance and time including: • increasing the speed, which increases the distance travelled in the same time; • increasing the speed reduces the time needed to cover the same distance. State and use the equation: $\text{speed} = \frac{\text{distance}}{\text{time}}$	Interpret the relationship between speed, distance and time including the: • effect of changing any one or two of the quantities. State and use the equation: $\text{speed} = \frac{\text{distance}}{\text{time}}$ (A change of subject may be required.)
Describe, draw and interpret qualitatively simple graphs of distance against time. Describe and interpret the gradient (steepness) of a distance-time graph as speed: • higher speed steeper gradient.	Draw and interpret quantitatively simple graphs of distance against time: • qualitatively for non-uniform speed; • calculate speed from the gradient of a straight line graph.

MODULE P3: FORCES FOR TRANSPORT

Item P3b: Changing Speed

Summary: In this item the idea of acceleration is developed. The concept of velocity is not used here to avoid confusion. This is developed further in P5 and P6. Accelerations (involving the change in speed) of real cars can be used and graphically illustrated and studied. Practical measurements of bicycles and sprint starts can be done to collect and analyse real data. The experiments on acceleration allow the opportunity to collect and analyse science data using ICT tools and the interpretation of the data using creative thought to develop theories.

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Practical measurements of bicycles, sprint starts, falling objects can be done to collect and analyse real data for calculating acceleration.	Describe the trends in speed and time from a simple speed-time graph: • horizontal line – constant speed; • straight line positive gradient – increasing speed; • straight line negative gradient – decreasing speed.
Use of real car data from web sites or magazines to illustrate and develop further the concepts of: • speed; • acceleration.	Recognise that acceleration involves a change in speed (limited to a straight line): • speeding up; • slowing down. State that acceleration is measured in metres per second squared, $m/s^{2.}$

MODULE P3: FORCES FOR TRANSPORT

Links with other modules: P3a Speed, P5b Vectors and Equations of motions, P3c Forces and Motion

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe and interpret the gradient (steepness) of a speed-time graph as a measure of acceleration: • more acceleration, steeper gradient. Describe, draw and interpret qualitatively simple graphs of speed against time for uniform accelerations. Describe the area under the line of a speed-time graph as distance travelled.	Describe, draw and interpret simple graphs of speed against time including: • quantitatively for uniform acceleration; • calculations of speed from the gradient of a distance-time graph; • calculations of distance travelled from a speed-time graph for uniform acceleration; • calculations of acceleration from a speed-time graph for uniform acceleration and only qualitatively for non uniform acceleration.
Describe acceleration as change in speed per unit time. State and use the equation: acceleration = change in speed/ time taken.	State and use the equation: acceleration = change in speed/ time taken. (A change of subject may be required.) Explain that acceleration could involve either a change: • in speed; • in direction. Interpret the relationship between acceleration, change of speed and time to include: • effect of changing any one or two of the quantities.

MODULE P3: FORCES FOR TRANSPORT

Item P3c: Forces and Motion

Summary: Before taking your driving test you need to pass a theory test. Part of this involves driving safely and a knowledge of car stopping distances. Driving fast may be tempting but stopping safely is more important. In this item we start to understand the effects of forces on braking and the factors which affect stopping distances. The experiments using elastics, light gates and trolleys allows the opportunity to collect and analyse science data using ICT tools and the interpretation of the data using creative thought to develop theories. Work on stopping distances provides the opportunity to discuss how and why decisions about science and technology are made, including ethical issues and the social, economic and environmental effects of such decisions. This also provides the opportunity to illustrate that there are some questions that science cannot answer.

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Use of elastics, light gates and trolleys to explore acceleration.	Describe and recognise simple situations where forces cause things to speed up or slow down. Describe and recognise that for a given mass: • more force = more acceleration; • less force = less acceleration. Describe and recognise that for a given force: • more mass = less acceleration; • less mass = more acceleration. Describe and recognise that for a given acceleration: • more mass = more force; • less mass = less force.
Modelling stopping distances using a bicycle. Use of real car data from Highway Code data and web sites or magazines to illustrate the science of stopping distances.	Explain the significance to road safety of: • thinking distance; • braking distance; • stopping distance. Describe thinking distance as: • the distance travelled between the need for braking occurring and the brakes starting to act. Describe braking distance as: • the distance taken to stop once the brakes have been applied. Describe stopping distance as: • thinking distance + braking distance.

Can Do Tasks

I can calculate stopping distance knowing thinking and braking distances. 1 point

MODULE P3: FORCES FOR TRANSPORT

Links with other modules: P3a Speed, P3b Changing Speed

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe and interpret the relationship between force, mass and acceleration in everyday examples. State and use the equation: force = mass x acceleration.	State and use the equation: force = mass x acceleration. (A change of subject may be required.) Recognise that when body A exerts a force on body B, body B exerts an equal but opposite force on body A: • these constitute two different views of the same interaction and are not balanced forces.
Describe the factors which might increase thinking distance: • driver tiredness; • influence of alcohol or other drugs; • more speed; • distractions or lack of concentration. Describe the factors which might increase braking distance: • road conditions – slippy, icy, wet; • car conditions - bald tyres, poor brakes; • more speed. Interpret charts of thinking distances and braking distances. Explain the implications of stopping distances in road safety. • driving too close to the car in front; • speed limits; • road conditions.	Explain qualitatively everyday situations where braking distance is changed including: • friction; • mass; • speed; • braking force.

MODULE P3: FORCES FOR TRANSPORT

Item P3d: Work and Power

Summary: We do work whenever a force moves something. Transport, by its nature, is always on the move and energy is being transferred all the time. Some vehicles are more powerful than others but they still get us from A to B. In this item we will learn about power and the energy we use to provide it. Different power ratings, fuel consumption, costs and associated environmental issues about car use can be used to develop the skills of presenting information, developing an argument and drawing a conclusion using scientific terms. This also provides the opportunity to discuss how scientific knowledge and ideas change over time.

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
	Recognise everyday examples in which work is done and power is developed for example: • lifting weights; • climbing stairs; • pulling a sledge; • pushing a shopping trolley.
Measuring work done by candidates lifting weights themselves.	Recognise that work is done when a force moves an object. Recognise that when work is done it depends on: • the size of the force in newtons; • the distance in metres. State that energy is needed to do work. State that the joule is the unit for both work and energy.
Measuring power developed by candidates lifting known weights in for instance 100s time period. The plenary could focus on how efficient we are as machines.	Describe power as a measurement of how quickly work is being done. State that power is measured in watts (W). Recognise that cars: • have different power ratings; • have different fuel consumptions.

MODULE P3: FORCES FOR TRANSPORT

Links with other modules:

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
State and use the equation: work done = force x distance	State and use the equation: work done = force x distance (A change of subject may be required.)
State and use the equation: $\text{power} = \frac{\text{work done}}{\text{time}}$ Interpret fuel consumption figures from data on cars to include; • environmental issues; • costs.	State and use the equation: $\text{power} = \frac{\text{work done}}{\text{time}}$ (A change of subject may be required.)

MODULE P3: FORCES FOR TRANSPORT

Item P3e Energy on the move

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

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Exploring the significance of KE in braking distances applied to stopping distance charts.	Recognise everyday examples in which objects have kinetic energy.
Evaluating data from fuel consumption figures for cars.	Recognise and describe fossil fuels as the main fuel in road transport: • petrol; • diesel. Recognise and describe how electricity can be used for road transport: • battery driven cars; • solar power.
	Interpret data about fuel consumption (no recall required.)

MODULE P3: FORCES FOR TRANSPORT

Links with other modules: B4e Energy Flow, P2a Collecting Energy from the sun, P3h The energy of games and theme rides

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe everyday examples in which objects have kinetic energy. State and recognise that kinetic energy is greater for objects with: • higher speed; • greater mass.	Use the equation: $KE = \frac{1}{2} mv^2$ Apply the ideas of kinetic energy: • relationship between braking distances and speed; • everyday situations involving objects moving.
Interpret data about fuel consumption.	Describe and explain that car fuel consumption figures depend on: • energy required to increase KE; • energy required to do work against friction; • different driving styles and speeds; • different road conditions. Interpret data about fuel consumption.
Explain that electrically powered cars do not pollute at the point of use whereas fossil fuel cars do. Recognise that battery driven cars need to have the battery recharged: • this uses electricity produced from a power station; • power stations cause pollution.	

MODULE P3: FORCES FOR TRANSPORT

Item P3f Crumple Zones

Summary: Stopping cars safely involves absorbing energy. This happens in braking and also in collisions. Injuries can be reduced by clever car design and this unit explores the science behind the safety features of modern vehicles. Collisions are studied here in terms of energy, acceleration and force. In later units, P5 and P6, a more in depth study of collisions will involve the ideas of momentum and provides the opportunity to discuss how scientific knowledge and ideas change over time.

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Design, build and test model crumple zones with trolleys, paper and straws. Test seatbelt materials for stretching. Find out about safety features of cars and how they are tested, compared, and reported to the public. Research safety features in modern cars.	Describe the typical safety features of modern cars that require energy to be absorbed when vehicles stop: • heating in brakes; • crumple zones; • seat-belts; • air bags. State some typical active safety features of cars: • ABS brakes; • traction control; • safety cage. State some typical passive safety features of cars: • electric windows; • cruise control; • paddle shift controls - gears, stereo; • adjustable seating. Explain why seatbelts have to be replaced after a crash.

MODULE P3: FORCES FOR TRANSPORT

Links with other modules: P5d Momentum

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe how seatbelts, crumple zones, air bags are useful in a crash because they: • change shape; • reduce injuries; • absorb energy. Describe how typical active safety features can make driving safer. Describe how typical passive safety features can make driving safer.	Explain that forces can be reduced when stopping (e.g. crumple zones, braking distances, escape lanes, crash barriers, seatbelts and air bags) by: • increasing stopping or collision time; • increasing stopping or collision distance; • decreasing acceleration. Describe using the ideas of friction why ABS brakes reduce braking distances. Evaluate the effectiveness of given safety features in terms of saving lives.

MODULE P3: FORCES FOR TRANSPORT

Item P3g Falling Safely

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

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Investigate factors affecting the speed of a falling whirly-gig or parachute. Investigate factors affecting the speed of plasticine shapes as they fall through wall-paper paste.	Describe how falling objects: • get faster as they fall; • are pulled by a force called weight (gravity) towards the centre of the earth. Use experimental evidence to show that air resistance or drag can slow-down falling objects: • parachutes; • shuttle-cock in badminton. Recognise that frictional forces (drag, friction, air resistance): • act against the movement; • can be reduced (shape, lubricant). Recognise that the shape of moving objects can influence their top speeds: • wedge shape of sports car; • deflectors on lorries and caravans; • roof boxes on cars.
	Recognise that falling object do not experience drag when there is no atmosphere: • moon; • outer space.

MODULE P3: FORCES FOR TRANSPORT

Links with other modules: P5c Projectile Motion

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe how objects falling through Earth's atmosphere reach a terminal speed. Explain in terms of the balance of forces why objects: • increase speed; • decrease speed; • maintain steady speed.	Explain, in terms of balance of forces, why objects reach a terminal speed: • higher speed = more drag; • larger area = more drag; • weight (driving force) = drag gives terminal speed.
Recognise that acceleration in free-fall (g) is constant.	

MODULE P3: FORCES FOR TRANSPORT

Item P3h The energy of games and theme rides

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

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Investigate bouncing balls as an energy system whose efficiency can be measured (100% x bounce height / drop height).	Recognise that objects have gravitational potential energy because of their mass and position in Earth's gravitational field: • more mass = greater PE; • more height = greater PE.
Investigate models (toy cars on plastic track) or real roller-coasters as an energy system whose efficiency can be measured (100% x climb height / drop height).	Recognise everyday examples in which objects use gravitational potential energy.
	Recognise that moving objects have kinetic energy.

MODULE P3: FORCES FOR TRANSPORT

Links with other modules: P3e Energy on the move

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe everyday examples in which objects have gravitational potential energy. Recognise and interpret examples of energy transfer between gravitational potential energy and kinetic energy. When an object falls it converts PE to KE. PE is also greater when the gravitational field strength (g) is higher.	Explain that at terminal speed: • KE does not increase; • PE does work against friction. Use the equation: PE=mgh (A change of subject is required.)
Interpret a gravity ride (roller-coaster) in terms of: • KE; • PE; • energy transfer.	
Describe the effect of changing mass and speed on KE e.g. • doubling mass doubles KE; • doubling speed quadruples KE.	State and use the equation: weight = mass x gravitational field strength (A change of subject is required.)

MODULE B4: IT'S A GREEN WORLD

Item B4a Who planted that there?

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

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Examine a variety of leaves to look at common features. Design the 'ideal' leaf. Make leaf prints and examine stomata under a microscope. Examine prepared microscope slides showing internal structure of leaves.	Identify the chloroplasts, vacuole and cell wall in a plant cell. State that chloroplasts absorb light energy for photosynthesis. State that photosynthesis occurs mainly in the leaves. Describe the entry points of materials required for photosynthesis: • water through roots; • carbon dioxide through leaf pores. Describe the exit point of materials produced in photosynthesis: • oxygen through leaf pores.

MODULE B4: IT'S A GREEN WORLD

Links to other modules: B2c The Food Factory, B3b Diffusion, B3e Growing Up, B4b Water, water everywhere, B4e Energy Flow, B6a Understanding Bacteria

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Name and locate the parts of a leaf: • cuticle; • upper and lower epidermis; • palisade and spongy mesophyll layers; • stomata and guard cells; • veins. Explain how leaves are adapted for efficient photosynthesis: • broad so large surface area; • thin so short distance for gases to travel; • contain chlorophyll to absorb light; • have a network of veins for support and transport; • stomata for gas exchange. State that the exchange of gases is by diffusion. Explain how the structure of a leaf palisade cell is related to its function: • contains many chloroplasts.	Explain how the cellular structure of a leaf is adapted for efficient photosynthesis: • epidermis is transparent; • palisade layer at the top containing most of the chloroplasts; • air spaces in the spongy mesophyll allow diffusion between stomata and photosynthesising cells; • internal surface area / volume ratio very large.

MODULE B4: IT'S A GREEN WORLD

Item B4b Water, water everywhere

Summary: Water is important for all living things and plants are no exception. Water is needed for key life processes such as photosynthesis, support and transport of materials. Water enters plants by osmosis and leaves by transpiration. The investigations each provide the opportunity to plan to test a scientific idea, analyse and interpret data using qualitative and quantitative techniques, present information and draw a conclusion using scientific and technical conventions.

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Carry out experiments to demonstrate osmosis using visking tubing and different concentration solutions.	State that water moves in and out of plant cells through the cell wall and membrane.
Investigate the effects of changing solute concentration on potato discs/strips.	State that the plant cell wall provides support. State that lack of water can cause plants to droop (wilt).
Investigate how quickly detached leaves dry out when different surfaces are covered with petroleum jelly.	Describe how water travels through a plant: • absorption from soil through root hairs; • transport through the plant to the leaves; • evaporation from the leaves (transpiration).
Make leaf prints of upper and lower surfaces of leaves and examine with microscope to investigate number / distribution of stomata.	Explain that healthy plants must balance water loss with water uptake.

MODULE B4: IT'S A GREEN WORLD

Links to other modules: B2e Adapt to Fit, B3b Diffusion, B3e Growing Up, B4a Who planted that there?, B4c Transport in Plants, B6f Microscope Life in Water.

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe osmosis as the movement of water across a partially-permeable membrane from an area of high water concentration (i.e. dilute solution) to an area of low water concentration (i.e. concentrated solution). State that osmosis is a type of diffusion. Explain the term partially-permeable.	Explain that osmosis is the net movement of water molecules from an area of high water concentration to an area of low water concentration across a partially-permeable membrane and is a consequence of the random movement of individual particles. Predict the direction of water movement in osmosis.
State that the both the inelastic cell wall and water are essential for the support of plants.	Explain how plants are supported by the turgor pressure within cells: • water pressure acting against inelastic cell wall. Explain wilting in terms of a lack of turgor pressure. Explain the terms: flaccid, plasmolysed, turgid.
Explain that root hairs, by increasing surface area, increase the ability of roots to take up water by osmosis. State that transpiration provides plants with water for: • cooling; • photosynthesis; • support; • movement of minerals. Explain the loss of water from leaves in terms of the diffusion of water molecules.	Explain that transpiration and water loss from leaves are a consequence of the way in which leaves are adapted for efficient photosynthesis.
Describe how the structure of a leaf is adapted to reduce excessive water loss: • waxy cuticle; • small number of stomata on upper surface.	Explain how the cellular structure of a leaf is adapted to reduce water loss: • changes in guard cell turgidity (due to light intensity and availability of water) to regulate stomatal apertures; • number, distribution, position and size of stomata.
Describe the effects of the uptake and loss of water on animal cells.	Explain how the differences in the effects of water uptake and loss on plant and animal cells depend on the presence / absence of an inelastic cell wall. Use the terms: crenation and lysis.

MODULE B4: IT'S A GREEN WORLD

Item B4c Transport in plants

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

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Examine stained cells in celery left in ink.	Relate plant structure to function: • stem - support, transport; • leaf – photosynthesis; • flower – reproduction; • root - water and mineral uptake and anchorage.
Carry out experiments to show transpiration: • loss of water by plants; • plants lose water through their leaves; • which surface of a leaf loses most water; • weighing potted plants- loss of mass.	State that water travels up plant stems.
Carry out an experiment to show factors that affect transpiration rate: • light; • wind; • temperature; • humidity. ICT data logging opportunity.	Describe experiments to show that transpiration rate is affected by: • light intensity; • temperature; • air movement; • humidity.

MODULE B4: IT'S A GREEN WORLD

Links to other modules: B4b Water, water everywhere, B4d Plants need minerals too

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe the arrangement of xylem and phloem in a dicotyledonous root, stem and leaf: • vascular bundles. Relate xylem and phloem to their function: • xylem - transpiration - movement of water and minerals from the roots to the shoot and leaves; • phloem - translocation - movement of food substances (sugars) up and down stems to growing and storage tissues. State that both xylem and phloem form continuous systems in leaves, stems and roots.	Describe the structure of xylem and phloem: • xylem vessels - thick strengthened cellulose cell wall with a hollow lumen (dead cells); • phloem – columns of living cells.
Describe how transpiration helps cause water to be moved up xylem vessels. State that transpiration is the evaporation and diffusion of water from inside leaves.	
Describe how transpiration rate is increased by: • increase in light intensity; • increase in temperature; • increase in air movement; • decrease in humidity.	Explain why transpiration rate is increased by: • increase in light intensity; • increase in temperature; • increase in air movement; • decrease in humidity.

MODULE B4: IT'S A GREEN WORLD

Item B4d Plants need minerals too

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

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Survey the contents of fertilisers such as 'plant foods'.	State that fertilisers contain minerals such as nitrates, phosphates, potassium and magnesium compounds and that these are needed for plant growth. Interpret data on NPK values to show the relative proportions of nitrates, phosphates and potassium in fertilizers.
Carry out an experiment to show the results of mineral deficiencies in plants. Investigate fertilisers.	State that poor plant growth may be caused by a lack of one or more minerals in the soil.
	Recall that dissolved minerals are absorbed by the roots from the soil.

MODULE B4: IT'S A GREEN WORLD

Links to other modules: B1a Fit for Life, B3a Molecules of Life, B4c Transport in plants, B4f Farming, B4h Recycling, C4c Fertilisers and crop yield

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

MODULE B4: IT'S A GREEN WORLD

Item B4e Energy Flow

Summary: All living things need energy to live. Ultimately this energy comes from the sun. This item explains how energy from the sun flows through ecosystems and how humans can harness it. This item recaps and builds on work done at previous Key Stages. The work on energy transfer provides the opportunity to examine the ethical issues raised by decisions on plant use and the environmental effects of such decisions.

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Construct a mobile to illustrate trophic levels.	Explain the terms producer and consumer.
Survey peers on vegetarian diet.	State that energy enters food chains when plants absorb sunlight.
	State that plants produce biomass when they photosynthesise. Recall examples of fuels from biomass: • wood; • alcohol; • biogas.

MODULE B4: IT'S A GREEN WORLD

Links to other modules: B2c The Food Factory, B4a Who planted that there?, B4f Farming, P3e Energy on the Move, B6d Biofuels, B6f Microscopic Life in Water

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Construct pyramids of numbers from given information and explain what they show: • the numbers of organisms at each stage of a food chain. Construct pyramids of biomass from given information and explain what they show: • the mass of living material at each stage of a food web or chain. Distinguish between pyramids of numbers and pyramids of biomass.	
Explain that energy from the sun flows through food chains by photosynthesis and feeding. Interpret data on energy flow in food chains and webs. Explain how some energy is transferred to less useful forms at each stage (trophic level) in the food chain: • heat from respiration; • egestion.	Explain how the efficiency of energy transfer explains the shape of pyramids of biomass. Explain how the efficiency of energy transfer explains the limited length of food chains. Calculate the efficiency of energy transfer.
Describe different methods of transferring energy from biomass: • burning fast growing trees; • fermenting biomass using bacteria or yeast.	Explain reasons for developing biofuels: • renewable; • reduces air pollution; • energy self-reliance. Discuss choice of use of biomass to include: • eating it; • feeding it to livestock; • using it as a fuel; • growing the seeds.

MODULE B4: IT'S A GREEN WORLD

Item B4f Farming

Summary: Organic farming has become more widespread but intensive farming techniques are more common. This item looks at the issues concerning organic and intensive farming. Discussing different farming methods provides many opportunities to investigate why decisions about science and technology are made and the ethical issues raised. This can be developed to look at the social, economic and environmental effects of such decisions and highlights that there are some questions science cannot address.

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Arrange visit to a local farm / garden centre / small holding.	Analyse data to show that farmers can produce more food if they use herbicides and pesticides and other intensive practices, but that these practices can cause harm to the environment and to health. State that: • pesticides kill pests; • herbicides kill plants (weeds). State that examples of pesticides include: • insecticides to kill insects; • fungicides to kill fungi.
Role play exercise to highlight different view points on intensive farming.	Describe how intensive farming methods can increase productivity: • fish farming; • glasshouses; • hydroponics; • battery farming.
Survey use of organic food and reasons for choice. Grow lettuce / tomato plants using hydrponics. Investigate web sites such as DEFRA, LEAF.	Describe organic farming methods • no artificial fertilisers; • no herbicides; • no pesticides.
	Describe how pests can be controlled biologically by introducing predators.

MODULE B4: IT'S A GREEN WORLD

Links to other modules: B2c The Food Factory, B4d Plants need minerals too, B4e Energy Flow, B6e Life in Soil, B6f Microscopic Life in Water

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain that intensive farming means trying to produce as much food as possible from the land, plants and animals available. Explain that intensive farming methods may be efficient but they raise ethical dilemmas. Describe how intensive farming produces more food but: • pesticides may enter and accumulate in food chains; • pesticides may harm organisms which are not pests.	Explain how intensive food production improves the efficiency of energy transfer by reducing energy transfer: • to competing plants; • to pests; • as heat from farm animals by keeping them penned indoors (battery farming) – warm and less movement. Explain why pesticides may accumulate in food chains.
Describe how plants can be grown without soil (hydroponics). Describe possible uses of hydroponics: • glasshouse tomatoes; • plant growth in areas of barren soil.	Explain the advantages and disadvantages of hydroponics: • better control of mineral levels; • better control of disease; • lack of support for plant; • required addition of fertilisers.
Describe organic farming techniques: • use of animal manure and compost; • crop rotation; • use of nitrogen-fixing crops; • weeding; • varying seed planting times.	Discuss the advantages and disadvantages of organic farming techniques.
Explain the advantages and disadvantages of biological control. Explain how removing one organism from a food chain or web may affect other organisms.	

MODULE B4: IT'S A GREEN WORLD

Item B4g Decay

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

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

MODULE B4: IT'S A GREEN WORLD

Links to other modules: B4h Recycling, B6a Understanding Bacteria, B6d Biofuels

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe the effects on the rate of decay of changing: • temperature; • amount of oxygen; • amount of water.	Explain the effects of changing temperature, and the amounts of oxygen and water on the rate of decay: • effect on microbial respiration; • effect on growth and reproduction of micro-organisms.
State that detritivores feed on dead and decaying material (detritus): • earthworms, maggots, woodlice. Explain how detritivores increase the rate of decay: • produce larger surface area.	Explain the term saprophyte. Explain how decay involves saprophytic nutrition by bacteria and fungi.
Explain how food preservation methods reduce the rate of decay: • canning; • cooling; • freezing; • drying; • adding salt / sugar; • adding vinegar.	

MODULE B4: IT'S A GREEN WORLD

Item B4h Recycling

Summary: We are encouraged to recycle to save the Earth's resources, but natural recycling is nothing new. The survey of local recycling schemes provides the opportunity to use ICT sources and tools to collect secondary data.

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Survey of local recycling schemes.	State that as animals and plants grow they take in chemicals and incorporate elements from these into their bodies. State that when animals and plants die and decay these elements are recycled. State that elements that are recycled include: • carbon; • nitrogen.
Carry out an experiment to test soil for nitrogen. Examine clover roots to see nodules.	

MODULE B4: IT'S A GREEN WORLD

Links to other modules: B1a Fit for Life, B2d Compete or Die, B4d Plants need minerals too, B4g Decay, B2g Population out of Control, B6e Life in Soil.

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain how carbon is recycled in nature: • plants remove carbon dioxide from the air by photosynthesis; • feeding passes carbon compounds along a food chain or web; • plants and animals release carbon dioxide into the air, as a product of respiration; • soil bacteria and fungi, acting as decomposers, release carbon dioxide into the air; • burning of fossil fuels (combustion) releases carbon dioxide.	Explain that soil bacteria and fungi, acting as decomposers, release carbon dioxide into the air by respiration. Explain how carbon is recycled in the sea: • marine organism make shells made of carbonates; • shells become limestone; • carbon returns to air as carbon dioxide during volcanic eruption or weathering.
Explain how nitrogen is recycled in nature: • plants take in nitrates from the soil to make protein for growth; • feeding passes nitrogen compounds along a food chain or web; • nitrogen compounds in dead plants and animals are broken down by decomposers into nitrates and returned to the soil; State the abundance of nitrogen in the air (78%). Explain that nitrogen gas can't be used directly by animals or plants because it is too unreactive.	Explain how nitrogen is recycled in nature: • soil bacteria and fungi, acting as decomposers, convert proteins and urea into ammonia; • the conversion of this ammonia to nitrates by nitrifying bacteria; • the conversion of nitrates to nitrogen gas by denitrifying bacteria; • the fixing of nitrogen gas by nitrogen-fixing bacteria living in root nodules or the soil or by the action of lightning.

MODULE C4: CHEMICAL ECONOMICS

Item C4 Fundamental Chemical Concepts

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

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
These learning outcomes are intended to be taught throughout this specification.	Describe that in a chemical reaction reactants are changed into products. Recognise the reactants and products in a word equation.
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.	State the number of elements in a compound given its formula. State the number of atoms in a formula with no brackets. State 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.
These learning outcomes are intended to be taught throughout this specification.	Recognise that a molecule is made up of more than one atom joined together. Recognise that a molecular formula shows the numbers and types of atom in a molecule. State the number of atoms in a displayed formula. State the names of the different elements in a compound given its displayed formula. State the number of each different type of atom in a displayed formula.

MODULE C4: CHEMICAL ECONOMICS

Links with other modules: C1 to C6

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Construct word equations given the reactants and products.	
Construct balanced symbol equations given the formulae (no brackets) of the reactants and products. Explain that a symbol equation is balanced when the number of each type of atom is the same on both sides of an equation.	Construct balanced symbol equations given the formulae (some or all with brackets) of the reactants and products. Construct balanced symbol equations given the names of the reactants and products (limited to the learning outcomes in this specification).
State the number of atoms in a formula with brackets. State the number of each type of different atom in a formula with brackets.	Recall the formula of the following substances: • hydrochloric acid, nitric acid and sulfuric acid; • ammonia, calcium carbonate, copper oxide, potassium hydroxide, sodium carbonate and sodium hydroxide; • chlorides and sulphates of potassium, sodium and ammonium; • silver nitrate, silver chloride, barium chloride and barium sulphate.
Recognise 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.	Balance equations that use displayed formulae.

MODULE C4: CHEMICAL ECONOMICS

Item C4a Acids and Bases

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

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Carry out an experiment to test a variety of solutions to find pH: • reactions between acids and alkalis; • reactions between acids and bases. (Opportunity to use datalogger.)	Recognise that solutions with a pH of less than 7 are acids. Recognise that solutions with a pH of more than 7 are alkalis. Recognise that solutions with a pH of 7 are neutral.
Simple Investigation into the change in pH during neutralisation (not pH titration curves).	Describe the change in pH when an acid is neutralised by an alkali or vice versa: • pH increases when alkali added; • pH decreases when acid is added.
Investigate the reactions of acids with bases and carbonates e.g. hydrochloric acid with oxides, hydroxides and carbonates.	State that an acid can be neutralised by a base or alkali, or vice versa.
Research uses of sulfuric acid.	Describe some of the uses of sulfuric acid. • preparation of metal surfaces; • manufacture of fertilisers; • car battery acid.

MODULE C4: CHEMICAL ECONOMICS

Links with other modules: C5d Titration, C5g Strong and Weak Acids

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe how universal indicator can be used to estimate the pH of a solution.	
Describe an alkali as a soluble base. State that in neutralisation: acid + base → salt + water Explain the change in pH when an acid is neutralised by an alkali, or vice versa.	State that acids in solution contain hydrogen ions. State that alkalis in solution contain hydroxide ions. Describe neutralisation using the ionic equation: $H^+ + OH^- \rightarrow H_2O$
Recall that metal oxides and metal hydroxides neutralise acids because they are bases. Recall that carbonates neutralise acids to give water, a salt and carbon dioxide. Predict the name of the salt produced when a named base or carbonate is neutralised by a laboratory acid. • sulfuric acid; • nitric acid; • hydrochloric acid.	Construct word equations to show the neutralisation of acids by bases and carbonates (without given the names of the products). Construct balanced symbol equations for the neutralisation of acids by bases and carbonates limited to: • sulfuric acid, nitric acid, and hydrochloric acid; • ammonia, potassium hydroxide, sodium hydroxide and copper oxide; • sodium carbonate and calcium carbonate.

MODULE C4: CHEMICAL ECONOMICS

Item C4b Reacting Masses

Summary: Quantitative aspects of chemistry are introduced. Ideas can be extended and applied to industrial contexts. The use of relative atomic masses to calculate formula masses is developed and chemical equations are used quantitatively in 'reacting masses' calculations. The idea of percentage yield is used in relation to 'loss' of product during a reaction and in terms of the difficulty of getting a reversible reaction to go to completion. Wider social and economic considerations of an industrial process are studied. This item provides opportunities to present information using technical, scientific and mathematical language. Investigating the relationship between mass of malachite and mass of copper oxide that can be obtained from it, gives the opportunity to use ICT as part of teaching and learning.

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Looking at the periodic table to find relative atomic masses. Relative formula mass calculations.	Look up relative atomic masses using the periodic table. Calculate the relative formula mass of a substance from its formula (no brackets) given the appropriate relative atomic masses.
Class experiment to find out the relationship between mass of malachite and mass of copper oxide that can be obtained from it – opportunity to use spreadsheets for analysis of results.	Recognise that the greater the amount of starting materials (reactants) used, the greater the amount of new substances (products) formed. State that the total mass of reactants at the start of a reaction is equal to the total mass of products made.
Preparation of ammonium sulphate. See activities in C4c.	Describe percentage yield as a way of comparing amount of product made (actual yield) to amount expected (predicted yield): • 100% yield means that no product has been lost; • 0% yield means that no product has been made. Recognise possible reasons (given experimental details) why the percentage yield of a product is less than 100% e.g: • loss in filtration; • loss in evaporation; • loss in transferring liquids; • loss in heating.

MODULE C4: CHEMICAL ECONOMICS

Links with other modules: C3a What are atoms like?

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Calculate the relative formula mass of a substance from its formula (with brackets) given appropriate relative atomic masses.	
Use simple ratios to calculate reacting masses and product masses given the mass of a reactant and a product.	Explain why mass is conserved in chemical reactions. Interpret chemical equations quantitatively. Calculate masses of products or reactants from equations using relative formula masses.
State the formula: $\text{percentage yield} = \frac{\text{actual yield} \times 100}{\text{predicted yield}}$ Calculate percentage yield given 'actual yield' and 'predicted yield'.	

MODULE C4: CHEMICAL ECONOMICS

Item C4c Fertilisers and crop yield

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

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Survey of fertilisers available at garden centres and commercially (via Internet searches). Poster about fertilisers.	State that fertilisers make crops grow faster and bigger. State that plants absorb minerals through their roots.
Survey of fertilisers available at garden centres and commercially (via Internet searches). Poster about fertilisers.	Describe fertilisers as chemicals that provide plants with essential chemical elements. Recall that nitrogen, phosphorus and potassium are three essential elements needed for plant growth. Recognise the essential elements given the formula of a fertiliser.
Preparation of a fertiliser by the neutralisation of an acid by an alkali (e.g. potassium nitrate or ammonium sulphate).	Label the apparatus needed to prepare a fertiliser by the neutralisation of an acid with an alkali: • burette and measuring cylinder; • filter funnel. State the names of two nitrogenous fertilisers manufactured from ammonia e.g: • ammonium nitrate; • ammonium phosphate; • ammonium sulphate; • urea.

MODULE C4: CHEMICAL ECONOMICS

Links with other modules: C4b Reacting Masses and C4d Making Ammonia – Haber Process and Costs, B4d Energy Flow

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain that fertilisers must first dissolve in water before they can be absorbed by plants. State that fertilisers increase crop yield.	Explain how the use of fertilisers increases crop yield: • replaces essential elements used by a previous crop or provides extra essential elements; • more nitrogen gets incorporated into plant protein so increased growth; Describe the process of eutrophication: • run-off of fertiliser; • increase of nitrate or phosphate in river water; • algal bloom; • blocks off sunlight to other plants which die; • aerobic bacteria use up oxygen; • most living organisms die.
Calculate the relative formula mass of a fertiliser given its formula and the appropriate relative atomic masses.	Calculate the percentage by mass of each essential element of a fertiliser given its formula and the appropriate relative atomic masses.
State the name of the acid and the alkali needed to make each of the following fertilisers: • ammonium nitrate; • ammonium phosphate; • ammonium sulphate; • potassium nitrate.	Describe the preparation of a named synthetic fertiliser by the reaction of an acid and an alkali: • names of reactants; • experimental method; • how a neutral solution is obtained; • how solid fertiliser is obtained.

MODULE C4: CHEMICAL ECONOMICS

Item C4d Making ammonia – Haber Process and costs

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

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

MODULE C4: CHEMICAL ECONOMICS

Links with other modules:C2h Faster or Slower (2) C4c Fertilisers and Crop Yields, C4f Batch or Continuous and C5f Equilibria

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

MODULE C4: CHEMICAL ECONOMICS

Item C4e Detergents

Summary: Cleaning and washing are important in the life of a teenager. Everyone is looking for more 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 will be considered as well as the scientific accuracy of some advertisements for detergents

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

MODULE C4: CHEMICAL ECONOMICS

Links with other modules:C1b Food Additives, C1c Smells, B6g Enzymes in Action

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain the advantages of using low temperature washes in terms of energy saving and the type of clothes that can be washed.	Describe the chemical nature of a detergent and how detergents work: • hydrophilic head; • hydrophobic tail.
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.
Describe that many detergents are made by the neutralisation of acids with alkalis.	
Interpret data from experiments on the effectiveness of washing up liquids and washing powders.	Interpret data from experiments on the effectiveness of washing up liquids and washing powders.

MODULE C4: CHEMICAL ECONOMICS

Item C4f Batch or Continuous

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

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Industrial case studies.	Recall that ammonia is made all the time in a continuous process. Describe that speciality chemicals such as medicines and pharmaceutical drugs are often made on demand in a batch process.
Industrial case studies.	State that the factors that affect the cost of making and developing a medicine or pharmaceutical drug include: • research and testing; • labour costs; • energy costs; • raw materials; • time taken for development; • marketing.
Practical extraction of a natural oil from a plant. Research plants used as source of drugs.	Recall that the raw materials for speciality chemicals such as pharmaceuticals can be either made synthetically or extracted from plants.

MODULE C4: CHEMICAL ECONOMICS

Links with other modules:C4d Making Ammonia – Haber Process and Costs and C6h Analgesics, C6c Alcohols

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Compare the relatively small scale production of pharmaceutical drugs to the large scale industrial manufacture of ammonia.	Evaluate the advantages and disadvantages of batch and continuous manufacturing processes given relevant data and information.
Describe the factors contributing to the high costs involved in making and developing a new medicine or pharmaceutical drug: • often more labour intensive; • less automation possible; • research and testing may take many years; • raw materials likely to be rare and/or involve expensive extraction from plants; • legislative demands.	Explain how economic considerations determine the development of new drugs in relation to: • research and development time and associated labour costs; • time required to meet legal requirements including timescale for testing and human trials; • anticipated demand for new product ; • length of pay back time for initial investment.
Describe how chemicals are extracted from plant sources: • crushing; • dissolving in suitable solvent; • chromatography.	

MODULE C4: CHEMICAL ECONOMICS

Item C4g Nanochemistry

Summary: Young people are usually interested in acquiring the newest, micro gadget available. Electronic items are becoming smaller each year. This is due to nanotechnology. This item looks at some aspects of nanochemistry – the discovery of buckminsterfullerene, leading to the development of fullerenes – the starting point for nanotubes. Uses of nanotubes in electronic systems and as industrial catalysts are explored.

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Examine and compare the structures of diamond, graphite and buckminsterfullerene. The discovery of buckminsterfullerene.	Recall that three forms of carbon are: • diamond; • graphite; • buckminster fullerene (bucky balls).
	Describe the physical properties of diamond: • lustrous, colourless and clear (transparent); • hard and has a high melting point; • insoluble in water; • does not conduct electricity. Recall that diamond is used in cutting tools and jewellery.
	Describe the physical properties of graphite: • black, lustrous and opaque; • slippery; • insoluble in water; • conducts electricity. Recall that graphite is used as an electrode, in pencil leads and in lubricants.
Build models of fullerenes and nanotubes. (RSC – Contemporary chemistry for schools and colleges has useful worksheets etc).	Describe the physical properties of buckminster fullerene: • black solid; • deep red in solution in petrol. Describe that fullerenes can be joined together to make nanotubes. State that nanotubes: • are very strong; • conduct electricity.
Survey of uses of fullerenes (via internet).	State that chemistry works with materials on a large scale. State that nanochemistry works with materials at the atomic level.

MODULE C4: CHEMICAL ECONOMICS

Links with other modules:C3h Metal Structure and Properties

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Recognise the structures of diamond, graphite and buckminster fullerene.	Explain that diamond, graphite and fullerenes are all allotropes of carbon.
Explain that diamond is used in cutting tools because it is very hard and has a high melting point. Explain that diamond is used in jewellery because it is lustrous and colourless.	Explain the properties of diamond in terms of its structure: • does not conduct electricity since it has no free electrons; • hard and has a high melting point because of the presence of many strong covalent bonds.
Explain that graphite is used in pencil leads because it is slippery and black. Explain that graphite is used in lubricants because it is slippery. Explain that graphite is used as an electrode in electrolysis because it conducts electricity and has a high melting point.	Explain the properties of graphite in terms of its structure: • conducts electricity because it has delocalised electrons that can move; • slippery because layers of carbon atoms are weakly held together and can slide easily over each other; • high melting point because there are many strong covalent bonds to break.
State that Buckminster fullerene has the formula C_{60}. Describe some uses of nanotubes: • semiconductors in electrical circuits; • industrial catalysts; • reinforce graphite in tennis rackets.	Describe the use of fullerenes to 'cage' other molecules. Describe the use of 'caged molecules' in new drug delivery systems. Explain the use of nanotubes as catalysts: • catalyst attached to nanotubes; • large surface area available.
Describe that nanoparticles have different properties from the 'bulk' chemical.	Describe molecular manufacturing in terms of molecule-by-molecule building of a product, using positional chemistry or by starting with a bigger structure and then removing matter to produce nanoscale features.

MODULE C4: CHEMICAL ECONOMICS

Item C4h How pure is our water?

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

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Use text-books, video and/or internet and information from local water companies to find out about the water resources in the United Kingdom and the need to conserve water.	State different types of water resources found in the United Kingdom: • lakes; • rivers; • aquifers; • reservoirs. Recall that water is an important resource for many important industrial chemical processes: • a cheap raw material; • as a coolant; • as a solvent.
Research the pollutants found in water.	State some of the pollutants that may be found in domestic water supplies: • nitrate residues; • lead compounds; • pesticide residues.
Visit a water purification plant. Design a poster to describe the purification of domestic water.	State the types of substances present in water before it is purified: • dissolved salts and minerals; • microbes; • pollutants; • insoluble materials. Describe that chlorination kills microbes in water.
Investigate the solution chemistry of some dissolved ions.	State that barium chloride solution is used to test for sulfate ion: • gives a white ppt. State that silver nitrate solution is used to test for halide ions: • chloride ions give a white ppt; • bromide ions give a cream ppt; • iodide ions give a pale yellow ppt.
Discuss the need for clean water in the developing world (e.g. use of material from Oxfam etc.)	

MODULE C4: CHEMICAL ECONOMICS

Links with other modules:C3g Transition Elements, C5h Ionic Equations and C6d Chemistry of Sodium Chloride (NaCl)

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

MODULE P4: RADIATION FOR LIFE

Item P4a: Sparks

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

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Investigate the effect of charged insulators on small uncharged particles.	Describe and recognise that insulating materials can become charged when rubbed with another insulating material. State that there are two kinds of charge: • positive; • negative.
Carry out experiments to investigate the efficiency of different types of duster. Carry out experiments to demonstrate the forces between charges.	Describe and recognise that when some materials are rubbed they attract other objects: • small pieces of paper or cork to a rubbed comb or strip of plastic; • certain types of dusting brushes become charged and attract dust as they pass over it.
	Recognise and describe how you can get an electrostatic shock from charged objects: • synthetic clothing. Recognise and describe how you can get an electrostatic shock if you become charged and then become earthed: • touching water pipes after walking a floor covered with an insulating material e.g. vinyl.

MODULE P4: RADIATION FOR LIFE

Links with other modules: P4b Electrostatics 2: uses of electrostatics

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
	Describe static electricity in terms of the movement of electrons: • a positive charge due to lack of electrons; • a negative charge due to an excess of electrons.
State and recognise that like charges repel and unlike charges attract. State and recognise that electrostatic phenomena are caused by the transfer of electrons.	
Explain how static electricity can be dangerous when: • in atmospheres where explosions could occur e.g. inflammable gases or vapours or with high concentrations of oxygen; • in situations where large quantities of charge could flow through the body to earth. Explain how static electricity can be a nuisance: • dirt and dust attracted to insulators (plastic containers, TV monitors etc); • causing clothing to "cling".	Explain how the chance of receiving an electric shock can be reduced by: • correct earthing; • use of insulating mats; • using shoes with insulating soles. Explain why it is necessary to earth lorries containing inflammable gases and liquids and powders before unloading. Explain how anti-static sprays, liquids and cloths help reduce the problems of static electricity.

MODULE P4: RADIATION FOR LIFE

Item P4b Uses of electrostatics

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

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
	Recognise and describe how static electricity can be useful: • restarting a heart when it has stopped (defibrillator); • photocopiers/laser printers (detailed structural knowledge not required); • removing dust from smoke in chimneys; • paint spraying.

MODULE P4: RADIATION FOR LIFE

Links with other modules: P4a Electrostatics - Sparks

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe how static electricity can be useful for restarting the heart when it has stopped (defibrillator): • paddles charged; • good electrical contact with patient's chest; • charge passed through patient to make heart contract; • care taken not to shock operator.	Explain how static electricity can be useful for restarting the heart when it has stopped (defibrillator): • paddles charged; • good electrical contact with patient's chest; • charge passed through patient to make heart contract; • care taken not to shock operator.
Describe how static electricity can be useful for electrostatic dust precipitators to remove smoke particles etc from chimneys: • metal plates/grids put into chimneys; • connected to a high PD • dust particles attracted to plate/grid; • dust attracts together to form larger particles; • dust falls back down chimney when particles are heavy enough.	Explain how static electricity can be useful in electrostatic dust precipitators to remove smoke particles etc from chimneys: • metal plates/grids put into chimneys; • connected to a high PD; • dust particles attracted to plate/grid; • dust are attracted together to form larger particles; • dust falls back down chimney when particles are heavy enough.
Describe how static electricity can be useful for paint spraying: • spray gun charged; • paint particles charged; • repel giving fine spray; • object charged oppositely to paint; • attracts paint; • even coat, less waste, shadows painted.	Explain how static electricity can be useful paint spraying: • spray gun charged; • paint particles charged; • repel giving fine spray; • object charged oppositely to paint; • attracts paint; • even coat, less waste, shadows painted.

MODULE P4: RADIATION FOR LIFE

Item P4c Safe Electricals

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

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
	Recognise that a complete loop is required for a circuit to work. State that an earthed conductor cannot become live.
Carry out an experiment to investigate circuits and the effects of resistors and variable resistors.	Describe and recognise how resistors can be used to change the current in a circuit.
	State the colour coding for live, neutral and earth wires: • live – brown; • neutral – blue; • earth – green/yellow. Describe that an earthed conductor cannot become live.
Investigate fuses and RCDs.	Describe reasons for the use of fuses circuit breakers (as re-settable fuses).
	Describe and recognise that “double insulated” appliances do not need earthing.

MODULE P4: RADIATION FOR LIFE

Links with other modules: P6a Resisting

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Explain the behaviour of simple circuits in terms of the flow of electric charge.	
Describe how variable resistors can be used to change the current in a circuit: • rheostat configured as a variable resistor only. Describe the relationships between current, potential difference (pd) and resistance: • for a given resistor, current increases as pd increases and vice versa; • for a fixed pd, current decreases as resistance increases and vice versa. State and use the equation: resistance = $\frac{\text{voltage}}{\text{current}}$	State and use the equation: resistance = $\frac{\text{voltage}}{\text{current}}$ (A change of subject may be required.)
Describe and explain the functions of the live, neutral and earth wires: • live – carries the high voltage; • neutral – the second wire to complete the circuit; • earth – a safety wire to stop the appliance becoming live.	
Describe how a wire fuse works: • if the current becomes too large; • wire fuse melts, breaking the circuit.	Explain how a wire fuse reduces the risk of fire: If the appliance develops a fault: • too large a current causes the fuse melt; • preventing flow of current; • prevents flex overheating and causing fire; • prevents further damage to appliance. Explain the reasons for the use of fuses/circuit breakers as re-settable fuses (structure and mode of operation not required). Explain how a wire fuse and earthing protects people.
Explain why “double insulated” appliances do not need earthing: • case of appliance is a non conductor and cannot become live.	

MODULE P4: RADIATION FOR LIFE

Item P4d Ultrasound

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

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Look at ultrasound pictures and investigate the hearing range of pupils in the class. Investigate the properties of longitudinal waves.	State and recognise that ultrasound is a longitudinal wave. Recognise features of a longitudinal wave: • amplitude; • wavelength; • frequency; • compression; • rarefaction.
	Describe and recognise that ultrasound can be used in medicine: • to look inside people by scanning the body; • to break down kidney and other stones; • to measure the speed of blood flow in the body.

MODULE P4: RADIATION FOR LIFE

Links with other modules: P1g Light

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe features of longitudinal waves: • amplitude; • wavelength; • frequency; • compression; • rarefaction. State and recognise that the frequency of ultrasound is higher than the upper threshold of human hearing.	Describe the motion of particles in longitudinal and transverse waves.
Describe applications of ultrasound: • body scans; • breaking down kidney and other stones.	Explain how ultrasound is used in: • body scans (reflections from different layers; • breaking down accumulations in the body such as kidney stones. Explain the reasons for using ultrasound rather than X-rays: • able to produce images of soft tissue; • does not damage living cells.

MODULE P4: RADIATION FOR LIFE

Item P4e: Treatment

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

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Demonstrate and model the tracer idea with a radioactive source hidden in school skeleton and detect outside.	Recall that nuclear radiation is used in medicine. Recall that x-rays and gamma rays are electromagnetic waves.
	Recall that nuclear radiation can damage cells. Recognise that gamma rays are used to treat cancer. Recall that nuclear radiation is used to sterilize hospital equipment. Recall that the person in hospitals who takes x-rays and uses radiation is a radiographer.

MODULE P4: RADIATION FOR LIFE

Links with other modules: P2d Nuclear Reactions, P2e Our Magnetic Field, P4f What is radioactivity?

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Recall that only beta and gamma radiation can pass through skin.	Explain that: • gamma rays are given out from the nucleus of certain radioactive materials; • X-rays are made by firing high speed electrons at metal targets; • X-rays are easier to control than gamma rays.
Describe that beta or gamma emitters are used as tracers in the body.	Explain how radioactive sources are used in medicine: 1 to treat cancer: • gamma rays focused on tumour; • wide beam used; • rotated round the patient with tumour at centre; • limiting damage to non-cancerous tissue. 2 as a tracer: • beta or gamma emitter; • drunk/eaten/ingested/injected into the body; • allowed to spread through the body; • followed on the outside by a radiation detector.
Describe that X-rays and gamma rays: • have similar wavelengths; • are produced in different ways.	

MODULE P4: RADIATION FOR LIFE

Item P4f What is radioactivity?

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

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Investigate the variation of background radiation with location. Investigate the reality of long half-lives and the dangers of nuclear waste. Explore how the idea of half-life is used to date artefacts in archaeology.	Describe and recognise that the radioactivity of an object is measured by the number of nuclear decays emitted per second. Describe and recognise that radioactivity decreases with time.
	Describe that radiation comes from the nucleus.

MODULE P4: RADIATION FOR LIFE

Links with other modules: P2d Nuclear Reactions, P2e Our Magnetic Field, P4e Treatment, P4h Fission, P4g Uses of radioisotopes, C3a What are atoms like?, C3b How atoms combine – Ionic Bonding

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

MODULE P4: RADIATION FOR LIFE

Item P4g Uses of radioistopes

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

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Use the internet to find levels of background radiation in different parts of the UK.	Describe and recognise that there is background radiation in the environment which is always present.
	State that radioisotopes are used as tracers in industry and hospitals.
Look inside ionisation based smoke detectors and identify the relevant parts.	Describe that alpha sources are used in some smoke detectors.

MODULE P4: RADIATION FOR LIFE

Links with other modules: P2d Nuclear Reactions, P2e Our Magnetic Field, P4f What is radioactivity? P4h Fission

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe background radiation and state that it is caused by radioactive substances in rocks and soil and by cosmic rays.	Explain that some background radiation comes from waste products and man made sources eg waste from: • industry; • hospitals.
Recall examples of the use of tracers: • to track dispersal of waste; • to find leaks/blockages in underground pipes; • to find the route of underground pipes.	Describe how tracers are used in industry: • radioactive material put into pipe; • gamma source used so that it can penetrate to the surface; • progress tracked with detector above ground; • leak/blockage shown by reduces/no radioactivity after this point.
Describe how a smoke detector with an alpha source works.	
Recall that radioactivity can be used to date rocks.	Explain how the radioactive dating of rocks depends on the calculation of the uranium/lead ratio.
Recall that measurements from radioactive carbon can be used to find the date of old materials.	Explain how measurements of the activity of radioactive carbon can lead to an approximate age for different materials: • the amount of Carbon 14 in the air has not changed for thousands of years; • when an object dies (e.g. wood) gaseous exchange with the air stops; • as the Carbon 14 in the wood decays the activity of the sample decreases; • the ratio of current activity from living matter to the activity of the sample leads to a reasonably accurate date.

MODULE P4: RADIATION FOR LIFE

Item P4h Fission

Summary: This unit deals with work on nuclear fission. Nuclear fission is a major source of energy and can be used to produce electricity. Oil and gas will become less important as supplies decrease and alternative forms of energy will be needed. This unit explains the process of nuclear fission and how the energy produced can be harnessed to produce electricity.

Suggested activities and experiences to select from	Assessable learning outcomes Foundation Tier only: low demand
Use ICT simulations of chain reactions.	Recognise that nuclear power stations use uranium as a fuel. Describe the main stages in the production of electricity: • source of energy; • used to produce steam; • used to produce electricity.
	Describe that the decay of uranium can be a chain reaction. Describe that a nuclear bomb is a chain reaction that has gone out of control. Recall that materials can be made radioactive by putting them into a nuclear reactor.

MODULE P4: RADIATION FOR LIFE

Links with other modules: P2c Fuels for Power, P4f What is radioactivity? P4g Uses of radioisotopes

Assessable learning outcomes both tiers: standard demand	Assessable learning outcomes Higher Tier only: high demand
Describe how domestic electricity is generated at a nuclear power station: • nuclear reaction; • producing heat; • producing steam; • turning a turbine; • turning a generator.	Describe what happens to allow uranium to release energy: • uranium nucleus hit by neutron; • causes nucleus to split; • energy released.
Describe the process that gives out energy in a nuclear reactor as nuclear fission. State that nuclear fission produces radioactive waste. Describe how materials become radioactive when they absorb extra neutrons.	Explain what is meant by a chain reaction: • when each uranium nucleus splits more than one neutron is given out; • these neutrons can cause further uranium nuclei to split. Explain how scientists stop nuclear reactions going out of control: • rods placed in the reactor; • to absorb some of the neutrons; • allowing enough neutrons to remain to keep the process operating.

4 Scheme of Assessment

4.1 Units of Assessment

GCSE Additional Science B (J641)	
Unit 1: Additional Science B Unit 1 – modules B3, C3, P3 (B623)	
33⅓% of the total GCSE marks 60 minutes written paper 60marks	This question paper: • is offered in Foundation and Higher Tiers; • focuses on modules B3, C3 and P3; • uses structured questions throughout (there is no choice of questions).
Unit 2: Additional Science B Unit 2 – modules B4, C4, P4 (B624)	
33⅓% of the total GCSE marks 1 hr written paper 60 marks	This question paper: • is offered in Foundation and Higher Tiers; • focuses on modules B4, C4 and P4; • uses structured questions throughout (there is no choice of questions).
Unit 3: Additional Science B Unit 3 – Research Study, Data Task and Practical Skills (B626)	
33⅓% of the total GCSE marks Coursework 60 marks	Candidates produce a portfolio comprising three elements: • Research Study (24 marks) • Data Task (30 marks) • Practical Skills (6 marks)

4.2 Unit Options

There are no unit options within this specification.

4.3 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 B623 and B624, candidates are entered for an option in either the Foundation Tier or the Higher Tier. Unit B626 (skills 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 B623/01 and B624/02.

4.4 Assessment Availability

There are two examination sessions each year, in January and June.

Availability of Units of Assessment

	B623	B624	B626
June 2007	✓	-	-
January 2008	✓	✓	-
June 2008	✓	✓	✓

After June 2008, Units B623 and B624 will be available in both the January and June sessions. The skills assessment, Unit B626, will only be available in the June session.

The Foundation and Higher tier papers covering the same unit will be timetabled on the same day, and will commence at the same time. The papers timetabled simultaneously will contain common questions, or part questions, targeting the overlapping grades C and D.

4.5 Assessment Objectives

The Assessment Objectives describe the intellectual and practical skills that candidates should be able to demonstrate, and which will be assessed.

Assessment Objective 1 (AO1): Knowledge and understanding of science and how science works.

Candidates should be able to:

- demonstrate knowledge and understanding of the scientific facts, concepts techniques and terminology in the specification;
- show understanding of how scientific evidence is collected and its relationship with scientific explanations and theories;
- show understanding of how scientific knowledge and ideas change over time and how these changes are validated.

Assessment Objective 2 (AO2): Application of skills knowledge and understanding.

Candidates should be able to:

- apply concepts, develop arguments or draw conclusions related to familiar and unfamiliar situations;
- plan a scientific task, such as a practical procedure, testing an idea, answering a question or solving a problem;
- show understanding of how decisions about science and technology are made in different situations, including contemporary situations and those raising ethical issues;
- evaluate the impact of scientific developments or processes on individuals, communities or the environment.

Assessment Objective 3 (AO3): Practical, enquiry and data-handling skills.

Candidates should be able to:

- carry out practical tasks safely and skilfully;
- evaluate the methods they use when collecting first-hand and secondary data;
- analyse and interpret qualitative and quantitative data from different sources;
- consider the validity and reliability of data in presenting and justifying conclusions.

Weighting of Assessment Objectives

Assessment Objective	Weighting
AO1	34.0%
AO2	39.3%
AO3	26.6%

4.6 Quality of Written Communication

Candidates are expected to:

- present information in a form that suits its purpose;
- ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;

Where appropriate they should also use a suitable structure and style of writing

Candidates' quality of written communication will be assessed in the Science Research report.

5 Internal Assessment

5.1 Nature of Skills Assessment

Rationale

The assessment of skills involves a variety of approaches to avoid the 'done that before' response. It provides regular feedback to candidates to ensure a sense of achievement and continuous motivation. It contains assessment targets that are achievable by the least able candidates, but differentiation to challenge and reward the most able.

Skills assessment comprises a **Research Study**, a **Data Task** and **Practical Skills**. The research study provides candidates with the opportunity to explore the ways in which scientific evidence is collected and how scientific explanations and theories are developed. The Data Task provides the opportunity to experience the collection and analysis of practical data. The ability of the candidate to carry out practical tasks safely and skilfully is assessed by the teacher at the end of the course, by taking an overview of practical work carried out during the course.

Introduction

The portfolio of work done during the course (for Unit B626) accounts for one third of the marks for this specification. Portfolio work is assessed by teachers, internally standardised and then externally moderated.

Research Study: Candidates are required to use stimulus material provided by OCR and other sources of information to research scientific ideas. The number of reports attempted is at the discretion of the centre, but the results of only one may be submitted.

Data Task: Candidates are required to analyse and evaluate data and to plan further work (which will not be carried out). The number of tasks attempted is at the discretion of the centre, but the results of only one may be submitted.

Practical Skills: The ability to carry out practical tasks safely and skilfully is assessed holistically.

Summary of the Elements of Unit B626

Assessment element	Element marks		Weighting
Research Study	A Collecting information	6 marks	13.3% overall
	B Linking information to explanations	6 marks	
	C Developing and using scientific ideas	6 marks	
	D Quality of written communication	6 marks	
	Total max mark = 24 marks		
Data Task	A Interpreting the data	6 marks	16.6% overall
	B Analysis of the data	6 marks	
	C Evaluation of the data	6 marks	
	D Justifying a conclusion	6 marks	
	E Planning further work	6 marks	
	Total max mark = 30 marks		
Practical Skills	An overview of practical skills throughout the course. Total max mark = 6 marks		3.4% overall

5.2 Marking Internally Assessed Work

Element 1: Research Study

Mark submitted out of 24.

This element of the assessment requires the candidates to use stimulus material provided by OCR, supplemented by electronic (internet, CD ROMs, databases, simulations) and/or more traditional sources of information (books, magazines, leaflets).

Candidates are required to research scientific ideas and the way they, for example:

- have developed over time
- influence technological developments
- interact with social, economic and environmental contexts.

Candidates are given about a week to carry out this research and they then complete a written report, under supervision, on their findings.

The report may be submitted as a hand written or word processed document.

The report should be less than 800 words in length. Reports in excess of 800 words will indicate poor structure and unselective choice of material. A written report should be illustrated by pictures, diagrams and tables as appropriate. At the end of the report the sources used should be listed, with references made to these sources in the body of the report, where appropriate.

A set of Research Study tasks, including detailed guidance for teachers, will be available.

Arrival at Marks for Research Study

The award of marks is based on the professional judgement of the science teacher working within a framework of performance descriptions related to various qualities. For each quality different aspects of performance are identified in the level of response grid. For each quality, a series of

three descriptions of performance (for 2, 4 and 6 marks) illustrates what might be expected for candidates working at different levels.

Marking decisions for candidates should be recorded on the Research Study cover sheet. This cover sheet can be downloaded from the OCR website www.ocr.org.uk.

Candidates may not always report their work in a particular order; evidence of achievement may be located almost anywhere in the report. Thus, it is necessary to look at the whole report for evidence of each quality.

For any one quality, a tick on the grid should be used to indicate the performance statement that best matches the work. Intermediate marks of 1, 3 or 5 can be used where performance exceeds that required by one statement but does not adequately match that required by the next higher statement. When each aspect of performance has been assessed in this way, the marks are added together to give a total mark on a scale 0-24 marks.

This method of marking can be applied even where there is a wide variation between performance for different qualities. Thus, weak performance for one quality need not depress marks too far if other qualities show better performance.

Skills to be assessed (Programme of Study – PoS – references are given for each)

A: Collecting information

The ability to structure research to select suitable sources of information, which will address the issues.

Candidates are expected to be able to:

Provide evidence for testing ideas and developing theories (PoS 3.6ib)

Collect data from secondary sources, including the use of ICT sources and tools (PoS 3.6iib)

B: Interpreting information

The ability to analyse information and make connections to scientific theories and models.

Candidates are expected to be able to:

Interpret data, using creative thought, to provide evidence for testing ideas (PoS 3.6ib)

Analyse scientific information or ideas (PoS 3.6iiia)

Understand that many phenomena can be explained by developing and using scientific theories, models and ideas (PoS 3.6ic)

C: Developing and using scientific ideas

The ability to relate research to the development of scientific ideas over time.

Candidates are expected to be able to:

Show how uncertainties in scientific theories and explanations change over time (PoS 3.6ivc)

Describe the role of the scientific community in validating these changes (PoS 3.6ivc)

Know why decisions about science and technology are made, including those that raise ethical issues and know about the social, economic and environmental effects of such decisions (POS 3.6ivb)

D: Quality of written communication

Candidates are expected to be able to:

Develop an argument using scientific, technical and mathematical language (PoS 3.6iiic)

Research Study Level of Response Grid

Quality Assessed		Number of Marks					
		1	2	3	4	5	6
A	Collecting information		An attempt has been made to collect some information from at least one suitable source.		Relevant information is collected from more than one suitable source.		Relevant, detailed information is collected from more than one suitable source and is clearly referenced in the report.
B	Interpreting information		At attempt has been made to interpret the information.		The information has been interpreted but not always thoroughly and/or correctly.		The information has been interpreted effectively, with skill and understanding.
C	Developing and using scientific ideas		An attempt has been made to describe the influences and/ or development of scientific ideas.		Demonstrates some understanding of the interaction between scientific ideas and their context.		Demonstrates a clear and detailed understanding of the interaction between scientific ideas and their context.
D	Quality of written communication		Spelling, punctuation and grammar is of generally poor quality. Little or no relevant scientific or technical vocabulary is used.		Spelling, punctuation and grammar are generally sound. Appropriate scientific or technical vocabulary is used.		Spelling, punctuation and grammar show very few errors. The report shows full and effective use of relevant scientific and technical terms.

Element 2: Data Task

Mark submitted out of 30.

This element of the assessment requires candidates to analyse and evaluate data.

The task will consist of two stages. In the first stage the candidates will obtain some data.

Because the actual collection of the data is not assessed, a flexible approach can be used. Some tasks will allow the candidates to collect data by using a practical procedure and they can work individually, or in pairs or small groups or as a whole class or by viewing a teacher-demonstration. For other tasks the collection of the data can be made using a CD-ROM or an internet search or a literature search. The principal reasons for the candidates having to collect the data are to:

- enhance their awareness of the techniques required;
- focus on the quality of what they have collected;
- provide help in planning the collection of further data;
- increase their access to ways of analysing and evaluating it.

For the second stage of the task the candidates can either analyse and evaluate the data they have collected or can use similar data provide by OCR.

Candidates will then work individually to complete a written report about the data which is based on questions given to them. The report will be produced under supervision.

The report may be submitted as a hand written or word processed document.

Candidates may attempt any number of the Data Tasks during the course, but the assessment of only one of them will 'count' for their GCSE award.

A set of Data Tasks, including teacher guidance, will be available for use.

Arrival at Marks for Data Task

The award of marks is based on the professional judgement of the science teacher, working within a framework of performance descriptions related to various qualities. For each quality different aspects of performance are identified in the level of response grid. For each quality, a series of three descriptions of performance (for 2, 4 and 6 marks) illustrates what might be expected for candidates working at different levels.

Marking decisions for candidates should be recorded on the Data Task cover sheet. This cover sheet can be downloaded from the OCR website www.ocr.org.uk.

Candidates may not always report their work in a particular order; evidence of achievement may be located almost anywhere in the report. Thus, it is necessary to look at the whole report for evidence of each quality.

For any one quality, a tick on the grid should be used to indicate the performance statement that best matches the work. Intermediate marks of 1, 3 or 5 can be used where performance exceeds that required by one statement but does not adequately match that required by the next higher statement. When each aspect of performance has been assessed in this way, the marks are added together to give a total mark on a scale 0-30 marks.

This method of marking can be applied even where there is a wide variation between performance for different qualities. Thus, a weak performance for one quality need not depress marks too far if other qualities show better performance.

Detailed advice on the award of marks for each OCR-set task will be provided with the task.

Skills to be assessed (Programme of Study – PoS – references are given for each)

A: Interpreting the data

The ability to present data in such a manner as to bring out any patterns that are present.

Candidates are expected to be able to:

Interpret data, using creative thought, to provide evidence for testing ideas (PoS 3.6ib)

Present information using scientific conventions and symbols (PoS 3.6iiic)

B: Analysis of the data

The ability to analyse the data/information and interpret it to show trends or patterns.

Candidates are expected to be able to:

Interpret data, using creative thought, to provide evidence for testing ideas (PoS 3.6ib)

Analyse scientific information or ideas (PoS 3.6iiia)

C: Evaluation of the data

The ability to evaluate the data/information to reach judgements about its reliability and validity.

Candidates are expected to be able to:

Consider the validity and reliability of data as evidence (PoS 3.6id)

Interpret and question scientific information or ideas (PoS 3.6iiia)

D: Justifying a conclusion

The ability to draw a conclusion based on the evidence and to justify this.

Candidates are expected to be able to:

Draw a conclusion using scientific, technical and mathematical language, conventions and symbols and ICT tools (PoS 3.6iiic)

Question scientific information or ideas (PoS 3.6iiia)

E: Planning further work

The ability to plan further work which would help to make the conclusions more secure.

Candidates are expected to be able to:

Plan to test a scientific idea, answer a scientific question or solve a scientific problem (PoS 3.6iia)

Data Task Level of Response Grid

Quality Assessed		Number of Marks					
		1	2	3	4	5	6
A	Interpreting the data		A limited number of results are displayed in tables, charts or graphs using given axes and scales.		Data is displayed using appropriate tables, charts or graphs, allowing some errors in scaling or plotting.		Data is displayed to show general relationships using appropriate complex charts or diagrams e.g. histograms, scatter-grams, or in graphs with correctly selected scales and axes.
B	Analysis of the data		At least one trend / pattern is identified and outlined correctly.		The main trend(s)/pattern(s) are described correctly and there is some evidence of processing quantitative data.		The main trends/ patterns are described correctly with reference to the quantitative data. The data has been processed to reveal additional information and/or detect anomalies.
C	Evaluation of the data		An attempt has been made to consider the quality of the data and the methods used to collect it.		There is consideration of the reliability of the data and an attempt to identify how the methods used enabled valid data to be collected.		There is detailed consideration of the data in terms of both validity and reliability and a clear appreciation of the limitations of the methods used.
D	Justifying a conclusion		A conclusion is given which is related to the data collected.		A considered conclusion is given with justification based on an analysis of the data collected and linked to the underpinning science.		A considered conclusion is given with a well-argued justification based on careful analysis of the data and clearly linked to relevant scientific knowledge and understanding.
E	Planning further work		Some consideration is given to further relevant practical work.		Relevant further practical work is planned in detail.		There is detailed consideration of relevant further practical work and a clear appreciation of how this would further understanding of the topic.

Element 3: Practical Skills

Mark submitted out of 6.

This element of the assessment requires the teacher to take an overview of each candidate's practical work during the course.

Arrival at Marks for Practical Skills

The award of marks is based on the professional judgment of the science teacher, working within a framework of descriptions of performance.

Skill to be assessed (Programme of Study – PoS – references are given)

Practical Skills

The ability to work safely and accurately when carrying out practical activities in science.

Candidates are expected to be able to:

Work accurately and safely, individually and with others, when collecting first-hand data.

Practical Skills Level of Response Grid

Quality Assessed	Number of Marks					
	1	2	3	4	5	6
Working safely and accurately		Practical work is carried out safely and accurately under close supervision and with much guidance.		Practical work is carried out safely and accurately with some guidance.		Practical work is carried out safely and accurately with awareness of risks.

Further detailed guidance on how to assess the practical skills will be provided in guidance to teachers.

Recording and Submitting Marks for Internally Assessed Work

The final total mark for elements 1, 2 and 3 must be submitted to OCR on form MS1 by **15th May** in the year of entry for the unit. These forms are produced and despatched at the relevant time based on entry information provided by the centre.

All assessed work which has contributed to candidates' final totals must be available for moderation.

5.3 Regulations for Internally Assessed Work

Supervision and Authentication of Work

OCR expects teachers to supervise and guide candidates who are undertaking work that is internally assessed. The degree of teacher guidance will vary according to the kind of work being undertaken. It should be remembered, however, that candidates are required to reach their own judgments and conclusions.

When supervising internally assessed tasks, teachers are expected to:

- offer candidates advice about how best to approach such tasks;
- exercise supervision of the work in order to monitor progress and to prevent plagiarism;
- ensure that the work is completed in accordance with the specification requirements and can be assessed in accordance with the specified mark descriptions and procedures.

Work should, wherever possible, be carried out under supervision. However, it is accepted that some tasks may require candidates to undertake work outside the centre. Where this is the case, the centre must ensure that sufficient supervised work takes place to allow the teachers concerned to authenticate each candidate's work with confidence.

Production and Presentation of Internally Assessed Work

Candidates must observe certain procedures in the production of internally assessed work.

Any copied material must be suitably acknowledged.

Where work is based on the use of secondary data, the original sources must be clearly identified.

Annotation of Candidates' Work

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

The writing of comments on candidates' work provides a means of dialogue and feedback between teacher and candidate and a means of communication between teachers during the internal standardisation.

Moderation

All internally assessed work is marked by the teacher and internally standardised by the centre. Marks are then submitted to OCR by 15th May, after which moderation takes place in accordance with OCR procedures. The purpose of moderation is to ensure that the standard of the award of marks is the same for each centre and that each teacher has applied the standards appropriately across the range of candidates within the centre.

It is the responsibility of the centre to carry out effective internal standardisation to ensure that similar standards are applied by each teacher involved in the assessment. The Moderator will require a written statement describing how internal standardisation has been carried out within the centre.

External moderation will be by postal sample selected by the Moderator.

Minimum Requirements for Internally Assessed Work

If a candidate submits no work for this internally assessed unit, then the candidate should be indicated as being absent from that unit on the mark sheets submitted to OCR. If a candidate completes any work at all for an internally assessed unit, then the work should be assessed and the appropriate mark awarded, which may be zero.

6 Technical Information

6.1 Making Unit Entries

Please note that centres must be registered with OCR in order to make any entries, including estimated entries. It is recommended that centres apply to OCR to become a registered centre well in advance of making their first entries. Centres should be aware that a minimum of ten candidates for summer examinations is normally required.

Unit Entry Options

Within Units B623 and B624 candidates must be entered for either the Foundation Tier or the Higher Tier option. It is not necessary for candidates to enter at the same tier in every unit. Candidates may, if they wish, attempt papers at both tiers, but not in the same examination session, since the papers will be timetabled simultaneously.

Entry code	Option code	Component to be taken	
B623	F	01	Additional Science B Unit 1 – modules B3, C3, P3 Foundation
	H	02	Additional Science B Unit 1– modules B3, C3, P3 Higher
B624	F	01	Additional Science B Unit 2 – modules B4, C4, P4 Foundation
	H	02	Additional Science B Unit 2 – modules B4, C4, P4 Higher
B626	-	01	Additional Science B Unit 3 – Research Study, Data Task and Practical Skills

Candidate entries must be made by 21 October for the January session and by 21 February for the June session.

6.2 Making Qualification Entries

Candidates must be entered for certification code **J641** to claim their overall GCSE grade.

If a certification entry is not made, no overall grade can be awarded.

A candidate who has completed all the units required for the qualification may enter for certification either in the same examination session (entries made at the usual time or within a specified period after publication of results) or at a later session.

First certification will be available in June 2008 and every January and June thereafter.

6.3 Grading

GCSE results are awarded on the scale A*-G. Units are awarded a* to g. Grades are awarded on certificates. Results for candidates who fail to achieve the minimum grade (G or g) will be recorded as *unclassified* (U or u).

In unitised schemes, candidates can take units across several different sessions. They can also re-sit units or choose from optional units where available. When working out candidates' overall grades OCR needs to be able to compare performance on the same unit in different sessions when different grade boundaries have been set, and between different units. OCR uses uniform marks to enable this to be done.

A candidate's uniform mark is calculated from the candidate's raw mark. The raw grade 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. 71/100.

Results for each unit will be published in the form of uniform marks according to the following scales.

	Unit Grade								
	a*	a	b	c	d	e	f	g	u
Units 1, 2 and 3	100-90	89-80	79-70	69-60	59-50	49-40	39-30	29-20	19-0

Higher tier who fail to gain a'd' grade candidates may achieve an "allowed e". Higher tier candidates who miss the allowed grade 'e' will be given a uniform mark in the range f-u but will be graded as 'u'.

Candidates' uniform marks for each module are aggregated and grades for the specification are generated on the following scale.

Qualification Grade								
A*	A	B	C	D	E	F	G	U
300-270	269-240	239-210	209-180	179-150	149-120	119-90	89-60	59-0

The candidate's grade will be determined by this total mark. Thus, 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 the assessment may be balanced by better performance in others. Candidates achieving less than the minimum mark for grade G will be unclassified.

6.4 Result Enquiries and Appeals

Under certain circumstances, a centre may wish to query the grade available to one or more candidates or to submit an appeal against an outcome of such an enquiry. Enquiries about unit results must be made immediately following the series in which the relevant unit was taken.

For procedures relating to enquires on results and appeals, centres should consult the OCR *Handbook for Centres* and the document *Enquiries about Results and Appeals – Information and Guidance for Centres* produced by the Joint Council. Copies of the most recent editions of these papers can be obtained from OCR.

6.5 Shelf-Life of Units

Individual unit results, prior to certification of the qualification, have a shelf-life limited only by that of the qualification.

6.6 Unit and Qualification Re-sits

Candidates may re-sit any unit an **unlimited** number of times.

For each unit the best score will be used towards the final overall grade.

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

6.7 Guided Learning Hours

GCSE Science requires 120 guided learning hours in total.

6.8 Code of Practice/Subject Criteria/Common Criteria Requirements

These specifications comply in all respects with the revised *GCSE, GCE, VCE, GNVQ and AEA Code of Practice 2005/6*, the subject criteria for GCSE science and *The Statutory Regulation of External Qualifications 2004*.

6.9 Arrangements for Candidates with Particular Requirements

For candidates who are unable to complete the full assessment or whose performance may be adversely affected through no fault of their own, teachers should consult the *Access Arrangements and Special Consideration Regulations and Guidance Relating to Candidates who are Eligible for Adjustments in Examinations*. In such cases advice should be sought from OCR as early as possible during the course.

6.10 Prohibited Qualifications and Classification Code

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

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.

The classification code for this specification is 1320.

7 Other Specification Issues

7.1 Overlap with other Qualifications

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

7.2 Progression from these Qualifications

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

Many candidates who enter employment with one or more GCSEs will undertake training or further part-time study with the support of their employers.

Progression to further study from GCSE will depend upon the number and nature of the grades achieved. Candidates who are awarded mainly grades G to D at GCSE may either strengthen their base through further study of qualifications at Foundation Level (Level 1) or Intermediate Level (Level 2), for example, OCR GCSE Applied Science (Double Award), OCR GCSE Additional Applied Science. Candidates who are awarded grades C to A* at GCSE are well prepared to broaden their base through further study of qualifications at Intermediate level, for example, OCR GCSE Applied Science (Double Award), OCR GCSE Additional Applied Science or study at Advanced Level (Level 3) within the National Qualifications Framework, for example OCR GCE Biology, OCR GCE Human Biology, OCR GCE Chemistry, OCR GCE Physics, OCR GCE Science.

7.3 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:

- gathering information from the World Wide Web 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 software to present ideas and information on paper and on screen.

The examples listed in the table show some points in the specification where opportunities might more easily be found.

ICT	Possible Opportunities
Gathering information	Internal assessment B3c, B4d, B4f, B4g, C3e, C3h, C4d, C4g, P3c, P4g
Data logging	Internal assessment B3c, B4c, C4a, C4b, P3a
Processing data	Internal assessment C4b, C4d, P3a
Visualisation	Internal assessment B3a, B3d, C4d, P4h
Making presentations	Internal assessment B3c, C3h

7.4 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.

Citizenship Programme of Study	Examples of opportunities for Teaching the Issues during the Course
Section 1: Knowledge and understanding about becoming informed citizens	
The work of parliament, the government and the courts in making and shaping the law	
How the economy functions, including the role of business and financial services	
The opportunities for individuals and voluntary groups to bring about social change locally, nationally, in Europe and internationally	
The media's role in society, including the internet, in providing information and affecting opinion	C4e
The rights and responsibilities of consumers, employers and employees	B3c, C4e, P3f
The issues and challenges of global interdependence and responsibility, including sustainable development and Local Agenda 21	B3g
Section 2 : Enquiry and communication	
Researching a topical scientific issue by analysing information from different sources, including ICT-based sources, showing an awareness of the use and abuse of statistics	Internal Assessment B3c, C4d, C4g, P3e, P3f

Citizenship Programme of Study	Examples of opportunities for Teaching the Issues during the Course
Expressing, justifying and defending orally and in writing a personal opinion about a topical scientific issue.	Internal Assessment
Contributing to group and class discussions	There will be opportunities for discussion in every module. Here are some specific examples. B3e, B3g, C4d, P3d
Section 3: Developing skills of participation and responsible action	
Consider and evaluate views that are not their own	Internal Assessment B3g, C4h
Participating in science-based school and community activities	B4g, C4h

7.5 Key Skills

These specifications provide opportunities for the development of the Key Skills of *Communication*, *Application of Number*, *Information Technology*, *Working with Others*, I*mproving 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 the skills assessment unit.

Level	Communication				Application of Number			IT			Working with Others			Improving Own Learning and Performance			Problem Solving		
	.1a	.1b	.2	.3	.1	.2	.3	.1	.2	.3	.1	.2	.3	.1	.2	.3	.1	.2	.3
1			✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
2			✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		

7.6 Spiritual, Moral, Ethical, Social, Legislative, Economic and Cultural Issues

Spiritual, moral, ethical, social and cultural issues are a major feature of this specification. The content of this course includes aspects which have a profound influence on how people think about themselves, their immediate environment, the Earth as a whole and the Universe.

Issue	Opportunities for Teaching the Issues during the Course
The commitment of scientists to publish their findings and subject their ideas to testing by others.	
Risk and the factors which decide the level of risk people are willing to accept in different circumstances.	B3g, P3c, P3f, P4a
The range of factors which have to be considered when weighing the costs and benefits of scientific activity.	Internal Assessment B3g, B4f, C4d, C4e, C4f
The ethical implications of selected scientific issues.	B3c, B3e, B3g, B3h, B4f, C4e
Scientific explanations which give insight into human nature.	B3a
Scientific explanations which give insight into the local and global environment.	Internal Assessment C4c, C4h, P4f, P4g
Scientific explanations which give insight into our planet and its place in the Universe	

7.7 Sustainable Development, Health and Safety Considerations and European Developments

OCR has taken account of the 1988 Resolution of the Council of the European Community and the Report Environmental Responsibility: An Agenda for Further and Higher Education, 1993 in preparing this specification and associated specimen assessments.

Issue	Examples of opportunities for Teaching the Issues during the Course
Environmental issues	
Air pollution	
Natural disasters and how to predict them	C4h
Food and agriculture	B3f, B3g, B4f, C4c, C4h
Origins and management of waste materials	B4g, B4h, C4h
Energy resources	
Health and Safety issues	
Safe practice in the laboratory	There will be opportunities to demonstrate safe practice in the laboratory in most modules. Internal Assessment
Health and disease	B3c, B3e, C4f, P4b, P4d
Food and nutrition	B4e, B4g
Living with radiation	

Although this specification does not make specific reference to the European dimension it may be drawn into the course of study in a number of ways. The table below provides some appropriate opportunities.

Issue	Examples of opportunities for Teaching the Issues during the Course
The importance of the science-based industry to European economies	B4f, C4d
Environmental issues which extend over a larger area than the UK	C4h
Differences in attitudes to key issues in different parts of Europe	

7.8 Avoidance of Bias

OCR has taken great care in preparation of these specifications and assessment materials to avoid bias of any kind.

7.9 Language

These specifications and associated assessment materials are in English only.

7.10 Support and Resources

Support and additional resources are available from the OCR GCSE science website **www.gcse-science.com** where centres should register their intention to offer this qualification. Registering on this site provides access to a teachers' forum and local support networks.

Appendix A: Grade Descriptions

Grade F

Candidates demonstrate a limited knowledge and understanding of science content and how science works. They use a limited range of the concepts, techniques and facts from the specification, and demonstrate basic communication and numerical skills, with some limited use of technical terms and techniques.

They show some awareness of how scientific information is collected and that science can explain many phenomena.

They use and apply their knowledge and understanding of simple principles and concepts in some specific contexts. With help they plan a scientific task, such as a practical procedure, testing an idea, answering a question, or solving a problem, using a limited range of information in an uncritical manner. They are aware that decisions have to be made about uses of science and technology and, in simple situations familiar to them, identify some of those responsible for the decisions. They describe some benefits and drawbacks of scientific developments with which they are familiar and issues related to these.

They follow simple instructions for carrying out a practical task and work safely as they do so.

Candidates identify simple patterns in data they gather from first-hand and secondary sources. They present evidence as simple tables, charts and graphs, and draw simple conclusions consistent with the evidence they have collected.

Grade C

Candidates demonstrate a good overall knowledge and understanding of science content and how science works, and of the concepts, techniques, and facts across most of the specification. They demonstrate knowledge of technical vocabulary and techniques, and use these appropriately. They demonstrate communication and numerical skills appropriate to most situations.

They demonstrate an awareness of how scientific evidence is collected and are aware that scientific knowledge and theories can be changed by new evidence.

Candidates use and apply scientific knowledge and understanding in some general situations. They use this knowledge, together with information from other sources, to help plan a scientific task, such as a practical procedure, testing an idea, answering a question, or solving a problem.

They describe how, and why, decisions about uses of science are made in some familiar contexts. They demonstrate good understanding of the benefits and risks of scientific advances, and identify ethical issues related to these.

They carry out practical tasks safely and competently, using equipment appropriately and making relevant observations, appropriate to the task. They use appropriate methods for collecting first-hand and secondary data, interpret the data appropriately, and undertake some evaluation of their methods.

Candidates present data in ways appropriate to the context. They draw conclusions consistent with the evidence they have collected and evaluate how strongly their evidence supports these conclusions.

Grade A

Candidates demonstrate a detailed knowledge and understanding of science content and how science works, encompassing the principal concepts, techniques, and facts across all areas of the specification. They use technical vocabulary and techniques with fluency, clearly demonstrating communication and numerical skills appropriate to a range of situations.

They demonstrate a good understanding of the relationships between data, evidence and scientific explanations and theories. They are aware of areas of uncertainty in scientific knowledge and explain how scientific theories can be changed by new evidence.

Candidates use and apply their knowledge and understanding in a range of tasks and situations. They use this knowledge, together with information from other sources, effectively in planning a scientific task, such as a practical procedure, testing an idea, answering a question, or solving a problem.

Candidates describe how, and why, decisions about uses of science are made in contexts familiar to them, and apply this knowledge to unfamiliar situations. They demonstrate good understanding of the benefits and risks of scientific advances, and identify ethical issues related to these.

They choose appropriate methods for collecting first-hand and secondary data, interpret and question data skilfully, and evaluate the methods they use. They carry out a range of practical tasks safely and skilfully, selecting and using equipment appropriately to make relevant and precise observations.

Candidates select a method of presenting data appropriate to the task. They draw and justify conclusions consistent with the evidence they have collected and suggest improvements to the methods used that would enable them to collect more valid and reliable evidence.

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Appendix B: Requirements Relating to Mathematics

During the course of study for this specification, many opportunities will arise for quantitative work, including appropriate calculations. The mathematical requirements which form part of the specification are listed below. Items in the first table may be examined in written papers covering both Tiers. Items in the second table may be examined only in written papers covering the Higher Tier.

Both Tiers
add, subtract, multiply and divide whole numbers
recognise and use expressions in decimal form
make approximations and estimates to obtain reasonable answers
use simple formulae expressed in words
understand and use averages
read, interpret, and draw simple inferences from tables and statistical diagrams
find fractions or percentages of quantities
construct and interpret pie-charts
calculate with fractions, decimals, percentage or ratio
solve simple equations
substitute numbers in simple equations
interpret and use graphs
plot graphs from data provided, given the axes and scales
choose by simple inspection and then draw the best smooth curve through a set of points on a graph
Higher Tier only
recognise and use expressions in standard form
manipulate equations
select appropriate axes and scales for graph plotting
determine the intercept of a linear graph
understand and use inverse proportion
calculate the gradient of a graph
statistical methods e.g. cumulative frequency, box plots, histograms

Appendix C: Physical Quantities and Units

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

Fundamental Physical Quantities	
Physical quantity	Unit(s)
length	metre (m); kilometre (km); centimetre (cm); millimetre (mm)
mass	kilogram (kg); gram (g); milligram (mg)
time	second (s); millisecond (ms)
temperature	degree Celsius (ºC); 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^oC
specific latent heat	J/kg

Appendix D: Health and Safety

In UK law, health and safety is the responsibility of the employer. For most Centres entering candidates for GCSE examinations this is likely to be the Local Education Authority or the Governing Body. Teachers have a duty to co-operate with their employer on health and safety matters. Various regulations, but especially the COSHH Regulations 1996 and the Management of Health and Safety at Work Regulations 1992, require that before any activity involving a hazardous procedure or harmful microorganisms is carried out, or hazardous chemicals are used or made, the employer must provide a risk assessment.

A useful summary of the requirements for risk assessment in school or college science can be found in Chapter 4 of Safety in Science Education. 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, 10th edition, 1996, ASE ISBN 0 86357 250 2;

Hazcards, 1995 with 1998 and 2000 updates, CLEAPSS School Science Service*;

CLEAPSS Laboratory Handbook, 1997 with 2001 update, CLEAPSS School Science Service*;

CLEAPSS Shorter Handbook (CLEAPSS 2000) CLEAPSS School Science Service*;

Hazardous Chemicals, A manual for Science Education, (SSERC, 1997) ISBN 0 9531776 0 2.

*Note that CLEAPSS publications are only available to members or associates.

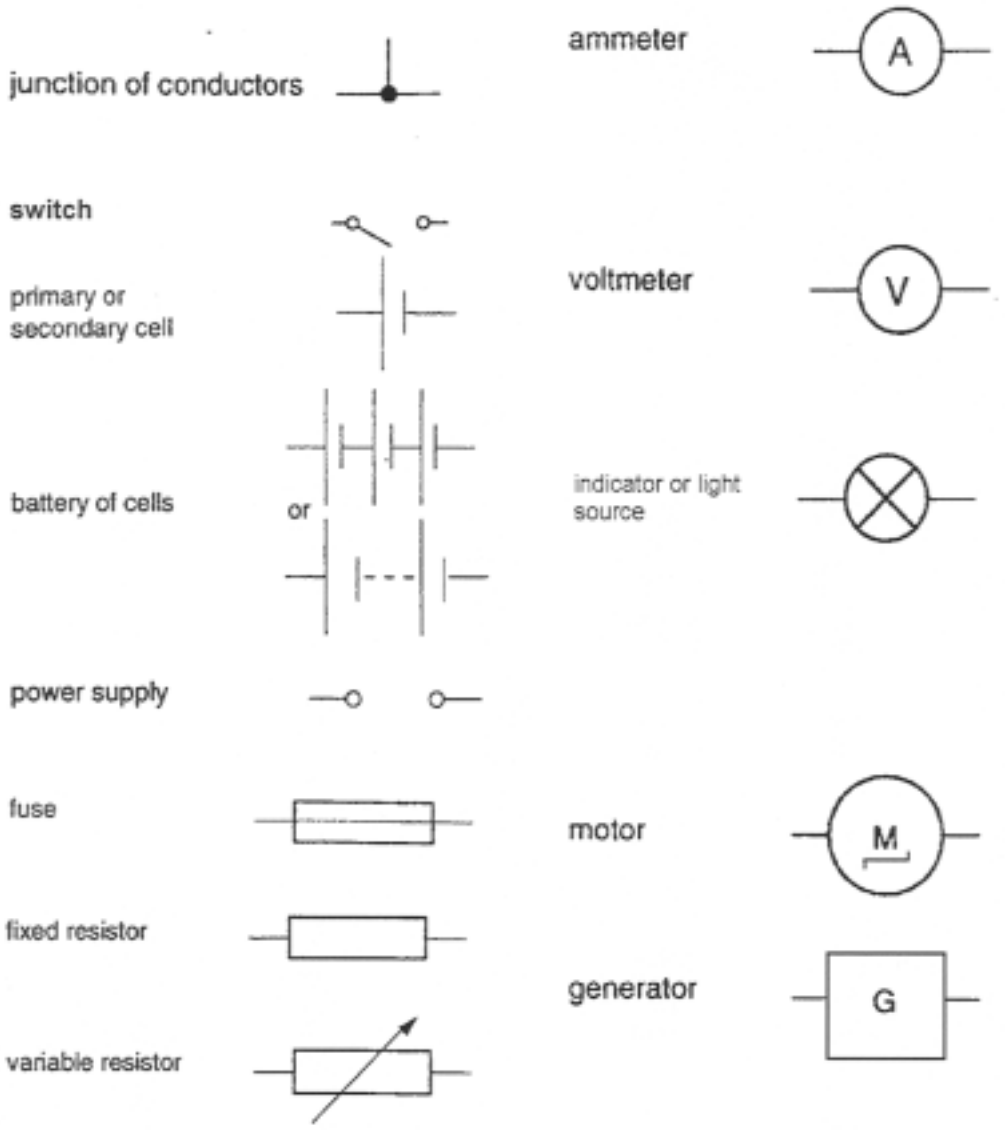
Where an employer has adopted these or other publications as the basis of their model risk assessments, an individual Centre then has to review them, to see if there is a need to modify or adapt them in some way to suit the particular conditions of the establishment. Such adaptations might include a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

When candidates are planning their own investigative work the teacher has a duty to check the plans before the practical work starts and to monitor the activity as it proceeds.

Appendix E: Electrical Symbols



Appendix F: Periodic Table

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