OCR Gateway
GCSE Additional Science
2011

GCSE Additional Science:
Biology

Item B3a: Molecules of life

Identify the mitochondria in an animal cell.	**Cells**
Recall that respiration occurs in the mitochondria providing energy for life processes.	**Respiration**
Explain why liver and muscle cells have large numbers of mitochondria.	**Cells**
(HT) Recall that: • some structures in cells, such as ribosomes, are too small to be seen with the light microscope • ribosomes are in the cytoplasm and are the site of protein synthesis.	**Cells**
Recall that chromosomes in the nucleus: • carry coded information in the form of genes • are made of a molecule called DNA.	**DNA**
Recall that the information in genes is in the form of coded instructions called the genetic code.	**Genes and Protein Synthesis**
Understand that the genetic code controls cell activity and consequently some characteristics of the organism.	**Genes and Protein Synthesis**
Recall that DNA controls the production of different proteins.	**Genes and Protein Synthesis**
Recall that proteins are needed for the growth and repair of cells.	**Genes and Protein Synthesis**
Describe the structure of DNA as two strands coiled to form a double helix, each strand containing chemicals called bases, of which there are four formed by pairs of bases.	**Genes and Protein Synthesis**
Recall that each gene: • contains a different sequence of bases • codes for a particular protein.	**Genes and Protein Synthesis**
Recall that proteins are made in the cytoplasm and understand why a copy of the gene is needed: the gene itself cannot leave the nucleus.	**Genes and Protein Synthesis**
(HT) Recall that the four bases of DNA are A, T, C and G (full names will not be required).	**Genes and Protein Synthesis**
(HT) Describe the complementary base pairings: A – T and G – C.	**Genes and Protein Synthesis**
(HT) Explain how protein structure is determined by the DNA base code, to include: • the base sequence determines amino acid sequence • each amino acid is coded for by a sequence of 3 bases.	**Genes and Protein Synthesis**
(HT) Explain how the code needed to produce a protein is carried from the DNA to the ribosomes by a molecule called mRNA.	**DNA**
(HT) Explain how DNA controls cell function by controlling the production of proteins, some of which are enzymes.	**Genes and Protein Synthesis**
Recall that the structure of DNA was first worked out by two scientists called Watson and Crick.	**DNA**
Describe how Watson and Crick used data from other scientists to build a model of DNA, to include: • X-ray data showing that there were two chains wound in a helix • data indicating that the bases occurred in pairs.	**DNA**
(HT) Explain why new discoveries, such as Watson and Crick's, are not accepted or rewarded immediately, to include: • the importance of other scientists repeating or testing the work.	**DNA**

Item B3b: Proteins and mutations

Recall some examples of proteins to include: • collagen • insulin • haemoglobin	**Genes and Protein Sythesis**
Recognise that proteins are made of long chains of amino acids.	**Genes and Protein Sythesis**
Describe some functions of proteins, to include: • structural (limited to collagen) • hormones (limited to insulin) • carrier molecules (limited to haemoglobin) • enzymes.	**Genes and Protein Sythesis**
(HT) Explain how each protein has its own number and sequence of amino acids, which results in differently shaped molecules, which have different functions.	**Genes and Protein Sythesis**
Describe enzymes as: • proteins • molecules that speed up a chemical reaction • working best at a particular temperature. Understand that enzymes have active sites that substrate molecules fit into when a reaction takes place.	**Enzymes**
Recognise that proteins are made of long chains of amino acids.	**Genes and Protein Sythesis**
Describe enzymes as: • biological catalysts • catalysing chemical reactions occurring in living cells: respiration, photosynthesis, protein synthesis • having a high specificity for their substrate.	**Enzymes**
Explain the specificity of enzymes in terms of the ‘lock and key’ mechanism.	**Enzymes**
Describe how changing temperature and pH, away from the optimum, will change the rate of reaction of an enzyme-catalysed reaction.	**Enzymes**
(HT) Explain how enzyme activity is affected by pH and temperature, to include: • lower collision rates at low temperatures • denaturing at extremes of pH and high temperatures • denaturing as an irreversible change inhibiting enzyme function • denaturing changing the shape of the active site.	**Enzymes**
(HT) Calculate and interpret the Q10 value for a reaction over a 10℃ interval, given graphical or numerical data, using the formula: Q10 = rate at higher temperature rate at lower temperature	**Enzymes**
Recognise that different cells and different organisms will produce different proteins.	**Genes and Protein Sythesis**
Describe gene mutations as changes to genes.	**Genes and Protein Sythesis**
Recall that gene mutations may lead to the production of different proteins.	**Genes and Protein Sythesis**
Understand that mutations occur spontaneously but can be made to occur more often by radiation or chemicals.	**Genes and Protein Sythesis**
Understand that mutations are often harmful but may be beneficial or have no effect.	**Genes and Protein Sythesis**
(HT) Understand that only some of the full set of genes are used in any one cell; some genes are switched off.	**Genes and Protein Sythesis**

(HT) Understand that the genes switched on determine the functions of a cell.	**Genes and Protein Sythesis**
(HT) Explain how changes to genes alter, or prevent the production of the protein which is normally made.	**Genes and Protein Sythesis**

Item B3c: Respiration

Recognise that the energy provided by respiration is needed for all life processes in plants and in animals.	**Respiration**
Recall and use the word equation for aerobic respiration: glucose + oxygen -- carbon dioxide + water	**Respiration**
Describe examples of life processes that require energy from respiration, to include: • muscle contraction • protein synthesis • control of body temperature in mammals.	**Respiration**
Recall and use the symbol equation for aerobic respiration: $C_6H_{12}O_6 + 6O_2 \quad 6CO_2 + 6H_2O$	**Respiration**
Use data from experiments to compare respiration rates, to include: • increased oxygen consumption • increased carbon dioxide production.	**Respiration**
Calculate the respiratory quotient (RQ) using the formula (data provided): RQ = carbon dioxide produced oxygen used	**Respiration**
(HT) Recall that respiration results in the production of ATP and that ATP is used as the energy source for many processes in cells.	**Respiration**
(HT) Explain how the rate of oxygen consumption can be used as an estimate of metabolic rate because aerobic respiration requires oxygen.	**Respiration**
(HT) Explain why the rate of respiration is influenced by changes in temperature and pH.	**Respiration**
Explain why breathing and pulse rates increase during exercise.	**Anaerobic Respiration**
Describe an experiment to measure resting pulse rate and recovery time after exercise.	**Anaerobic Respiration**
Analyse given data from a pulse rate experiment.	**Anaerobic Respiration**
Explain why anaerobic respiration takes place during hard exercise in addition to aerobic respiration.	**Anaerobic Respiration**
Recall that this produces lactic acid which accumulates in muscles causing pain and fatigue.	**Anaerobic Respiration**
Recall and use the word equation for anaerobic respiration which releases energy: glucose --- lactic acid	**Anaerobic Respiration**
Understand that anaerobic respiration releases much less energy per glucose molecule than aerobic respiration.	**Anaerobic Respiration**
(HT) Explain fatigue in terms of lactic acid build up (oxygen debt) and how this is removed during recovery, to include: • hard exercise causing lack of oxygen in cells • the incomplete breakdown of glucose • continued panting replacing oxygen allowing aerobic respiration • increased heart rate ensuring that blood carries lactic acid away to the liver.	**Anaerobic Respiration**

Item B3d: Cell division

Describe the difference between simple organisms which are unicellular and more complex organisms which are multicellular.	**Multicellular Organisms**
Explain the advantages of being multicellular: • allows organism to be larger • allows for cell differentiation • allows organism to be more complex.	**Multicellular Organisms**
(HT) Explain why becoming multicellular requires the development of specialised organ systems, limited to: • communication between cells • supplying the cells with nutrients • controlling exchanges with the environment.	**Multicellular Organisms**
Recall that most body cells contain chromosomes in matching pairs.	**Mitosis**
Explain why the chromosomes have to be copied to produce new cells for growth.	**Mitosis**
Recall that this type of cell division is also needed for: • replacement of worn out cells • repair to damaged tissue • asexual reproduction.	**Mitosis**
Recall that new cells for growth are produced by mitosis.	**Mitosis**
Explain why these new cells are genetically identical.	**Mitosis**
Recall that in mammals, body cells are diploid (two copies of each chromosome).	**Meiosis and Reproduction**
Explain why DNA replication must take place before cells divide.	**Mitosis**
(HT) Describe how, prior to mitosis, DNA replication occurs, to include: • ‘unzipping’ to form single strands • new double strands forming by complementary base pairing.	**Mitosis**
(HT) Describe how in mitosis the chromosomes: • line up along the centre of the cell • they then divide • the copies move to opposite poles of the cell.	**Mitosis**
Recall that in sexual reproduction gametes join in fertilisation.	**Meiosis and Reproduction**
Recall that gametes have half the number of chromosomes of body cells.	**Meiosis and Reproduction**
Understand that in sexual reproduction to produce a unique individual half the genes come from each parent.	**Meiosis and Reproduction**
Explain why sperm cells are produced in large numbers: to increase the chance of fertilisation.	**Meiosis and Reproduction**
Recall that gametes are produced by meiosis.	**Meiosis and Reproduction**
Describe gametes as haploid (contain one chromosome from each pair).	**Meiosis and Reproduction**
Explain why fertilisation results in genetic variation, limited to: • gametes combine to form a diploid zygote • genes on the chromosomes combine to control the characteristics of the zygote.	**Meiosis and Reproduction**
Explain how the structure of a sperm cell is adapted to its function, to include: • many mitochondria to provide energy • an acrosome that releases enzymes to digest the egg membrane.	**Meiosis and Reproduction**

(HT) Explain why, in meiosis, the chromosome number is halved and each cell is genetically different, to include: • one chromosome from each pair separate to opposite poles of the cell in the first division • chromosomes divide and the copies move to opposite poles of the cell in the second division.	**Meiosis and Reproduction**

Item B3e: The Circulatory system	
Describe the functions of components of the blood: • red blood cells • white blood cells • platelets.	**The Circulatory System**
Explain how the structure of a red blood cell is adapted to its function: size, shape, contains haemoglobin, lack of nucleus.	**The Circulatory System**
Describe the function of plasma.	**The Circulatory System**
(HT) Explain how the structure of a red blood cell is adapted to its function in terms of the small size providing a large surface area to volume ratio.	**The Circulatory System**
(HT) Describe how haemoglobin in red blood cells reacts with oxygen in the lungs to form oxyhaemoglobin and how the reverse of this reaction happens in the tissues.	**The Circulatory System**
Recall that the blood moves around the body in: • arteries • veins • capillaries.	**The Circulatory System**
Describe how the parts of the circulatory system work together to bring about the transport of substances around the body, to include: • arteries transporting blood away from the heart • veins transporting blood to the heart • capillaries exchanging materials with tissues.	**The Circulatory System**
(HT) Explain how the adaptations of arteries, veins and capillaries relate to their functions, to include: • thick muscular and elastic wall in arteries • large lumen and presence of valves in veins • permeability of capillaries.	**The Circulatory System**
Describe the functions of the heart in the pumping of blood, to include: • the right side of the heart pumping blood to the lungs • the left side of the heart pumping blood to the rest of the body.	**The Circulatory System**
Recall that blood in arteries is under higher pressure than blood in the veins.	**The Circulatory System**
Explain, in terms of pressure difference, why blood flows from one area to another.	**The Circulatory System**
Identify the names and positions of the parts of the heart and describe their functions, to include: • left and right ventricles to pump blood • left and right atria to receive blood • semilunar, tricuspid and bicuspid valves to prevent back flow • four main blood vessels of the heart.	**The Circulatory System**
Explain why the left ventricle has a thicker muscle wall than the right ventricle.	**The Circulatory System**

(HT) Explain the advantage of the double circulatory system in mammals, to include: • higher pressures • therefore greater rate of flow to the tissues.	**The Circulatory System**

Item B3f: Growth and development	
Describe the functions of parts of a plant cell to include: • vacuole, containing cell sap and providing support • the cell wall, made of cellulose to provide support.	**Cells**
Describe how to make a stained slide of an onion cell.	**Cells**
Understand that bacterial cells are smaller and simpler than plant and animal cells.	**Cells**
Identify simple differences between bacterial cells and plant and animal cells.	**Cells**
Recall that bacterial cells lack: • a ‘true’ nucleus • mitochondria • chloroplasts.	**Cells**
(HT) Describe the difference between the arrangement of DNA in a bacterial cell and a plant/animal cell to include: • presence/absence of a nucleus • single circular strand/chromosomes.	**Cells**
Recall that growth can be measured as an increase in height, wet mass or dry mass.	**Plant and Animal Growth**
Interpret data on a typical growth curve for an individual.	**Plant and Animal Growth**
Recall that dry mass is the best measure of growth.	**Plant and Animal Growth**
Interpret data on increase in mass (including wet and dry mass).	**Plant and Animal Growth**
Describe the main phases of a typical growth curve.	**Plant and Animal Growth**
Recall that in human growth there are two phases of rapid growth, one just after birth and the other in adolescence.	**Plant and Animal Growth**
(HT) Explain the advantages and disadvantages of measuring growth by: • length • wet mass • dry mass.	**Plant and Animal Growth**
(HT) Explain why the growth of parts of an organism may differ from the growth rate of the whole organism.	**Plant and Animal Growth**
Describe the process of growth as cell division followed by cells becoming specialised.	**Plant and Animal Growth**
Recall that the process of cells becoming specialised is called differentiation.	**Plant and Animal Growth**
Recall that undifferentiated cells called stem cells can develop into different cells, tissues and organs.	**Stem Cells**
Recall that stem cells can be obtained from embryonic tissue and could potentially be used to treat medical conditions.	**Stem Cells**
Discuss issues arising from stem cell research in animals.	**Stem Cells**
(HT) Explain the difference between adult and embryonic stem cells.	**Stem Cells**
Understand that animals grow in the early stages of their lives whereas plants grow continually.	**Plant and Animal Growth**
Understand that all parts of an animal are involved in growth whereas plants grow at specific parts of the plant.	**Plant and Animal Growth**

Explain why plant growth differs form animal growth, to include: • animals tend to grow to a finite size but many plants can grow continuously • plant cell division is mainly restricted to areas called meristems • cell enlargement is the main method by which plants gain height • many plant cells retain the ability to differentiate but most animal cells lose it at an early stage.	**Plant and Animal Growth**

Item B3g: New genes for old	
Describe the process of selective breeding as involving the: • selection of desired characteristics • cross breeding • selection of suitable offspring over many generations.	**Altering Genes**
Explain how selective breeding can contribute to improved agricultural yields.	**Altering Genes**
Recognise that a selective breeding programme may lead to inbreeding, which can cause health problems within the species.	**Altering Genes**
(HT) Explain how a selective breeding programme may reduce the gene pool leading to problems of inbreeding, to include: • accumulation of harmful recessive characteristics • reduction in variation.	**Altering Genes**
Recall that: • selected genes can be artificially transferred from one living organism to another • this transfer of genes is called genetic engineering or genetic modification • the transfer of genes can produce organisms with different characteristics.	**Altering Genes**
Identify features of plants and animals that might be selected for in a genetic engineering programme.	**Altering Genes**
Explain some potential advantages and risks of genetic engineering: • advantage – organisms with desired features are produced rapidly • risks – inserted genes may have unexpected harmful effects.	**Altering Genes**
Describe, in outline only, some examples of genetic engineering: • taking the genes from carrots that control betacarotene production and putting them into rice. Humans can then convert the beta-carotene from rice into Vitamin A (solving the problem of parts of the world relying on rice but lacking vitamin A) • the production of human insulin by genetically engineered bacteria • transferring resistance to herbicides, frost damage or disease to crop plants.	**Altering Genes**
Discuss the ethical issues involved in genetic modification.	**Altering Genes**
(HT) Understand the principles of genetic engineering, to include: • selection of desired characteristics • isolation of genes responsible • insertion of the genes into other organisms • replication of these organisms.	**Altering Genes**
Recognise that in the future it may be possible to use genetic engineering to change a person's genes and cure certain disorders.	**Altering Genes**

Recall that changing a person’s genes in an attempt to cure disorders is called gene therapy.	**Altering Genes**
(HT) Recall that gene therapy could involve body cells or gametes.	**Altering Genes**
(HT) Explain why gene therapy involving gametes is controversial.	**Altering Genes**

Item B3h: Cloning	
Recall that: • cloning is an example of asexual reproduction • cloning produces genetically identical copies (clones).	**Cloning**
Recall that Dolly the sheep was the first mammal cloned from an adult.	**Cloning**
Recognise that identical twins are naturally occurring clones	**Cloning**
Understand that Dolly the sheep was produced by the process of nuclear transfer and that nuclear transfer involves placing the nucleus of a body cell into an egg cell.	**Cloning**
Describe some possible uses of cloning, limited to: • mass producing animals with desirable characteristics • producing animals that have been genetically engineered to provide human products • producing human embryos to supply stem cells for therapy.	**Cloning**
Understand the ethical dilemmas concerning human cloning	**Cloning**
(HT) Describe in outline the cloning technique used to produce Dolly, to include: • nucleus removed from an egg cell • egg cell nucleus replaced with the nucleus from an udder cell • egg cell given an electric shock to make it divide • embryo implanted into a surrogate mother sheep • embryo grows into a clone of the sheep from which the udder cell came.	**Cloning**
(HT) Describe the benefits and risks of using cloning technology.	**Cloning**
(HT) Explain the possible implications of using genetically modified animals to supply replacement organs for humans.	**Cloning**
Recognise that plants grown from cuttings or tissue culture are clones.	**Asexual Reproduction**
Describe how spider plants, potatoes and strawberries reproduce asexually.	**Asexual Reproduction**
Describe how to take a cutting.	**Asexual Reproduction**
Describe the advantages and disadvantages associated with the commercial use of cloned plants, to include: • advantage – can be sure of the characteristics of the plant since all plants will be genetically identical • advantage – it is possible to mass produce plants that may be dif cult 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.	**Asexual Reproduction**
(HT) Describe plant cloning by tissue culture, to include: • selection for characteristics • large number of small pieces of tissue • aseptic technique • use of suitable growth medium and conditions.	**Asexual Reproduction**

(HT) 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.	Asexual Reproduction

Module B4: It's A Green World

Item B4a: Ecology in the local environment	
Describe how to use collecting/counting methods, to include: • pooters • nets • pitfall traps • quadrats.	Investigating Ecosystems
Describe a method to show the variety of plants and animals living in a small area such as a 1m quadrat.	Investigating Ecosystems
Use keys to identify plants and animals.	Investigating Ecosystems
Use data from collecting/counting methods to calculate an estimate of the population size based on: • scaling up from a small sample area • the use of capture-recapture data, given the formula: population size = number in 1st sample × number in 2nd sample / number in 2nd sample previously marked	Investigating Ecosystems
(HT) Explain the effect of sample size on the accuracy of an estimate of population size.	Investigating Ecosystems
(HT) Explain the need to make certain assumptions when using capture-recapture data, to include: • no death, immigration or emigration • identical sampling methods • marking not affecting survival rate.	Investigating Ecosystems
Explain how the distribution of organisms within a habitat is affected by the presence of other living organisms as well as physical factors.	Investigating Ecosystems
Explain the differences between: • ecosystem and habitat • community and population.	Investigating Ecosystems
Describe how to map the distribution of organisms in a habitat using a transect line.	Investigating Ecosystems
Interpret data from kite diagrams showing the distribution of organisms.	Investigating Ecosystems
(HT) Explain what it means for an ecosystem to be described as self supporting in all factors other than an energy source.	Investigating Ecosystems
(HT) Describe zonation as a gradual change in the distribution of species across a habitat.	Investigating Ecosystems
(HT) Explain how a gradual change of an abiotic factor can result in the zonation of organisms in a habitat.	Investigating Ecosystems
Define biodiversity as the variety of different species living in a habitat.	Investigating Ecosystems
Identify native woodlands and lakes as natural ecosystems and forestry plantations and fish farms as artificial ecosystems.	Investigating Ecosystems
Compare the biodiversity of natural ecosystems and artificial ecosystems to include: • native woodlands and lakes with forestry plantations and fish farms.	Investigating Ecosystems

(HT) Explain reasons for the differences between the biodiversity of native woodlands and lakes compared with forestry plantations and fish farms.	**Investigating Ecosystems**

Item B4b: Photosynthesis	
Recall and use the word equation for photosynthesis: (light energy) carbon dioxide + water --- glucose + oxygen (chlorophyll) Understand that oxygen is a waste product in this reaction.	**Photosynthesis**
Recall and use the balanced symbol equation for photosynthesis: (light energy) $6CO_2 + 6H_2O$ --- $C_6H_{12}O_6 + 6O_2$ (chlorophyll)	**Photosynthesis**
Describe the development of the understanding of the process of photosynthesis, to include: • the view of Greek scientists that plants gained mass only by taking in minerals from the soil • Van Helmont's experimental conclusion that plant growth cannot be solely due to nutrients from the soil • Priestley's experiment which showed that oxygen is produced by plants.	**Photosynthesis**
(HT) Explain how experiments using isotopes have increased our understanding of photosynthesis, to include: that oxygen produced by photosynthesis comes from the water and not the carbon dioxide.	**Photosynthesis**
(HT) Describe photosynthesis as a two stage process: • light energy is used to split water, releasing oxygen gas and hydrogen ions • carbon dioxide gas combines with the hydrogen to make glucose.	**Photosynthesis**
Recall that the glucose made in photosynthesis is transported as soluble sugars but is stored as insoluble starch.	**Uses of Glucose in Plants**
Recall that glucose and starch can be converted to other substances in plants to be used for energy, growth and storage products.	**Uses of Glucose in Plants**
Describe the conversion of glucose and starch to other substances in plants and their use: • glucose for energy (respiration) • cellulose for cell walls • proteins for growth and repair • starch, fats and oils for storage.	**Uses of Glucose in Plants**
(HT) Explain why insoluble substances such as starch are used for storage: • does not move away in solution from storage areas • does not affect water concentration inside cells.	**Uses of Glucose in Plants**
Explain why plants grow faster in the summer because of more: • light • warmth.	**Photosynthesis**
Describe how photosynthesis can be increased by providing: • more carbon dioxide • more light • higher temperature.	**Photosynthesis**

(HT) Explain the effects of limiting factors on the rate of photosynthesis: • CO_2 • light • temperature.	**Photosynthesis**
Understand that plants carry out respiration as well as photosynthesis.	**Uses of Glucose in Plants**
Explain why plants carry out respiration all the time.	**Uses of Glucose in Plants**
(HT) Explain why plants take in carbon dioxide and give out oxygen during the day and do the reverse at night, in terms of both photosynthesis and respiration.	**Photosynthesis**

Item B4c: Leaves and photosynthesis

Understand why chloroplasts are not found in all plant cells.	**Leaves**
Recall that chlorophyll pigments in chloroplasts absorb light energy for photosynthesis.	**Leaves**
Recall the entry points of materials required for photosynthesis: • water through root hairs • carbon dioxide through stomata.	**Leaves**
Recall the exit point of materials produced in photosynthesis: • oxygen through stomata.	**Leaves**
Understand that broader leaves enable more sunlight to be absorbed.	**Leaves**
Name and locate the parts of a leaf: • cuticle • upper and lower epidermis • palisade and spongy mesophyll layers • stomata and guard cells • vascular bundle.	**Leaves**
Explain how leaves are adapted for efficient photosynthesis: • broad so large surface area • thin so short distance for gases to diffuse • contain chlorophyll and other pigments to absorb light from different parts of the spectrum • have a network of vascular bundles for support and transport • guard cells which open and close the stomata.	**Leaves**
(HT) Explain how the cellular structure of a leaf is adapted for efficient photosynthesis: • epidermis is transparent • palisade layer at the top containing most of the chloroplasts • air spaces in the spongy mesophyll allow diffusion between stomata and photosynthesising cells • internal surface area to volume ratio very large.	**Leaves**
(HT) Interpret data on the absorption of light by photosynthetic pigments (chlorophyll a and b, carotene and xanthophyll) to explain how plants maximise the use of energy from the Sun.	**Leaves**

Item B4d: Diffusion and osmosis

Recall that substances move in and out of cells by diffusion through the cell membrane.	**Diffusion**

Describe diffusion as the movement of a substance from a region of high to low concentration.	**Diffusion**
Explain the net movement of particles by diffusion from an area of high concentration to an area of low concentration, as a consequence of the random movement of individual particles.	**Diffusion**
Describe how molecules enter and leave cells by diffusion through the cell membrane.	**Diffusion**
(HT) Explain how the rate of diffusion is increased by: • a shorter distance • a greater concentration difference (gradient) • a greater surface area.	**Diffusion**
Recognise that water moves in and out of plant cells by osmosis through the cell membrane.	**Osmosis**
Describe osmosis as the movement of water across a partially-permeable membrane from an area of high water concentration (ie dilute solution) to an area of low water concentration (ie concentrated solution).	**Osmosis**
Recall that osmosis is a type of diffusion.	**Osmosis**
Explain the term partially-permeable.	**Osmosis**
(HT) Explain the net movement of water molecules by osmosis from an area of high water concentration to an area of low water concentration across a partially-permeable membrane, as a consequence of the random movement of individual particles.	**Osmosis**
(HT) Predict the direction of water movement in osmosis.	**Osmosis**
Recall that the plant cell wall provides support.	**The Movement of Water in Plants**
Understand that lack of water can cause plants to droop (wilt).	**The Movement of Water in Plants**
Explain how plants are supported by the turgor pressure within cells: • water pressure acting against inelastic cell wall.	**The Movement of Water in Plants**
Explain wilting in terms of a lack of turgor pressure.	**The Movement of Water in Plants**
(HT) Explain the terms: flaccid, plasmolysed and turgid.	**The Movement of Water in Plants**
Describe how carbon dioxide and oxygen diffuse in and out of plants through the leaves.	**Leaves**
Explain how leaves are adapted to increase the rate of diffusion of carbon dioxide and oxygen.	**Leaves**
Recall that water moves in and out of animal cells through the cell membrane.	**Leaves**
Describe the effects of the uptake and loss of water on animal cells.	**The Movement of Water in Plants**
(HT) Explain why there are differences in the effects of water uptake and loss on plant and animal cells.	**The Movement of Water in Plants**
(HT) Use the terms: crenation and lysis.	**The Movement of Water in Plants**

Item B4e: Transport in plants	
Describe the arrangement of xylem and phloem in a dicotyledonous root, stem and leaf, to include vascular bundles.	**The Movement of Water in Plants**
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.	**The Movement of Water in Plants**
Understand that both xylem and phloem form continuous systems in leaves, stems and roots.	**The Movement of Water in Plants**

(HT) 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.	The Movement of Water in Plants
Describe how water travels through a plant: • absorption from soil through root hairs • transport through the plant, up the stem to the leaves • evaporation from the leaves (transpiration).	The Movement of Water in Plants
Recall transpiration as the evaporation and diffusion of water from inside leaves.	The Movement of Water in Plants
Describe how transpiration causes waters to be moved up xylem vessels.	The Movement of Water in Plants
(HT) Explain how transpiration and water loss from leaves are a consequence of the way in which leaves are adapted for ef cient photosynthesis.	The Movement of Water in Plants
Describe experiments to show that transpiration rate is affected by: • light intensity • temperature • air movement • humidity.	The Movement of Water in Plants
Describe the effect on transpiration rate of: • increase in light intensity • increase in temperature • increase in air movement • decrease in humidity.	The Movement of Water in Plants
Interpret data from experiments on transpiration rate.	The Movement of Water in Plants
(HT) Explain why transpiration rate is increased by: • increase in light intensity • increase in temperature • increase in air movement • decrease in humidity.	The Movement of Water in Plants
Understand that healthy plants must balance water loss with water uptake.	The Movement of Water in Plants
Explain how root hairs increase the ability of roots to take up water by osmosis.	The Movement of Water in Plants
Recall that transpiration provides plants with water for: cooling, photosynthesis, support and the movement of minerals	The Movement of Water in Plants
(HT) 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.	The Movement of Water in Plants

Item B4f: Plants need minerals	
Recall that fertilisers contain minerals such as nitrates, phosphates, potassium and magnesium compounds and that these are needed for plant growth.	Minerals for Plants
Interpret data on NPK values to show the relative proportions of nitrates, phosphates and potassium in fertilisers.	Minerals for Plants

Explain why plants require: • nitrates: for proteins which are needed for cell growth • phosphates: for respiration and growth • potassium compounds: for respiration and photosynthesis • magnesium compounds: for photosynthesis.	**Minerals for Plants**
(HT) Describe how elements obtained from soil minerals are used in the production of compounds in plants, limited to: • nitrogen to make amino acids • phosphorus to make DNA and cell membranes • potassium to help enzymes (in photosynthesis and respiration) • magnesium to make chlorophyll.	**Minerals for Plants**
Describe experiments to show the effects on plants of mineral deficiencies: • soil-less culture • each trial missing one mineral.	**Minerals for Plants**
Relate mineral deficiencies to the resulting poor plant growth: • nitrate – poor growth and yellow leaves • phosphate – poor root growth and discoloured leaves • potassium – poor ower and fruit growth and discoloured leaves • magnesium – yellow leaves.	**Minerals for Plants**
Describe how minerals are absorbed, to include: • dissolved in solution • by the root hairs • from the soil.	**Minerals for Plants**
Recall that minerals are usually present in soil in quite low concentrations.	**Minerals for Plants**
(HT) Explain how minerals are taken up into root hair cells by active transport.	**Active Transport**
(HT) Understand that active transport can move substances from low concentrations to high concentrations (against the concentration gradient), across a cell membrane, using energy and respiration.	**Active Transport**

Item B4g: Decay	
Recall the key factors in the process of decay: • presence of microorganisms • temperature • oxygen • moisture.	**Decay**
Explain why decay is important for plant growth.	**Decay**
Describe the effects on the rate of decay of changing: • temperature • amount of oxygen • amount of water.	**Decay**

(HT) Explain why changing temperature, and the amounts of oxygen and water, affect the rate of decay in terms of the: • effect on microbial respiration • effect on growth and reproduction of microorganisms.	**Decay**
Describe how to carry out an experiment to show that decay is caused by the decomposers bacteria and fungi.	**Decay**
Recall that detritivores, including earthworms, maggots and woodlice, feed on dead and decaying material (detritus).	**Decay**
Explain how detritivores increase the rate of decay by producing a larger surface area.	**Decay**
(HT) Explain the term saprophyte.	**Decay**
(HT) Explain how saprophytic fungi digest dead material, in terms of extracellular digestion.	**Decay**
Recall that microorganisms are used to: • break down human waste (sewage) • break down plant waste (compost).	**Decay**
Recognise that food preservation techniques reduce the rate of decay: • canning • cooling • freezing • drying • adding salt/sugar • adding vinegar.	**Decay**
Explain how food preservation methods reduce the rate of decay.	**Decay**

Item B4h: Farming

Analyse data to show that farmers can produce more food if they use pesticides and understand that these practices can cause harm to the environment and to health.	**Farming**
Recall that pesticides kill pests which are any organisms that damage crops.	**Farming**
Recall that examples of pesticides include: • insecticides to kill insects • fungicides to kill fungi • herbicides to kill plants (weeds).	**Farming**
Explain the disadvantages of using pesticides: • pesticides may enter and accumulate in food chains • pesticides may harm organisms which are not pests • some pesticides are persistent.	**Farming**
Recall that intensive farming means trying to produce as much food as possible from the land, plants and animals available. Describe how intensive farming methods can increase productivity methods limited to: • fish farming • glasshouses • hydroponics • battery farming.	**Farming**

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

OCR Gateway
GCSE Additional Science
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GCSE Additional Science:
Chemistry

Module C3: Chemical Economics	**Boardworks Presentation**

Item C3: Fundamental Chemical Concepts	
Understand that in a chemical reaction reactants are changed into products.	**Formulae and Equations**
Recognise the reactants and products in a word equation.	**Formulae and Equations**
Construct word equations given the reactants and products.	**Formulae and Equations**
Construct word equations (not all reactants and products given).	**Formulae and Equations**
Recognise the reactants and the products in a symbol equation.	**Formulae and Equations**
Construct balanced symbol equations given the formulae (no brackets) of the reactants and products.	**Formulae and Equations**
Explain why a symbol equation is balanced.	**Formulae and Equations**
(HT) Construct balanced symbol equations given the formulae (some or all with brackets) of the reactants and products.	**Formulae and Equations**
(HT) Construct balanced symbol equations given the names of the reactants and products (limited to the learning outcomes in C3).	**Formulae and Equations**
Deduce the number of elements in a compound given its formula.	**Formulae and Equations**
Deduce the number of atoms in a formula with no brackets.	**Formulae and Equations**
Deduce the number of each different type of atom in a formula with no brackets.	**Formulae and Equations**
Deduce the number of atoms in a formula with brackets.	**Formulae and Equations**
Deduce the number of each type of different atom in a formula with brackets.	**Formulae and Equations**
Recall the formula of the following substances: • calcium carbonate • carbon dioxide, hydrogen and water • hydrochloric acid.	**Representing Chemicals**
(HT) Recall the formula of the following substances: • sulfuric acid • calcium chloride, magnesium chloride and magnesium sulfate.	**Representing Chemicals**
Recognise whether a substance is an element or a compound from its formula.	**Representing Chemicals**
Deduce the names of the different elements in a compound given its formula.	**Formulae and Equations**
Understand that a molecule is made up of more than one atom joined together.	**Representing Chemicals**
Understand that a molecular formula shows the numbers and types of atom in a molecule.	**Representing Chemicals**
Deduce the number of atoms in a displayed formula.	**Representing Chemicals**
Deduce the names of the different elements in a compound given its displayed formula.	**Representing Chemicals**
Deduce the number of each different type of atom in a displayed formula.	**Representing Chemicals**
Understand that a displayed formula shows both the atoms and the bonds in a molecule.	**Representing Chemicals**
Write the molecular formula of a compound given its displayed formula.	**Representing Chemicals**
Construct balanced equations using displayed formulae.	**Representing Chemicals**
Recognise whether a particle is an atom, molecule or ion given its formula.	**Representing Chemicals**
Understand that atoms contain smaller particles one of which is a negative electron.	**Ions and Ionic Bonding / Atomic Structure**
Understand that positive ions are formed when electrons are lost from atoms.	**Ions and Ionic Bonding**
Understand that negative ions are formed when electrons are gained by atoms.	**Ions and Ionic Bonding**

Recall that two types of chemical bond holding atoms together are: • Ionic bonds • covalent bonds.	**Ions and Ionic Bonding**
Understand that an ionic bond is the attraction between a positive ion and a negative ion.	**Ions and Ionic Bonding**
Understand that a covalent bond is a shared pair of electrons.	**Covalent Bonding**
(HT) Explain how an ionic bond is formed.	**Ions and Ionic Bonding**
(HT) Explain how a covalent bond is formed.	

Item C3a: Rate of reaction (1)	
Recognise that some reactions can be fast and others very slow: • rusting is a slow reaction • burning and explosions are very fast reactions.	**Measuring Reaction Rates**
Understand that the rate of a reaction measures how much product is formed in a fixed time period.	**Measuring Reaction Rates**
Understand common units for the rate of reaction: • g/s or g/min • cm3/s or cm3/min.	**Measuring Reaction Rates**
Label the laboratory apparatus needed to measure the rate of reaction producing a gas: • gas syringe • flask.	**Measuring Reaction Rates**
Plot experimental results involving gas volumes or mass loss on a graph.	**Measuring Reaction Rates**
Plot experimental results involving reaction times on a graph.	**Measuring Reaction Rates**
Interpret data in tabular, graphical and written form about the rate of reaction or reaction time for example: • reading off values from a graph • comparing rates of reaction by comparing gradients of graphs • comparing rates of reaction using reaction times.	**Measuring Reaction Rates**
Interpret data in tabular, graphical and written form about the rate of reaction or reaction time for example: • comparing the rate of reaction during a reaction.	**Measuring Reaction Rates**
(HT) Interpret data from tabular, graphical and written form about the rate of reaction or reaction time for example: • calculating the rate of reaction from the slope of an appropriate graph including determining units • extrapolation • interpolation.	**Measuring Reaction Rates**
Explain why a reaction stops.	**Measuring Reaction Rates**
Recognise and use the idea that the amount of product formed is directly proportional to the amount of limiting reactant used.	**Measuring Reaction Rates**
Recall that the limiting reactant is the reactant not in excess that is all used up at the end of the reaction.	**Measuring Reaction Rates**
Explain, in terms of reacting particles, why the amount of product formed is directly proportional to the amount of limiting reactant used.	**Measuring Reaction Rates**

Item C3b: Rate of reaction (2)	
Recognise that chemical reactions take place when particles collide.	Changing Reaction Rates
Understand that the rate of reaction depends on the number of collisions between reacting particles.	Changing Reaction Rates
(HT) Understand that the rate of reaction depends on the: • collision frequency of reacting particles • energy transferred during the collision (whether the collision is successful or effective).	Changing Reaction Rates
Describe the effect of changing temperature on the rate of a chemical reaction.	Changing Reaction Rates
Explain, in terms of the reacting particle model, why changes in temperature change the rate of reaction.	Changing Reaction Rates
(HT) Explain using the reacting particle model, why changes in temperature change the rate of reaction in terms of successful collisions between particles.	Changing Reaction Rates
Describe the effect of changing the concentration on the rate of a chemical reaction.	Changing Reaction Rates
Explain, in terms of the reacting particle model, why changes in concentration change the rate of reaction.	Changing Reaction Rates
(HT) Explain using the reacting particle model, why changes in concentration change the rate of reaction in terms of successful collisions between particles.	Changing Reaction Rates
Describe the effect of changing the pressure on the rate of a chemical reaction of gases.	Changing Reaction Rates
Explain, in terms of the reacting particle model, why changes in pressure change the rate of reaction.	Changing Reaction Rates
(HT) Explain using the reacting particle model, why changes in pressure change the rate of reaction in terms of successful collisions between particles.	Changing Reaction Rates
Interpret data in tabular, graphical and written form about the effect of temperature, concentration and pressure on the rate of reaction for example: • reading off values from a graph • comparing rates of reaction by comparing gradients of graphs • comparing rates of reaction using reaction times.	Changing Reaction Rates
Interpret data in tabular, graphical and written form about the effect of temperature and concentration on the rate of reaction for example: • deciding when a reaction has finished • comparing the rate of reaction during a reaction.	Changing Reaction Rates
Draw sketch graphs to show the effect of changing temperature, concentration or pressure on: • rate of reaction • amount of product formed in a reaction.	Changing Reaction Rates
(HT) Interpret data from tabular, graphical and written form about the effect of temperature and concentration on the rate of reaction for example: • calculating the rate of reaction from the slope of an appropriate graph • extrapolation • interpolation.	Changing Reaction Rates

Item C3c: Rate of reaction (3)	
Recall that the rate of a reaction can be increased by the addition of a catalyst.	**Catalysts**
Describe a catalyst as a substance which changes the rate of reaction and is unchanged at the end of the reaction.	**Catalysts**
Understand why only a small amount of a catalyst is needed to catalyse large amounts of reactants and that a catalyst is specific to a particular reaction.	**Catalysts**
Recall that the rate of a reaction can be increased by using powdered reactant rather than a lump (or vice versa).	**Changing Reaction Rates**
Explain, in terms of reacting particles and surface area, the difference in rate of reaction between a lump and powdered reactant.	**Changing Reaction Rates**
(HT) Explain, in terms of collisions between reacting particles, the difference in rate of reaction between a lump and powdered reactant.	**Changing Reaction Rates**
Describe an explosion as a very fast reaction which releases a large volume of gaseous products.	**Measuring Reaction Rates**
Explain the dangers of fine combustible powders in factories (eg custard powder, flour or sulfur).	**Measuring Reaction Rates**
Interpret data in tabular, graphical and written form about the effect of surface area and the addition of a catalyst on the rate of reaction, for example: • reading off values from a graph • comparing rates of reaction by comparing gradients of graphs • comparing rates of reaction using reaction times.	**Changing Reaction Rates / Catalysts**
Interpret data in tabular, graphical and written form about the effect of surface area and the addition of a catalyst on the rate of reaction: • deciding when a reaction has finished • comparing the rate of reaction during a reaction.	**Changing Reaction Rates / Catalysts**
Draw sketch graphs to show the effect of changing surface area and the addition of a catalyst on the: • rate of reaction • amount of product formed in a reaction.	**Changing Reaction Rates / Catalysts**
(HT) Interpret data from tabular, graphical and written form about the effect of surface area and the addition of a catalyst on the rate of reaction: • calculating the rate of reaction from the slope of an appropriate graph • extrapolation • interpolation.	**Changing Reaction Rates / Catalysts**

Item C3d: Reacting masses	
Calculate the relative formula mass of a substance from its formula (no brackets) given the appropriate relative atomic masses.	Formulae and Equations
Calculate the relative formula mass of a substance from its formula (with brackets) given appropriate relative atomic masses.	Formulae and Equations
Understand that the total mass of reactants at the start of a reaction is equal to the total mass of products made and that this is called the principle of conservation of mass.	Quantitative Chemistry
Use the principle of conservation of mass to calculate mass of reactant or product for example: • mass of gaseous product formed during decomposition • mass of oxygen that reacts with a known mass of magnesium to make magnesium oxide.	Quantitative Chemistry
Use provided relative formula masses and a symbol equation (1:1 molar ratio) to show that mass is conserved during a reaction.	Quantitative Chemistry
Explain why mass is conserved in chemical reactions.	Quantitative Chemistry
(HT) Use relative formula masses and a provided symbol equation to show that mass is conserved during a reaction.	Quantitative Chemistry
Use simple ratios to calculate reacting masses and product masses given the mass of a reactant and a product.	Quantitative Chemistry
Recognise and use the idea that the mass of product formed is directly proportional to the mass of limiting reactant used.	Quantitative Chemistry
(HT) Interpret chemical equations quantitatively.	Quantitative Chemistry
(HT) Calculate masses of products or reactants from balanced symbol equations using relative formula masses.	Quantitative Chemistry

Item C3e: Percentage yield and atom economy	
Understand percentage yield as a way of comparing amount of product made (actual yield) to amount expected (predicted yield): • 100% yield means that no product has been lost • 0% yield means that no product has been made.	Yield
Recognise possible reasons (given experimental details) why the percentage yield of a product is less than 100% for example: • loss in filtration • loss in evaporation • loss in transferring liquids • not all reactants react to make product.	Yield
Recall and use the formula: $\text{percentage yield} = \frac{\text{actual yield}}{\text{predicted yield}} \times 100$	Yield
(HT) Explain why an industrial process wants as high a percentage yield as possible, to include: • reducing the reactants wasted • reducing cost.	Yield
Understand atom economy as a way of measuring the amount of atoms that are wasted when manufacturing a chemical: • 100% atom economy means that all atoms in the reactant have been converted to the desired product • the higher the atom economy the ‘greener’ the process.	Atom Economy

Recall and use the formula: atom economy = $\frac{\text{Mr of desired products}}{\text{sum of Mr of all products}} \times 100$	Atom Economy
Calculate atom economy when given balanced symbol equation (1:1 molar ratio) and appropriate relative formula masses.	Atom Economy
(HT) Calculate atom economy when given balanced symbol equation and appropriate relative formula masses.	Atom Economy
(HT) Explain why an industrial process wants as high an atom economy as possible: • to reduce the production of unwanted products • to make the process more sustainable.	Atom Economy
Interpretation of simple percentage yield and atom economy data.	Yield
Interpretation of complex percentage yield and atom economy data.	Yield

Item C3f: Energy	
Recall that an exothermic reaction is one in which energy is transferred into the surroundings (releases energy).	Energy and Reactions
Recall that an endothermic reaction is one in which energy is taken from the surroundings (absorbs energy).	Energy and Reactions
Recognise exothermic and endothermic reactions using temperature changes.	Energy and Reactions
Recall bond making as an exothermic process and bond breaking as an endothermic process.	Energy and Reactions
(HT) Explain why a reaction is exothermic or endothermic using the energy changes that occur during bond breaking and bond making.	Energy and Reactions
Describe, using a diagram, a simple calorimetric method for comparing the energy transferred in combustion reactions: • use of spirit burner or a bottled gas burner • heating water in a copper calorimeter • measuring the temperature change • fair tests.	
Interpret and use data from simple calorimetric experiments related to the combustion of fuels to compare which fuel releases the most energy.	
Describe a simple calorimetric method for comparing the energy transferred per gram of fuel combusted: • use of spirit burner or a bottled gas burner • heating water in a copper calorimeter • measuring mass of fuel burnt • measuring temperature change • fair and reliable tests.	

Calculate the energy transferred by using the formula (no recall needed): • energy transferred (in J) = m × c × T • where m = mass of water heated • c = specific heat capacity (4.2J/g°C) • T = temperature change.	
(HT) Use the formula: energy transferred (in J) = m × c × T to calculate: m = mass of water heated T = temperature change. Calculate the energy output of a fuel in J/g by recalling and using the formula: energy per gram = energy released (in J) / mass of fuel burnt (in g)	

Item C3g: Batch or continuous?

Describe the differences between a batch and a continuous process.	
Explain why batch processes are often used for the production of pharmaceutical drugs but continuous processes are used to produce chemicals such as ammonia.	
(HT) Evaluate the advantages and disadvantages of batch and continuous manufacturing processes given relevant data and information.	
List the factors that affect the cost of making and developing a pharmaceutical drug: • research and testing • labour costs • energy costs • raw materials • time taken for development • marketing.	
Explain why pharmaceutical drugs need to be thoroughly tested before they can be licensed for use.	
Explain why it is often expensive to make and develop new pharmaceutical drugs.	
(HT) Explain why it is dif cult to test and develop new pharmaceutical drugs that are safe to use.	
Recall that the raw materials for speciality chemicals such as pharmaceuticals can be either made synthetically or extracted from plants.	
Describe how chemicals are extracted from plant sources: • crushing • boiling and dissolving in suitable solvent • chromatography.	
Explain why it is important to manufacture pharmaceutical drugs to be as pure as possible.	
Describe how melting point, boiling point and thin layer chromatography can be used to establish the purity of a compound.	
Interpret melting point, boiling point and chromatographic data relating to the purity of a substance.	

Item C3h: Allotropes of carbon and nanochemistry	
Explain why diamond, graphite and Buckminster fullerene are all forms of carbon.	Giant Covalent Structures
Recognise the structures of diamond, graphite and Buckminster fullerene.	Giant Covalent Structures
Explain why diamond, graphite and fullerenes are allotropes of carbon.	Giant Covalent Structures
List the physical properties of diamond: • lustrous, colourless and clear (transparent) • hard and has a high melting point • insoluble in water • does not conduct electricity.	Giant Covalent Structures
Explain, in terms of properties, why diamond is used in cutting tools and jewellery.	Giant Covalent Structures
(HT) Explain, in terms of structure and bonding, why diamond: • does not conduct electricity • is hard and has a high melting point.	Giant Covalent Structures
List the physical properties of graphite: • black, lustrous and opaque • slippery • insoluble in water • conducts electricity.	Giant Covalent Structures
Explain, in terms of properties, why graphite is used: • in pencil leads • in lubricants.	Giant Covalent Structures
(HT) Explain, in terms of structure and bonding, why graphite: • conducts electricity • is slippery • has a high melting point.	Giant Covalent Structures
Explain why diamond and graphite have a giant molecular structure.	Giant Covalent Structures
(HT) Predict and explain the properties of substances that have a giant molecular structure.	Giant Covalent Structures
Recall that nanotubes are used to reinforce graphite in tennis rackets because nanotubes are very strong.	Giant Covalent Structures
Recall that nanotubes are used as semiconductors in electrical circuits.	Giant Covalent Structures
Explain why fullerenes can be used in new drug delivery systems.	Giant Covalent Structures
(HT) Explain how the structure of nanotubes enables them to be used as catalysts.	Giant Covalent Structures

Module C4: The Periodic Table

Item C4: Fundamental Chemical Concepts	
Understand that in a chemical reaction reactants are changed into products.	Formulae and Equations
Recognise the reactants and products in a word equation.	Formulae and Equations
Construct word equations given the reactants and products.	Formulae and Equations
Construct word equations (not all reactants and products given).	Formulae and Equations
Recognise the reactants and the products in a symbol equation.	Formulae and Equations
Construct balanced symbol equations given the formulae (no brackets) of the reactants and products.	Formulae and Equations
Explain why a symbol equation is balanced.	Formulae and Equations
(HT) Construct balanced symbol equations given the formulae (some or all with brackets) of the reactants and products.	Formulae and Equations
(HT) Construct balanced symbol equations given the names of the reactants and products (limited to the learning outcomes in C4).	Formulae and Equations
Recognise whether a substance is an element or a compound from its formula.	Representing Chemicals
Deduce the names of the different elements in a compound given its formula.	Representing Chemicals
Understand that a molecule is made up of more than one atom joined together.	Representing Chemicals
Understand that a molecular formula shows the numbers and types of atom in a molecule.	Representing Chemicals
Deduce the number of atoms in a displayed formula.	Representing Chemicals
Deduce the names of the different elements in a compound given its displayed formula.	Representing Chemicals
Deduce the number of each different type of atom in a displayed formula.	Representing Chemicals
Understand that a displayed formula shows both the atoms and the bonds in a molecule.	Representing Chemicals
Write the molecular formula of a compound given its displayed formula.	Representing Chemicals
(HT) Construct balanced equations using displayed formulae.	Representing Chemicals
Recognise whether a particle is an atom, molecule or ion given its formula.	Representing Chemicals
Understand that atoms contain smaller particles one of which is a negative electron.	Ions and Ionic Bonding
Understand that positive ions are formed when electrons are lost from atoms.	Ions and Ionic Bonding
Understand that negative ions are formed when electrons are gained by atoms.	Ions and Ionic Bonding
Recall that two types of chemical bond holding atoms together are: • ionic bonds • covalent bonds.	Covalent Bonding / Ions and Ionic Bonding
Understand that an ionic bond is the attraction between a positive ion and a negative ion.	Ions and Ionic Bonding
Understand that a covalent bond is a shared pair of electrons.	Covalent Bonding
(HT) Explain how an ionic bond is formed.	Ions and Ionic Bonding
(HT) Explain how a covalent bond is formed.	Covalent Bonding

Item C4a: Atomic structure	
Recall that an atom has a nucleus surrounded by electrons.	**Atomic Structure**
Recall that a nucleus is positively charged, an electron is negatively charged and an atom is neutral.	**Atomic Structure**
Understand that atoms have a very small mass and a very small size.	**Atomic Structure**
Recall that the nucleus is made up of protons and neutrons.	**Atomic Structure**
Recall the relative charge and relative mass of an electron, a proton and a neutron: • electron charge –1 and mass 0.0005 (zero) • proton charge +1 and mass 1 • neutron charge 0 and mass 1.	**Atomic Structure**
(HT) Explain why an atom is neutral in terms of its subatomic particles.	**Atomic Structure**
(HT) Understand that atoms have a radius of about 10^{-10}m and a mass of about 10^{-23}g.	**Atomic Structure**
Identify the atomic number of an element or vice versa by using a periodic table.	**Atomic Structure**
Recall that atomic number is the number of protons in an atom.	**Atomic Structure**
Recall that mass number is the total number of protons and neutrons in an atom.	**Atomic Structure**
Describe isotopes as varieties of an element that have the same atomic number but different mass numbers.	**Isotopes**
Deduce the number of protons, electrons and neutrons in a particle given its atomic number and mass number: • using data in a table • using the conventional symbolism eg carbon-12 or $^{12}_{6}C$	**Isotopes**
(HT) Deduce the number of protons, electrons and neutrons in a charged particle given its atomic number, mass number and the charge on the particle: • using data in a table • using the conventional symbolism eg carbon-12 or $^{12}_{6}C$	**Isotopes**
(HT) Identify isotopes from data about the number of electrons, protons and neutrons in particles.	**Isotopes**
Explain why a substance is an element or a compound given its formula.	**Atomic Structure**
Describe the arrangement of elements in the periodic table.	**The Periodic Table**
Deduce the number of occupied shells or the number of electrons from the electronic structure of an element.	**Electron Arrangement**
Explain how the identity of an element can be deduced from its electronic structure.	**Electron Arrangement**
(HT) Deduce the electronic structure of the first 20 elements in the periodic table eg calcium is 2.8.8.2.	**Electron Arrangement**
Describe the main stages in the development of atomic structure illustrating the provisional nature of evidence: • Dalton's atomic theory (detail not required) • J.J. Thomson (discovery of the electron) • Rutherford (nuclear atom) • Bohr (electron orbits).	**Atomic Structure**
Describe Dalton's atomic theory and how the work of J.J. Thomson, Rutherford and Bohr contributed to the development of the theory of atomic structure: • the theory changed as new evidence was found • science explanations are provisional but more convincing when predictions are later con rmed.	**Atomic Structure**

(HT) Explain the significance of the work of Dalton, J.J. Thomson, Rutherford and Bohr in the development of the theory of atomic structure: • unexpected results (eg Geiger and Marsden’s experiment) led to the theory of a nuclear atom.	**Atomic Structure**

Item C4b: Ionic bonding	
Recall that an ion is a charged atom or group of atoms.	**Ions and Ionic Bonding**
Recognise an ion, an atom and a molecule from given formulae.	**Ions and Ionic Bonding**
Understand that atoms with an outer shell of 8 electrons have a stable electronic structure..	**Ions and Ionic Bonding**
Explain how and why metal atoms form positive ions.	**Ions and Ionic Bonding**
Explain how and why non-metal atoms form negative ions.	**Ions and Ionic Bonding**
Understand that, in ionic bonding, a metal and nonmetal combine by transferring electrons to form positive ions and negative ions which then attract one another.	**Ions and Ionic Bonding**
Deduce the formula of an ionic compound from the formula of the positive and negative ions	**Ions and Ionic Bonding**
(HT) Explain, using the “dot and cross” model, the ionic bonding in simple binary compounds.	**Ions and Ionic Bonding**
Compare the electrical conductivity of sodium chloride in solid, molten liquid and solution.	**Ionic Compounds**
Compare the melting points of sodium chloride and magnesium oxide.	**Ionic Compounds**
Recall that sodium chloride solution conducts electricity.	**Ionic Compounds**
Recall that magnesium oxide and sodium chloride conduct electricity when molten.	**Ionic Compounds**
Describe the structure of sodium chloride or magnesium oxide as a giant ionic lattice in which positive ions are strongly attracted to negative ions.	**Ionic Compounds**
(HT) Explain, in terms of structure and bonding, some of the physical properties of sodium chloride: • high melting points • electrical conductivity of solid, molten liquid and solution.	**Ionic Compounds**
(HT) Explain, in terms of structure and bonding, why the melting point of sodium chloride is lower than that of magnesium oxide.	**Ionic Compounds**
(HT) Predict and explain the properties of substances that have a giant ionic structure.	**Ionic Compounds**

Item C4c: The Periodic Table and covalent bonding	
Recall that there are two types of bonding: • ionic bonding between metals and non-metals • covalent bonding between non-metals.	**Ions and Ionic Bonding / Covalent Bonding**
Recall that non-metals combine together by sharing electron pairs and this is called covalent bonding.	**Covalent Bonding**
(HT) Explain, using the “dot and cross” model, the covalent bonding in simple binary compounds or molecules containing single and double covalent bonds.	**Covalent Bonding**
Recall that carbon dioxide and water do not conduct electricity.	**Covalent Bonding**
Describe carbon dioxide and water as simple molecules with weak intermolecular forces between molecules.	**Covalent Bonding**
HT) Explain, in terms of structure and bonding, some of the physical properties of carbon dioxide and water: • low melting points • do not conduct electricity.	**Covalent Bonding**
Predict and explain the properties of substances that have a simple molecular structure.	**Covalent Bonding**
Deduce, using a periodic table, elements that are in the same group.	**The Periodic Table**
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.	**The Periodic Table**

Recognise that the group number is the same as the number of electrons in the outer shell.	The Periodic Table
Deduce the group to which an element belongs from its electronic structure (limited to the s and p blocks).	The Periodic Table
Deduce, using a periodic table, elements that are in the same period.	The Periodic Table
Describe a period of elements as all the elements in a horizontal row of the periodic table.	The Periodic Table
Recognise that the period to which the element belongs corresponds to the number of occupied shells in the electronic structure.	The Periodic Table
Deduce the period to which the element belongs from its electronic structure.	The Periodic Table
Describe the main stages in the development of the classification of elements: • Dobereiner • Newlands • Mendeleev.	The Periodic Table
Understand that classification of elements was provisional, based on evidence gathered at the time.	The Periodic Table
Describe the evidence or observations that caused Newlands and Mendeleev to develop new models of periodic classification of elements.	The Periodic Table
(HT) Explain how further evidence con rmed Mendeleev's ideas about the periodic table: • confirmation of his predictions about unknown elements • how investigations on atomic structure (mass number and electronic structure) agreed with his ideas.	The Periodic Table

Item C4d: The Group 1 elements

Explain why the Group 1 elements are known as the alkali metals.	Group 1 Alkali Metals
Explain why Group 1 elements are stored under oil.	Group 1 Alkali Metals
Describe the reaction of lithium, sodium and potassium with water:	Group 1 Alkali Metals
• hydrogen is formed	Group 1 Alkali Metals
• an alkali is formed which is the hydroxide of the metal	Group 1 Alkali Metals
• the reactivity with water increases down Group 1	Group 1 Alkali Metals
• potassium gives a lilac flame.	Group 1 Alkali Metals
Construct the word equation for the reaction of a Group 1 element with water.	Group 1 Alkali Metals
Predict the properties of Group 1 elements rubidium and/or caesium with water. Construct the balanced symbol equation for the reaction of a Group 1 element with water (given all or some formulae) eg: $2Na + 2H_2O \quad 2NaOH + H_2$	Group 1 Alkali Metals
(HT) Construct the balanced symbol equation for the reaction of a Group 1 element with water (formulae not given) eg: $2Na + 2H_2O \quad 2NaOH + H_2$	Group 1 Alkali Metals
(HT) Predict the physical properties of rubidium and/or caesium given information about the other Group 1 elements.	Group 1 Alkali Metals
Recognise sodium, lithium and potassium as Group 1 elements.	Group 1 Alkali Metals
Explain why Group 1 elements have similar properties.	Group 1 Alkali Metals
(HT) Explain why Group 1 elements have similar properties, in terms of forming positive ions with stable electronic structures.	Group 1 Alkali Metals
(HT) Construct a balanced symbol equation to show the formation of an ion of a Group 1 element from its atom.	Group 1 Alkali Metals
(HT) Explain, in terms of electron loss, the trend in reactivity of the Group 1 elements with water.	Group 1 Alkali Metals
(HT) Recall the loss of electrons as oxidation.	Group 1 Alkali Metals
(HT) Explain why a process is oxidation from its ionic equation.	Group 1 Alkali Metals
Recall the flame test colours for lithium, sodium and potassium compounds.	Spectroscopy and Flame Tests

Interpret information about flame tests eg deduce the alkali metal present from flame colours.	**Spectroscopy and Flame Tests**
Describe how to use a flame test to identify the presence of lithium, sodium and potassium compounds: • use of moistened flame test wire • flame test wire dipped into solid sample • flame test wire put into blue Bunsen flame • colours of the flames.	**Spectroscopy and Flame Tests**

Item C4e: The Group 7 elements

Recall that the Group 7 elements are known as the halogens.	**Group 7 Halogens**
Recognise fluorine, chlorine, bromine and iodine as Group 7 elements.	**Group 7 Halogens**
Describe the uses of some Group 7 elements: • chlorine is used to sterilise water • chlorine is used to make pesticides and plastics • iodine is used to sterilise wounds.	**Group 7 Halogens**
Describe the uses of some Group 7 elements: • chlorine is used to sterilise water • chlorine is used to make pesticides and plastics • iodine is used to sterilise wounds.	**Group 7 Halogens**
(HT) Predict the properties of uorine or astatine given the properties of the other Group 7 elements eg: • physical properties • melting point • boiling point • displacement reactions.	**Group 7 Halogens**
Recognise that Group 7 elements react vigorously with Group 1 elements.	**Group 7 Halogens**
Construct the word equation for the reaction between a Group 1 element and a Group 7 element (product given).	**Group 7 Halogens**
Identify the metal halide formed when a Group 1 element reacts with a Group 7 element.	**Group 7 Halogens**
Construct the word equation for the reaction between a Group 1 element and a Group 7 element (product not given).	**Group 7 Halogens**
Construct the balanced symbol equation for the reaction of a Group 1 element with a Group 7 element (some or all formulae given).	**Group 7 Halogens**
(HT) Construct the balanced symbol equation for the reaction of a Group 1 element with a Group 7 element (formulae not given).	**Group 7 Halogens**
Recall that the reactivity of the Group 7 elements decreases down the group.	**Group 7 Halogens**
Construct the word equation for the reaction between a Group 7 element and a metal halide (reactants and products given).	**Group 7 Halogens**
Describe the displacement reactions of Group 7 elements with solutions of metal halides: • chlorine displaces bromides and iodides • bromine displaces iodides.	**Group 7 Halogens**
Construct the word equation for the reaction between a Group 7 element and a metal halide (not all reactants and products given).	**Group 7 Halogens**
Construct balanced symbol equations for the reactions between Group 7 elements and metal halides (some or all formulae given).	**Group 7 Halogens**
(HT) Construct balanced symbol equations for the reactions between Group 7 elements and metal halides (formulae not given).	**Group 7 Halogens**

(HT) Predict the feasibility of displacement reactions eg will bromine react with sodium astitide solution.	**Group 7 Halogens**
Explain why Group 7 elements have similar similar properties	**Group 7 Halogens**
(HT) Explain why Group 7 elements have similar properties, in terms of forming negative ions with stable electronic structures.	**Group 7 Halogens**
(HT) Construct an equation to show the formation of a halide ion from a halogen molecule.	**Group 7 Halogens**
HT) Explain, in terms of electron gain, the trend in reactivity of the Group 7 elements.	**Group 7 Halogens**
(HT) Recall the gain of electrons as reduction.	**Group 7 Halogens**
(HT) Explain why a process is reduction from its ionic equation.	**Group 7 Halogens**

Item C4f: Transition elements	
Identify whether an element is a transition element from its position in the periodic table.	
Recognise that all transition elements are metals and have typical metallic properties.	
Deduce the name or symbol of a transition element using the periodic table.	
Recall that copper and iron are transition elements.	
Recall that compounds of transition elements are often coloured: • copper compounds are often blue • iron(II) compounds are often light green • iron(III) compounds are often orange/brown.	
Recall that transition elements and their compounds are often used as catalysts: • iron in the Haber process • nickel in the manufacture of margarine.	
Describe thermal decomposition as a reaction in which a substance is broken down into at least two other substances by heat.	
Construct word equations for thermal decomposition reactions (all reactants and products given).	
Recall that the test for carbon dioxide is that it turns limewater milky.	
Describe the thermal decomposition of carbonates of transition elements including FeCO3, CuCO3, MnCO3 and ZnCO3: • metal oxide and carbon dioxide formed • word equations (not all products given) • colour change occurs (colours not needed).	

(HT) Construct the balanced symbol equations for the thermal decomposition of: • $FeCO_3$ • $CuCO_3$ • $MnCO_3$ • $ZnCO_3$	
Describe precipitation as a reaction between solutions that makes an insoluble solid.	**Precipitation Reactions**
Describe the use of sodium hydroxide solution to identify the presence of transition metal ions in solution: • Cu^{2+} gives a blue solid • Fe^{2+} gives a grey/green solid • Fe^{3+} gives an orange/brown solid • the solids are called precipitates.	**Precipitation Reactions**
(HT) Construct balanced symbol equations for the reactions between Cu^{2+}, Fe^{2+} and Fe^{3+} with OH^- (without state symbols) given the formulae of the ions.	**Precipitation Reactions**

Item C4g: Metal structure and properties

Explain why iron is used to make cars and bridges.	
Explain why copper is used to make electrical wiring.	
List the physical properties of metals: • lustrous, hard and high density • high tensile strength • high melting and boiling points • good conductors of heat and electricity.	
Interpret data about the properties of metals eg hardness, density and electrical conductivity.	
Explain why metals are suited to a given use (data will be provided).	
Suggest properties needed by a metal for a particular given use eg saucepan bases need to be good conductors of heat.	
Explain why metals are suited to a given use (data will be provided).	
Recognise that the particles in a metal are held together by metallic bonds.	**Metallic Bonding**
Understand that metals have high melting points and boiling points due to strong metallic bonds.	**Metallic Bonding**
Describe how metals conduct electricity.	**Metallic Bonding**
(HT) Describe metallic bonding as the strong attraction between a sea of delocalised electrons and close packed positive metal ions.	**Metallic Bonding**
(HT) Explain, in terms of structure, why metals have: • high melting points and boiling points • conduct electricity.	**Metallic Bonding**
Recall that at low temperatures some metals can be superconductors.	
Describe what is meant by the term superconductor.	
Describe the potential bene ts of superconductors: • loss free power transmission • super-fast electronic circuits • powerful electromagnets.	
(HT) Explain some of the drawbacks of superconductors.	

Item C4h: Purifying and testing water	
Interpret simple data about water resources in the United Kingdom (no recall is expected).	
Recall different types of water resources found in the United Kingdom: • lakes • rivers • aquifers • reservoirs.	
Explain why water is an important resource for many important industrial chemical processes.	
Interpret data about water resources in the United Kingdom (no recall is expected).	
Explain why it is important to conserve water.	
List some of the pollutants that may be found in domestic water supplies: • nitrate residues • lead compounds • pesticide residues.	
Explain why drinking water may contain some of the pollutants listed below: • nitrate • lead compounds • pesticide.	
List the types of substances present in water before it is purified: • dissolved salts and minerals • microbes • pollutants • insoluble materials.	
Recall that chlorination kills microbes in water.	
Describe the water purification process to include ltration, sedimentation and chlorination.	
(HT) Explain why some soluble substances are not removed from water during purification.	
(HT) Explain the disadvantages of using distillation of sea water to make large quantities of fresh water.	
Recall that barium chloride solution is used to test for sulfate ions: • gives a white precipitate.	
Recall that silver nitrate solution is used to test for halide ions: • chloride ions give a white precipitate • bromide ions give a cream precipitate • iodide ions give a pale yellow precipitate.	
Construct word equations for the reactions of barium chloride with sulfates and silver nitrate with halides (all reactants and products given).	
Interpret data about the testing of water with aqueous silver nitrate and barium chloride solutions.	
Construct word equations for the reactions of barium chloride with sulfates and silver nitrate with halides (not all reactants and products given).	
Understand that the reactions of barium chloride with sulfates and silver nitrate with halides are examples of precipitation reactions.	
(HT) Construct balanced symbol equations for the reactions of barium chloride with sulfates and silver nitrate with halides given the appropriate formulae.	

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Module P3: Forces for Transport	Boardworks Presentation
Item P3a: Speed	
Use the equation: average speed = distance / time to include change of units from km to m.	Speed
Understand why one type of speed camera takes two photographs: • a certain time apart • when the vehicle moves over marked lines a known distance apart on the road.	Speed
Understand how average speed cameras work.	Speed
Interpret the relationship between speed, distance and time including: • increasing the speed, which increases the distance travelled in the same time • increasing the speed reduces the time needed to cover the same distance. Use the equation, including a change of subject: distance = average speed × time $= \frac{(u + v)}{2} \times t$	Speed
(HT) Interpret the relationship between speed, distance and time to include the effect of changing any one or both of the quantities.	Speed
(HT) Use the equation, including a change of subject and/or units: distance = average speed × time $= \frac{(u + v)}{2} \times t$	Speed
Draw and interpret qualitatively graphs of distance against time.	Speed
(HT) Draw and interpret graphs of distance against time: • qualitatively for non-uniform speed • calculations of speed from the gradient of distance-time graph for uniform speed.	Speed
Item P3b: Changing speed	
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.	Speed
Describe, draw and interpret qualitatively, graphs of speed against time for uniform acceleration to include: • greater acceleration shown by a higher gradient • the significance of a positive or negative gradient • calculations of distance travelled from a simple speed-time graph for uniform acceleration.	Acceleration
(HT) Describe, draw and interpret graphs of speed against time including: • quantitatively for uniform acceleration • calculations of distance travelled from a speed-time graph for uniform acceleration • calculations of acceleration from a speed-time graph for uniform acceleration • qualitative interpretation of speed-time graphs for non-uniform acceleration.	Speed
Recognise that acceleration involves a change in speed (limited to motion in a straight line): • speeding up involves an acceleration • slowing down involves a deceleration • greater change in speed (in a given time) results in higher acceleration.	Acceleration
Recall that acceleration is measured in metres per second squared (m/s2).	Acceleration

Use the equation: acceleration = change in speed time taken when given the change in speed.	Acceleration
Describe acceleration as change in speed per unit time and that: • increase in speed results from a positive acceleration • decrease in speed results from a negative acceleration or deceleration. Use the equation including prior calculation of the change in speed: acceleration = change in speed time taken	Acceleration
(HT) Explain how acceleration can involve either a change: • in speed • in direction • in both speed and direction.	Acceleration
(HT) Interpret the relationship between acceleration, change of speed and time to include the effect of changing any one or two of the quantities.	Acceleration
(HT) Use the equation, including a change of subject: acceleration = change in speed time taken	Acceleration
Recognise that direction is important when describing the motion of an object.	Speed
Understand that the velocity of an object is its speed combined with its direction.	Speed
Recognise that for two objects moving in opposite directions at the same speed, their velocities will have identical magnitude but opposite signs.	Speed
Calculate the relative velocity of objects moving in parallel.	Speed

Item P3c: Forces and motion	
Recognise situations where forces cause things to: • speed up • slow down • stay at the same speed.	Acceleration
Use the equation: force = mass × acceleration when given mass and acceleration.	Acceleration
Describe and interpret the relationship between force, mass and acceleration in everyday examples.	Acceleration
Use the equation, including a change of subject: force = mass × acceleration	Acceleration
(HT) Use the equation, including a change of subject and the need to previously calculate the accelerating force: force = mass × acceleration	Acceleration
Describe thinking distance as: • the distance travelled between the need for braking occurring and the brakes starting to act.	Stopping Distances
Describe braking distance as: • the distance taken to stop once the brakes have been applied.	Stopping Distances
Describe stopping distance as: • thinking distance + braking distance.	Stopping Distances
Calculate stopping distance given values for thinking distance and braking distance.	Stopping Distances
Explain why thinking, braking and stopping distances are significant for road safety.	Stopping Distances
Explain how certain factors may increase thinking distance: • driver tiredness • influence of alcohol or other drugs • greater speed • distractions or lack of concentration.	Stopping Distances
Explain how certain factors may increase braking distance: • road conditions • car conditions • greater speed.	Stopping Distances
Interpret data about thinking distances and braking distances.	Stopping Distances
Explain the implications of stopping distances in road safety: • driving too close to the car in front (ie inside thinking distance) • speed limits • road conditions.	Stopping Distances
(HT) Explain qualitatively everyday situations where braking distance is changed including: • friction • mass • speed • braking force.	Stopping Distances
(HT) Draw and interpret the shapes of graphs for thinking and braking distance against speed.	Stopping Distances
(HT) Explain the effects of increased speed on: • thinking distance – increases linearly • braking distance – increases as a squared relationship eg if speed doubles braking distance increases by a factor of four, if speed trebles braking distance increases by a factor of nine.	Stopping Distances

Item P3d: Work and power	
Recall everyday examples in which work is done and power is developed to include: • lifting weights • climbing stairs • pulling a sledge • pushing a shopping trolley.	**Work and Power**
Use the equation: weight = mass × gravitational field strength	**Falling Objects**
(HT) Use the equation, including a change of subject: weight = mass × gravitational field strength	**Falling Objects**
Describe how energy is transferred when work is done.	**Work and Power**
Understand that the amount of work done depends on: • the size of the force in newtons (N) • the distance travelled in metres (m).	**Work and Power**
Recall that the joule is the unit for both work and energy.	**Work and Power**
Use the equation: work done = force × distance	**Work and Power**
Use the equation, including a change of subject: work done = force × distance	**Work and Power**
(HT) Use the equation: work done = force × distance then use the value for work done in the power equation below.	**Work and Power**
Describe power as a measurement of how quickly work is being done.	**Work and Power**
Recall that power is measured in watts (W).	**Work and Power**
Recognise that cars: • have different power ratings • have different engine sizes and these relate to fuel consumption.	**Powering Cars**
Use the equation: $\text{power} = \frac{\text{work done}}{\text{time}}$	**Work and Power**
Interpret fuel consumption figures from data on cars to include: • environmental issues • costs.	**Powering Cars**
(HT) Use the equation, including a change of subject: $\text{power} = \frac{\text{work done}}{\text{time}}$ when work has been calculated.	**Work and Power**
(HT) Use and understand the derivation of the power equation in the form: power = force × speed	**Work and Power**

Item P3e: Energy on the move	
Understand that kinetic energy (KE) depends on the mass and speed of an object.	**Potential and Kinetic Energy**
Use and apply the equation: KE = 1/2 mv2	**Potential and Kinetic Energy**
(HT) Use and apply the equation: KE = 1/2 mv2 including a change of subject.	**Potential and Kinetic Energy**
(HT) Apply the ideas of kinetic energy to: • relationship between braking distances and speed • everyday situations involving objects moving.	**Stopping Distances**
Recognise and describe (derivatives of) fossil fuels as the main fuels in road transport: • petrol • diesel.	**Powering Cars**
Recall that bio-fuels and solar energy are possible alternatives to fossil fuels.	**Powering Cars**
Describe how electricity can be used for road transport, and how its use could affect different groups of people and the environment: • battery driven cars • solar power / cars with solar panels.	**Powering Cars**
Describe arguments for and against the use of battery powered cars.	**Powering Cars**
Explain why electrically powered cars do not pollute at the point of use whereas fossil fuel cars do.	**Powering Cars**
Recognise that battery driven cars need to have the battery recharged: • this uses electricity produced from a power station • power stations cause pollution.	**Powering Cars**
Explain why we may have to rely on bio-fuelled and solar powered vehicles in the future.	**Powering Cars**
(HT) Explain how bio-fuelled and solar powered vehicles: • reduce pollution at the point of use • produce pollution in their production • may lead to an overall reduction in CO2 emissions.	**Powering Cars**
Draw conclusions from basic data about fuel consumption, including emissions (no recall required).	**Powering Cars**
Recognise that the shape of a moving object can influence its top speed and fuel consumption: • wedge shape of sports car • deflectors on lorries and caravans • roof boxes on cars • driving with car windows open.	**Falling Objects / Powering Cars**
Interpret data about fuel consumption, including emissions.	**Powering Cars**
(HT) Explain how car fuel consumption figures depend on: • energy required to increase KE • energy required to do work against friction • driving styles and speeds • road conditions.	**Powering Cars**
(HT) Evaluate and compare data about fuel consumption and emissions.	**Powering Cars**

Item P3f: Crumple zones	
Use the equation: momentum = mass × velocity to calculate momentum.	Momentum and Collisions
Use the equation including a change of subject: momentum = mass × velocity	Momentum and Collisions
Describe why the greater the mass of an object and/or the greater the velocity, the more momentum the object has in the direction of motion.	Momentum and Collisions
Use the equation: force = change in momentum time to calculate force.	Momentum and Collisions
(HT) Use and apply the equation including a change of subject: force = change in momentum time	Momentum and Collisions
(HT) Use Newton's second law of motion to explain the above points.	Momentum and Collisions
(HT) F = ma	Momentum and Collisions
Recall that a sudden change in momentum in a collision, results in a large force that can cause injury.	Car Safety
Explain how spreading the change in momentum over a longer time reduces the likelihood of injury.	Momentum and Collisions
Explain, using the ideas about momentum, the use of crumple zones, seatbelts and airbags in cars.	Car Safety
(HT) Explain why forces can be reduced when stopping (eg. crumple zones, braking distances, escape lanes, crash barriers, seatbelts and airbags) by: • increasing stopping or collision time • increasing stopping or collision distance • decreasing acceleration.	Car Safety
Describe the typical safety features of modern cars that require energy to be absorbed when vehicles stop: • heating in brakes, crumple zones, seat-belts, airbags.	Car Safety
Explain why seatbelts have to be replaced after a crash.	Car Safety
Recognise the risks and benefits arising from the use of seatbelts.	Car Safety
Recall and distinguish between typical safety features of cars which: • are intended to prevent accidents, or • are intended to protect occupants in the event of an accident.	Car Safety
Describe how seatbelts, crumple zones and airbags are useful in a crash because they: • change shape • absorb energy • reduce injuries.	Car Safety
Describe how test data may be gathered and used to identify and develop safety features for cars.	Car Safety
(HT) Evaluate the effectiveness of given safety features in terms of saving lives and reducing injuries.	Car Safety
(HT) Describe how ABS brakes: • make it possible to keep control of the steering of a vehicle in hazardous situations (eg when braking hard or going into a skid) • work by the brakes automatically pumping on and off to avoid skidding • sometimes reduce braking distances.	Car Safety
(HT) Analyse personal and social choices in terms of risk and benefits of wearing seatbelts.	Car Safety

Item P3g Falling safely	
Recognise that frictional forces (drag, friction, air resistance): • act against the movement • lead to energy loss and inef ciency • can be reduced (shape, lubricant).	Falling Objects
Explain how objects falling through the Earth's atmosphere reach a terminal speed.	Falling Objects
Explain in terms of the balance of forces how moving objects: • increase speed • decrease speed • maintain steady speed.	Falling Objects
(HT) Explain, in terms of balance of forces, why objects reach a terminal speed: • higher speed = more drag • larger area = more drag • weight (falling object) or driving force (eg a car) = drag when travelling at terminal speed.	Falling Objects
Understand why falling objects do not experience drag when there is no atmosphere.	Falling Objects
Recognise that acceleration due to gravity (g) is the same for any object at a given point on the Earth's surface.	Falling Objects
(HT) Understand that gravitational field strength or acceleration due to gravity: • is unaffected by atmospheric changes • varies slightly at different points on the Earth's surface • will be slightly different on the top of a mountain or down a mineshaft.	Falling Objects

Item P3h The energy of games and theme rides	
Recognise that objects have gravitational potential energy (GPE) because of their mass and position in Earth's gravitational field.	Potential and Kinetic Energy
Describe everyday examples in which objects have gravitational potential energy (GPE).	Potential and Kinetic Energy
Use the equation: GPE = mgh	Potential and Kinetic Energy
Recognise and interpret examples of energy transfer between gravitational potential energy (GPE) and kinetic energy (KE).	Potential and Kinetic Energy
(HT) Understand that for a body falling through the atmosphere at terminal speed: • kinetic energy (KE) does not increase • gravitational potential energy (GPE) is transferred to increased internal or thermal energy of the surrounding air particles through the mechanism of friction.	Potential and Kinetic Energy
(HT) Use and apply the equation, including a change of subject: GPE = mgh	Potential and Kinetic Energy
Recognise everyday examples in which objects use gravitational potential energy (GPE).	Potential and Kinetic Energy
Interpret a gravity ride (roller-coaster) in terms of: • kinetic energy (KE) • gravitational potential energy (GPE) • energy transfer.	Potential and Kinetic Energy
Describe the effect of changing mass and speed on kinetic energy (KE): • doubling mass doubles KE • doubling speed quadruples KE.	Potential and Kinetic Energy
(HT) Use and apply the relationship mgh = 1/2 mv2	Potential and Kinetic Energy
(HT) Show that for a given object falling to Earth, this relationship can be expressed as h = v2 ÷ 2g and give an example of how this formula could be used.	Potential and Kinetic Energy

Module P4: Radiation For Life

Item P4a: Sparks

Recognise that when some materials are rubbed they attract other objects: • certain types of dusting brushes become charged and attract dust as they pass over it.	**Static Electricity**
Recognise that insulating materials can become charged when rubbed with another insulating material. State that there are two kinds of charge: • positive • negative.	**Static Electricity**
Recognise that like charges repel and unlike charges attract.	**Static Electricity**
Understand that electrostatic phenomena are caused by the transfer of electrons, which have a negative charge.	**Static Electricity**
(HT) 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.	**Static Electricity**
(HT) Recognise that atoms or molecules that have become charged are ions.	**Static Electricity**
Describe how you can get an electrostatic shock from charged objects: • synthetic clothing.	**Static Electricity**
Describe how you can get an electrostatic shock if you become charged and then become earthed: • touching water pipes after walking on a floor covered with an insulating material eg synthetic carpet.	**Static Electricity**
Explain how static electricity can be dangerous when: • in atmospheres where explosions could occur eg in ammable gases or vapours or with high concentrations of oxygen • in situations where large quantities of charge could flow through the body to earth.	**Static Electricity**
Explain how static electricity can be a nuisance: • dirt and dust attracted to insulators (plastic containers, TV monitors etc) • causing clothing to "cling".	**Effects of Static Electricity**
(HT) Explain how the chance of receiving an electric shock can be reduced by: • correct earthing • use of insulating mats • using shoes with insulating soles • bonding fuel tanker to aircraft.	**Static Electricity / Electrical Wiring and Safety**
(HT) Explain how anti-static sprays, liquids and cloths help reduce the problems of static electricity.	**Effects of Static Electricity**

Item P4b: Uses of electrostatics	
Recall that electrostatics can be useful for electrostatic precipitators: • remove the dust or soot in smoke • used in chimneys.	Effects of Static Electricity
Recall that electrostatics can be useful for spraying: • spray painting • crop spraying.	Effects of Static Electricity
Recall that electrostatics can be useful for restarting the heart when it has stopped (defribrillator). Recall that defribrillators work by discharging charge.	Effects of Static Electricity
Explain how static electricity can be useful for electrostatic dust precipitators to remove smoke particles etc from chimneys: • dust passes through charged metal grid or past charged rods • dust particles become charged • plates are earthed or charged opposite to grid • dust particles attracted to plates • plates struck and dust falls to collector.	Effects of Static Electricity
(HT) Explain how static electricity is used in electrostatic dust precipitators to remove smoke particles etc from chimneys: • high voltage metal grids put into chimneys to produce a charge on the dust • dust particles gain or lose electrons • dust particles induce a charge on the earthed metal plate • dust particles are attracted to the plates.	Effects of Static Electricity
Explain how static electricity can be useful for paint spraying: • spray gun charged • paint particles charged the same so repel giving a fine spray and coat • object charged oppositely to paint so attracts paint into the 'shadows' of the object giving an even coat with less waste.	Effects of Static Electricity
(HT) Explain how static electricity is used in paint spraying, in terms of paint and car gaining and losing electrons and the resulting effects.	Effects of Static Electricity
Explain how static electricity can be useful for restarting the heart when it has stopped (defribrillator): • paddles charged • good electrical contact with patient's chest • charge passed through patient to make heart contract • care taken not to shock operator.	Effects of Static Electricity

Item P4c: Safe electricals	
Explain the behaviour of simple circuits in terms of the flow of electric charge. Describe and recognise how resistors can be used to change the current in a circuit. Describe how variable resistors can be used to change the current in a circuit: • longer wires give less current • thinner wires give less current (rheostat configured as a variable resistor only). Recall that resistance is measured in ohms.	Electrical Circuits / Current, Voltage and Resistance
Recall the colour coding for live, neutral and earth wires: • live – brown • neutral – blue • earth – green/yellow. State that an earthed conductor cannot become live.	Electrical Circuits / Electrical Wiring and Safety

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

Item P4d Ultrasound	
Recall that ultrasound is a longitudinal wave. Recognise features of a longitudinal wave: • wavelength • compression • rarefaction.	**Ultrasound**
Recognise that ultrasound can be used in medicine for diagnostic purposes: • to look inside people by scanning the body • to measure the speed of blood flow in the body (candidates are not expected to describe the Doppler effect)	**Ultrasound**
Describe features of longitudinal waves: • wavelength • frequency • compression (a region of higher pressure) • rarefaction (a region of lower pressure). Recall that the frequency of ultrasound is higher than the upper threshold of human hearing (20 000 Hz) because the ear cannot detect these very high frequencies.	**Ultrasound**

(HT) Describe and compare the motion and arrangement of particles in longitudinal and transverse physical waves: • wavelength • frequency • compression • rarefaction • amplitude.	Ultrasound
Recognise that ultrasound can be used in medicine for non-invasive therapeutic purposes such as to break down kidney and other stones.	Ultrasound
(HT) Explain how ultrasound is used in: • body scans (reflections from different layers returning at different times from different depths) • breaking down accumulations in the body such as kidney stones. Explain the reasons for using ultrasound rather than X-rays for certain scans: • able to produce images of soft tissue • does not damage living cells.	Ultrasound

Item P4e What is radioactivity?	
Recognise that the radioactivity or activity of an object is measured by the number of nuclear decays emitted per second. Understand that radioactivity decreases with time. Recall that nuclear radiation ionises materials.	Radioactive Decay / Half-life / Ionising Radiation
Recall that radiation comes from the nucleus of the atom.	Radioactive Substances
Describe radioactive substances as decaying naturally and giving out nuclear radiation in the form of alpha, beta and gamma. Explain and use the concept of half-life. Interpret graphical data of radioactive decay to include a qualitative description of half-life. Explain ionisation in terms of: • removal of electrons from particles • gain of electrons by particles.	Radioactive Substances
(HT) Interpret graphical or numerical data of radioactive decay to include calculation of half-life. Explain why alpha particles are such good ionisers.	Half-life
Describe radioactivity as coming from the nucleus of an atom that is unstable. Recall that an alpha particle is a helium nucleus. Recall that a beta particle is a fast moving electron.	Radioactive Substances / Radioactive Decay
(HT) Describe what happens to a nucleus when an alpha particle is emitted: • mass number decreases by 4 • nucleus has two fewer neutrons • nucleus has two fewer protons • atomic number decreases by 2 • new element formed. Describe what happens to a nucleus when a beta particle is emitted: • mass number is unchanged • nucleus has one less neutron • nucleus has one more proton • atomic number increases by one • new element formed. Construct and balance nuclear equations in terms of mass numbers and atomic numbers to represent alpha and beta decay.	Radioactive Decay

Item P4f Use of radioisotopes	
Understand why background radiation can vary. Recall that background radiation mainly comes from rocks and cosmic rays.	Radioactive Substances
Recall industrial examples of the use of tracers: • to track dispersal of waste • to find leaks/blockages in underground pipes • to find the route of underground pipes.	Ionizing radiation
Recall that alpha sources are used in some smoke detectors.	Ionizing radiation
Recall that radioactivity can be used to date rocks.	Half-life
Recall that some background radiation comes from waste products and man-made sources eg waste from: • industry • hospitals.	Radioactive Substances
(HT) Evaluate the relative significance of sources of background radiation.	Radioactive Substances
Describe how tracers are used in industry: • radioactive material put into pipe • progress tracked with detector above ground/ outside pipe • leak/blockage shown by reduction/no radioactivity after the point of blockage.	Ionizing radiation
(HT) Explain why gamma radiation is used as an industrial tracer.	Ionizing radiation
Explain how a smoke detector with an alpha source works: • smoke particles hit by alpha radiation • less ionisation of air particles • current is reduced causing alarm to sound.	Ionizing radiation
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.	Half-life
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 (eg wood) gaseous exchange with the air stops • as the Carbon-14 in the wood decays the activity of the sample decreases • the ratio of current activity from living matter to the activity of the sample is used to calculate the age within known limits.	Half-life

Item P4g Treatment	
Describe some similarities and differences between X-rays and gamma rays: • both are ionising electromagnetic waves • have similar wavelengths • are produced in different ways.	Ionizing Radiation
Recall that medical radioisotopes are produced by placing materials into a nuclear reactor.	
Describe uses of nuclear radiation in medicine, to include: • diagnosis • treatment of cancer using gamma rays • sterilisation of equipment. Recall that only beta and gamma radiation can pass through skin. Recall that nuclear radiation can damage cells. Describe the role of a radiographer and the safety precautions they must take.	Ionizing Radiation
Recall that materials absorb some ionising radiation. Understand how the image produced by the absorption of X-rays depends on the thickness and density of the absorbing materials.	Ionizing Radiation

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

Item P4h Fission and Fusion	
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.	Nuclear Fuels and Fission
Describe the process that gives out energy in a nuclear reactor as nuclear fission, and that it is kept under control. Recall that nuclear fission produces radioactivewaste.	Nuclear Fuels and Fission
Describe the difference between fission and fusion: • fission is the splitting of nuclei • fusion is the joining of nuclei.	Nuclear Fusion
Recall that one group of scientists have claimed to successfully achieve ‘cold fusion’. Explain why the claims are disputed: other scientists could not repeat their findings.	Nuclear Fusion
Describe how domestic electricity is generated at a nuclear power station: • nuclear reaction • producing heat • heating water to produce steam • spinning a turbine • driving a generator.	Nuclear Fuels and Fission
(HT) Describe what happens to allow uranium to release energy: • uranium nucleus hit by neutron • causes nucleus to split • energy released • more neutrons released.	Nuclear Fuels and Fission
Understand how the decay of uranium starts a chain reaction. Describe a nuclear bomb as a chain reaction that has gone out of control.	Nuclear Fuels and Fission

(HT) 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.	**Nuclear Fuels and Fission**
Describe how nuclear fusion releases energy: • fusion happens when two nuclei join together • fusion produces large amounts of heat energy • fusion happens at extremely high temperatures. Describe why fusion for power generation is difficult: • requires extremely high temperatures • high temperatures have to be safely managed. Understand why fusion power research is carried out as an international joint venture.	**Nuclear Fusion**
(HT) Explain how different isotopes of hydrogen can undergo fusion to form helium. Understand the conditions needed for fusion to take place, to include: • in stars, fusion happens under extremely high temperatures and pressures • fusion bombs are started with a fission reaction which creates exceptionally high temperatures • for power generation exceptionally high temperatures and/or pressures are required and this combination offers (to date) safety and practical challenges.	**Nuclear Fusion**
Explain why the ‘cold fusion’ experiments and data have been shared between scientists.	**Nuclear Fusion**
(HT) Explain why ‘cold fusion’ is still not accepted as a realistic method of energy production.	**Nuclear Fusion**