edexcel

INTERNATIONAL GCSE

Single, Double & Separate Sciences (2017)

MAPPING GUIDE

Pearson Edexcel International GCSE in Science

For first teaching September 2017
First examination June 2019

Pearson

Mapping Guide

Contents

INTRODUCTION

This document shows – side-by-side – the content of the Science (Single Award) and the Science (Double Award) specifications against those for the three separate sciences.

The content is arranged in columns: the left hand column shows the content of Science (Single Award); the middle column shows Science (Double Award) and the right hand column shows the separate science specification (in **bold** to match the specification).

Where columns are merged, this denotes content that is common across the different specifications e.g.

	(h) Transport		
2.51	understand why simple, unicellular organisms can rely on diffusion for movement of substances in and out of the cell		
2.52	understand the need for a transport system in multicellular organisms		
2.53		describe the role of phloem in transporting sucrose and amino acids between the leaves and other parts of the plant	
2.54		describe the role of xylem in transporting water and mineral ions from the roots to other parts of the plant	
2.55B			**understand how water is absorbed by root hair cells**
2.56B			**understand that transpiration is the evaporation of water from the surface of a plant**

Statements 2.51 and 2.52 are found in Science (Single Award), Science (Double Award) and Biology.
Statements 2.53 and 2.54 are found in Science (Double Award) and Biology.
Statements 2.55B and 2.56B are found in Biology only.

Note that there are no statements unique to Science (Single Award) or Science (Double Award); although some Single Award statements differ very slightly from the equivalent Double Award or separate science statement e.g.

	(h) Synthetic polymers	
4.45	understand how to draw the repeat unit of the addition polymer poly(ethene)	understand how to draw the repeat unit of an addition polymer, including poly(ethene), poly(propene), poly(chloroethene) and (poly)tetrafluoroethene

Core Practical statements appear in italic type, just as in the specifications.

INTERNATIONAL GCSE BIOLOGY

1 The nature and variety of living organisms

The following sub-topics are covered in this section.

(a) Characteristics of living organisms

(b) Variety of living organisms

	(a) Characteristics of living organisms		
1.1	understand how living organisms share the following characteristics: • they require nutrition • they respire • they excrete their waste • they respond to their surroundings • they move • they control their internal conditions • they reproduce • they grow and develop.		
	(b) Variety of living organisms		
1.2	describe the common features shown by eukaryotic organisms: plants, animals, fungi and protoctists Plants: these are multicellular organisms; their cells contain chloroplasts and are able to carry out photosynthesis; their cells have cellulose cell walls; they store carbohydrates as starch or sucrose. Examples include flowering plants, such as a cereal (for example, maize), and a herbaceous legume (for example, peas or beans). Animals: these are multicellular organisms; their cells do not contain chloroplasts and are not able to carry out photosynthesis; they have no cell walls; they usually have nervous co-ordination and are able to move from one place to another; they often store carbohydrate as glycogen. Examples include mammals (for example, humans) and insects (for example, housefly and mosquito). Fungi: these are organisms that are not able to carry out photosynthesis; their body is usually organised into a mycelium made from thread-like structures called hyphae, which contain many nuclei; some examples are single-celled; their cells have walls made of chitin; they feed by extracellular secretion of digestive enzymes onto food material and absorption of the organic products; this is known as saprotrophic nutrition; they may store carbohydrate as glycogen. Examples include Mucor, which has the typical fungal hyphal structure, and yeast, which is single-celled.		

	Protoctists: these are microscopic single-celled organisms. Some, like Amoeba, that live in pond water, have features like an animal cell, while others, like Chlorella, have chloroplasts and are more like plants. A pathogenic example is Plasmodium, responsible for causing malaria.
1.3	describe the common features shown by prokaryotic organisms such as bacteria Bacteria: these are microscopic single-celled organisms; they have a cell wall, cell membrane, cytoplasm and plasmids; they lack a nucleus but contain a circular chromosome of DNA; some bacteria can carry out photosynthesis but most feed off other living or dead organisms. Examples include *Lactobacillus bulgaricus*, a rod-shaped bacterium used in the production of yoghurt from milk, and *Pneumococcus*, a spherical bacterium that acts as the pathogen causing pneumonia.
1.4	understand the term pathogen and know that pathogens may include fungi, bacteria, protoctists or viruses. Viruses: these are not living organisms. They are small particles, smaller than bacteria; they are parasitic and can reproduce only inside living cells; they infect every type of living organism. They have a wide variety of shapes and sizes; they have no cellular structure but have a protein coat and contain one type of nucleic acid, either DNA or RNA. Examples include the tobacco mosaic virus that causes discolouring of the leaves of tobacco plants by preventing the formation of chloroplasts, the influenza virus that causes 'flu' and the HIV virus that causes AIDS.

2 Structure and functions in living organisms

The following sub-topics are covered in this section.

(a) Level of organisation

(b) Cell structure

(c) Biological molecules

(d) Movement of substances into and out of cells

(e) Nutrition

(f) Respiration

(g) Gas exchange

(h) Transport

	(a) Level of organisation		
2.1	describe the levels of organisation in organisms: organelles, cells, tissues, organs and systems		
	(b) Cell structure		
2.2	describe cell structures, including the nucleus, cytoplasm, cell membrane, cell wall, mitochondria, chloroplasts and vacuole	describe cell structures, including the nucleus, cytoplasm, cell membrane, cell wall, mitochondria, chloroplasts, ribosomes and vacuole	
2.3	describe the functions of the nucleus, cytoplasm, cell membrane, cell wall, mitochondria, chloroplasts and vacuole	describe the functions of the nucleus, cytoplasm, cell membrane, cell wall, mitochondria, chloroplasts, ribosomes and vacuole	
2.4	know the similarities and differences in the structure of plant and animal cells		
2.5B			**explain the importance of cell differentiation in the development of specialised cells**
2.6B			**understand the advantages and disadvantages of using stem cells in medicine**

	(c) Biological molecules		
2.7	identify the chemical elements present in carbohydrates, proteins and lipids (fats and oils)		
2.8	describe the structure of carbohydrates, proteins and lipids as large molecules made up from smaller basic units: starch and glycogen from simple sugars, protein from amino acids, and lipid from fatty acids and glycerol		
2.9	*Practical: investigate food samples for the presence of glucose, starch, protein and fat*		
2.10	understand the role of enzymes as biological catalysts in metabolic reactions		
2.11	understand how temperature changes can affect enzyme function, including changes to the shape of active site		
2.12	*Practical: investigate how enzyme activity can be affected by changes in temperature*		
2.13	understand how enzyme function can be affected by changes in pH altering the active site		
2.14B			***Practical: investigate how enzyme activity can be affected by changes in pH***
	(d) Movement of substances into and out of cells		
2.15	understand the processes of diffusion, osmosis and active transport by which substances move into and out of cells		
2.16	understand how factors affect the rate of movement of substances into and out of cells, including the effects of surface area to volume ratio, distance, temperature and concentration gradient		
2.17		*Practical: investigate diffusion and osmosis using living and non-living systems*	
	(e) Nutrition		
2.18	understand the process of photosynthesis and its importance in the conversion of light energy to chemical energy		
2.19	know the word equation and the balanced chemical symbol equation for photosynthesis		
2.20	understand how varying carbon dioxide concentration, light intensity and temperature affect the rate of photosynthesis		
2.21	describe the structure of the leaf and explain how it is adapted for photosynthesis		
2.22		understand that plants require mineral ions for growth, and that magnesium ions are needed for chlorophyll and nitrate ions are needed for amino acids	
2.23	*Practical: investigate photosynthesis, showing the evolution of oxygen from a water plant, the production of starch and the requirements of light, carbon dioxide and chlorophyll*		
2.24		understand that a balanced diet should include appropriate proportions of carbohydrate, protein, lipid, vitamins, minerals, water and dietary fibre	
2.25		identify the sources and describe the functions of carbohydrate, protein, lipid (fats and oils), vitamins A, C and D, the mineral ions calcium and iron, water and	

		dietary fibre as components of the diet	
2.26		understand how energy requirements vary with activity levels, age and pregnancy	
2.27	describe the structure and function of the human alimentary canal, including the mouth, oesophagus, stomach, small intestine (duodenum and ileum), large intestine (colon and rectum) and pancreas		
2.28		understand how food is moved through the gut by peristalsis	
2.29	understand the role of digestive enzymes, including the digestion of starch to glucose by amylase and maltase, the digestion of proteins to amino acids by proteases and the digestion of lipids to fatty acids and glycerol by lipases		
2.30		understand that bile is produced by the liver and stored in the gall bladder	
2.31		understand the role of bile in neutralising stomach acid and emulsifying lipids	
2.32		understand how the small intestine is adapted for absorption, including the structure of a villus	
2.33B			***Practical: investigate the energy content in a food sample***
	(f) Respiration		
2.34	understand how the process of respiration produces ATP in living organisms		
2.35	know that ATP provides energy for cells		
2.36	describe the differences between aerobic and anaerobic respiration		
2.37	know the word equation and the balanced chemical symbol equation for aerobic respiration in living organisms		
2.38	know the word equation for anaerobic respiration in plants and in animals		
2.39		*Practical: investigate the evolution of carbon dioxide and heat from respiring seeds or other suitable living organisms*	
	(g) Gas exchange		
2.40B			**understand the role of diffusion in gas exchange**
2.41B			**understand gas exchange (of carbon dioxide and oxygen) in relation to respiration and photosynthesis**
2.42B			**understand how the structure of the leaf is adapted for gas exchange**

2.43B			**describe the role of stomata in gas exchange**
2.44B			**understand how respiration continues during the day and night, but that the net exchange of carbon dioxide and oxygen depends on the intensity of light**
2.45B			***Practical: investigate the effect of light on net gas exchange from a leaf, using hydrogen-carbonate indicator***
2.46	describe the structure of the thorax, including the ribs, intercostal muscles, diaphragm, trachea, bronchi, bronchioles, alveoli and pleural membranes		
2.47	understand the role of the intercostal muscles and the diaphragm in ventilation		
2.48	explain how alveoli are adapted for gas exchange by diffusion between air in the lungs and blood in capillaries		
2.49		understand the biological consequences of smoking in relation to the lungs and the circulatory system, including coronary heart disease	
2.50		*Practical: investigate breathing in humans, including the release of carbon dioxide and the effect of exercise*	
	(h) Transport		
2.51	understand why simple, unicellular organisms can rely on diffusion for movement of substances in and out of the cell		
2.52	understand the need for a transport system in multicellular organisms		
2.53		describe the role of phloem in transporting sucrose and amino acids between the leaves and other parts of the plant	
2.54		describe the role of xylem in transporting water and mineral ions from the roots to other parts of the plant	
2.55B			**understand how water is absorbed by root hair cells**
2.56B			**understand that transpiration is the evaporation of water from the surface of a plant**
2.57B			**understand how the rate of transpiration is affected by changes in humidity, wind speed, temperature and light intensity**

2.58B			***Practical: investigate the role of environmental factors in determining the rate of transpiration from a leafy shoot***
2.59	describe the composition of the blood: red blood cells, white blood cells, platelets and plasma		
2.60	understand the role of plasma in the transport of carbon dioxide, digested food, urea, hormones and heat energy		
2.61	understand how adaptations of red blood cells make them suitable for the transport of oxygen, including shape, the absence of a nucleus and the presence of haemoglobin		
2.62	understand how the immune system responds to disease using white blood cells, illustrated by phagocytes ingesting pathogens and lymphocytes releasing antibodies specific to the pathogen		
2.63B			**understand how vaccination results in the manufacture of memory cells, which enable future antibody production to the pathogen to occur sooner, faster and in greater quantity**
2.64B			**understand how platelets are involved in blood clotting, which prevents blood loss and the entry of micro-organisms**
2.65	describe the structure of the heart and how it functions		
2.66		explain how the heart rate changes during exercise and under the influence of adrenaline	
2.67		understand how factors may increase the risk of developing coronary heart disease	
2.68	understand how the structure of arteries, veins and capillaries relates to their function		
2.69	understand the general structure of the circulation system, including the blood vessels to and from the heart and the lungs		
	(i) Excretion		
2.70		understand the origin of carbon dioxide and oxygen as waste products of metabolism and their loss from the stomata of a leaf	
2.71		know the excretory products of the lungs, kidneys and skin (organs of excretion)	
2.72B			**understand how the kidney carries out its roles of excretion and osmoregulation**
2.73B			**describe the structure of the urinary system, including the kidneys, ureters, bladder and urethra**

2.74B			**describe the structure of a nephron, including the Bowman's capsule and glomerulus, convoluted tubules, loop of Henle and collecting duct**
2.75B			**describe ultrafiltration in the Bowman's capsule and the composition of the glomerular filtrate**
2.76B			**understand how water is reabsorbed into the blood from the collecting duct**
2.77B			**understand why selective reabsorption of glucose occurs at the proximal convoluted tubule**
2.78B			**describe the role of ADH in regulating the water content of the blood**
2.79B			**understand that urine contains water, urea and ions**
	(j) Co-ordination and response		
2.80		understand how organisms are able to respond to changes in their environment	
2.81		understand that homeostasis is the maintenance of a constant internal environment, and that body water content and body temperature are both examples of homeostasis	
2.82		understand that a co-ordinated response requires a stimulus, a receptor and an effector	
2.83		understand that plants respond to stimuli	
2.84		describe the geotropic and phototropic responses of roots and stems	
2.85		understand the role of auxin in the phototropic response of stems	
2.86		describe how nervous and hormonal communication control responses and understand the differences between the two systems	
2.87		understand that the central nervous system consists of the brain and spinal cord and is linked to sense organs by nerves	
2.88		understand that stimulation of receptors in the sense organs sends electrical impulses along nerves into and out of the central nervous system, resulting in rapid responses	
2.89		understand the role of neurotransmitters at synapses	
2.90		describe the structure and functioning of a simple reflex arc illustrated by the withdrawal of a finger from a hot object	
2.91		describe the structure and function of the eye as a receptor	

2.92		understand the function of the eye in focusing on near and distant objects, and in responding to changes in light intensity	
2.93		describe the role of the skin in temperature regulation, with reference to sweating, vasoconstriction and vasodilation	
2.94		understand the sources, roles and effects of the following hormones: adrenaline, insulin, testosterone, progesterone and oestrogen	
2.95B			**understand the sources, roles and effects of the following hormones: ADH, FSH and LH**

3 Reproduction and inheritance

The following sub-topics are covered in this section.

(a) Reproduction

(b) Inheritance

	(a) Reproduction		
3.1	understand the differences between sexual and asexual reproduction		
3.2	understand that fertilisation involves the fusion of a male and female gamete to produce a zygote that undergoes cell division and develops into an embryo		
3.3	describe the structures of an insect-pollinated and a wind-pollinated flower and explain how each is adapted for pollination		
3.4	understand that the growth of the pollen tube followed by fertilisation leads to seed formation	understand that the growth of the pollen tube followed by fertilisation leads to seed and fruit formation	
3.5		*Practical: investigate the conditions needed for seed germination*	
3.6		understand how germinating seeds utilise food reserves until the seedling can carry out photosynthesis	
3.7		understand that plants can reproduce asexually by natural methods (illustrated by runners) and by artificial methods (illustrated by cuttings)	
3.8	understand how the structure of the male and female reproductive systems are adapted for their functions		
3.9		understand the roles of oestrogen and progesterone in the menstrual cycle	
3.10			**understand the roles of FSH and LH in the menstrual cycle**
3.11		describe the role of the placenta in the nutrition of the developing embryo	
3.12		understand how the developing embryo is protected by amniotic fluid	
3.13	understand the roles of oestrogen and testosterone in the development of secondary sexual characteristics		
	(b) Inheritance		
3.14		understand that the genome is the entire DNA of an organism and that a gene is a section of a molecule of DNA that codes for a specific protein	
3.15	understand that the nucleus of a cell contains chromosomes on which genes are located		

3.16B			**describe a DNA molecule as two strands coiled to form a double helix, the strands being linked by a series of paired bases: adenine (A) with thymine (T), and cytosine (C) with guanine (G)**
3.17B			**understand that an RNA molecule is single stranded and contains uracil (U) instead of thymine (T)**
3.18B			**describe the stages of protein synthesis including transcription and translation, including the role of mRNA, ribosomes, tRNA, codons and anticodons**
3.19	understand how genes exist in alternative forms called alleles which give rise to differences in inherited characteristics		
3.20	understand the meaning of the terms: dominant, recessive, homozygous, heterozygous, phenotype, and genotype		
3.21B			**understand the meaning of the term codominance**
3.22		understand that most phenotypic features are the result of polygenic inheritance rather than single genes	
3.23	describe patterns of monohybrid inheritance using a genetic diagram		
3.24		understand how to interpret family pedigrees	
3.25	predict probabilities of outcomes from monohybrid crosses		
3.26	understand how the sex of a person is controlled by one pair of chromosomes, XX in a female and XY in a male		
3.27	describe the determination of the sex of offspring at fertilisation, using a genetic diagram		
3.28		understand how division of a diploid cell by mitosis produces two cells that contain identical sets of chromosomes	
3.29		understand that mitosis occurs during growth, repair, cloning and asexual reproduction	
3.30		understand how division of a cell by meiosis produces four cells, each with half the number of chromosomes, and that this results in the formation of genetically different haploid gametes	
3.31	understand how random fertilisation produces genetic variation of offspring		
3.32		know that in human cells the diploid number of chromosomes is 46 and the haploid number is 23	
3.33	understand that variation within a species can be genetic, environmental, or a combination of both		

3.34		understand that mutation is a rare, random change in genetic material that can be inherited	
3.35B			**understand how a change in DNA can affect the phenotype by altering the sequence of amino acids in a protein**
3.36B			**understand how most genetic mutations have no effect on the phenotype, some have a small effect and rarely do they have a significant effect**
3.37B			**understand that the incidence of mutations can be increased by exposure to ionising radiation (for example, gamma rays, x-rays and ultraviolet rays) and some chemical mutagens (for example, chemicals in tobacco)**
3.38	explain Darwin's theory of evolution by natural selection		
3.39		understand how resistance to antibiotics can increase in bacterial populations, and appreciate how such an increase can lead to infections being difficult to control	

4 Reproduction and inheritance

The following sub-topics are covered in this section.

(a) The organism in the environment

(b) Feeding relationships

(c) Cycles within ecosystems

	(a) The organism in the environment		
4.1	understand the terms population, community, habitat and ecosystem		
4.2	*practical: investigate the population size of an organism in two different areas using quadrats*		
4.3B			**understand the term biodiversity**
4.4B			***Practical: investigate the distribution of organisms in their habitats and measure biodiversity using quadrats***
4.5	understand how abiotic and biotic factors affect the population size and distribution of organisms		
	(b) Feeding relationships		
4.6	understand the names given to different trophic levels, including producers, primary, secondary and tertiary consumers, and decomposers		
4.7	understand the concepts of food chains, food webs, pyramids of number, pyramids of biomass and pyramids of energy transfer		
4.8	understand the transfer of substances and energy along a food chain		
4.9	understand why only about 10% of energy is transferred from one trophic level to the next		
	(c) Cycles within ecosystems		
4.10	describe the stages in the carbon cycle, including respiration, photosynthesis, decomposition and combustion		
4.11B			**describe the stages in the nitrogen cycle, including the roles of nitrogen fixing bacteria, decomposers, nitrifying bacteria and denitrifying bacteria**

			(specific names of bacteria are not required)
	(d) Human influences on the environment		
4.12		understand the biological consequences of pollution of air by sulfur dioxide and carbon monoxide	
4.13		understand that water vapour, carbon dioxide, nitrous oxide, methane and CFCs are greenhouse gases	
4.14		understand how human activities contribute to greenhouse gases	
4.15		understand how an increase in greenhouse gases results in an enhanced greenhouse effect and that this may lead to global warming and its consequences	
4.16		understand the biological consequences of pollution of water by sewage	
4.17		understand the biological consequences of eutrophication caused by leached minerals from fertiliser	
4.18B			**understand the effects of deforestation, including leaching, soil erosion, disturbance of evapo-transpiration and the carbon cycle, and the balance of atmospheric gases**

5 Use of biological resources

The following sub-topics are covered in this section.

(a) Food production

(b) Selective breeding

(c) Genetic modification (genetic engineering)

(d) Cloning

	(a) Food production		
5.1	describe how glasshouses and polythene tunnels can be used to increase the yield of certain crops		
5.2	understand the effects on crop yield of increased carbon dioxide and increased temperature in glasshouses		
5.3		understand how the use of fertiliser can increase crop yield	
5.4		understand the reasons for pest control and the advantages and disadvantages of using pesticides and biological control with crop plants	
5.5	understand the role of yeast in the production of food including bread		
5.6	*Practical: investigate the role of anaerobic respiration by yeast in different conditions*		
5.7		understand the role of bacteria (*Lactobacillus*) in the production of yoghurt	
5.8		understand the use of an industrial fermenter and explain the need to provide suitable conditions in the fermenter, including aseptic precautions, nutrients, optimum temperature and pH, oxygenation and agitation, for the growth of microorganisms	
5.9			**understand the methods used to farm large numbers of fish to provide a source of protein, including maintaining water quality, controlling intraspecific and interspecific predation, controlling disease, removing waste products, controlling the quality and frequency of feeding, and selective breeding**
	(b) Selective breeding		
5.10		understand how selective breeding can develop plants with desired characteristics	

5.11		understand how selective breeding can develop animals with desired characteristics	
	(c) Genetic modification (genetic engineering)		
5.12	understand how restriction enzymes are used to cut DNA at specific sites and ligase enzymes are used to join pieces of DNA together		
5.13	understand how plasmids and viruses can act as vectors, which take up pieces of DNA, and then insert this recombinant DNA into other cells		
5.14	understand how large amounts of human insulin can be manufactured from genetically modified bacteria	understand how large amounts of human insulin can be manufactured from genetically modified bacteria that are grown in a fermenter	
5.15	understand how genetically modified plants can be used to improve food production		
5.16	understand that the term transgenic means the transfer of genetic material from one species to a different species		
	(d) Cloning		
5.17B			**describe the process of micropropagation (tissue culture) in which explants are grown *in vitro***
5.18B			**understand how micropropagation can be used to produce commercial quantities of genetically identical plants with desirable characteristics**
5.19B			**describe the stages in the production of cloned mammals involving the introduction of a diploid nucleus from a mature cell into an enucleated egg cell, illustrated by Dolly the sheep**
5.20B			**understand how cloned transgenic animals can be used to produce human proteins**

INTERNATIONAL GCSE CHEMISTRY

1 Principles of chemistry

The following sub-topics are covered in this section.

(a) States of matter

(b) Elements, compounds and mixtures

(c) Atomic structure

(d) The Periodic Table

(e) Chemical formulae and equations

(f) Ionic bonding

(g) Covalent bonding

	(a) States of matter		
1.1	understand the three states of matter in terms of the arrangement, movement and energy of the particles		
1.2	understand the interconversions between the three states of matter in terms of: • the names of the interconversions • how they are achieved • the changes in arrangement, movement and energy of the particles.		
1.3	understand how the results of experiments involving the dilution of coloured solutions and diffusion of gases can be explained		
1.4		know what is meant by the terms: • solvent • solute • solution • saturated solution.	
1.5C			**know what is meant by the term solubility in the units g per 100 g of solvent**
1.6C			**understand how to plot and interpret solubility curves**

1.7C			***Practical: investigate the solubility of a solid in water at a specific temperature***
	(b) Elements, compounds and mixtures		
1.8	understand how to classify a substance as an element, compound or mixture		
1.9	understand that a pure substance has a fixed melting and boiling point, but that a mixture may melt or boil over a range of temperatures		
1.10	describe these experimental techniques for the separation of mixtures: • simple distillation • fractional distillation • filtration • crystallization • paper chromatography.		
1.11	understand how a chromatogram provides information about the composition of a mixture		
1.12	understand how to use the calculation of R_f values to identify the components of a mixture		
1.13	*Practical: investigate paper chromatography using inks/food colourings*		
	(c) Atomic structure		
1.14	know what is meant by the terms atom and molecule		
1.15	know the structure of an atom in terms of the positions, relative masses and relative charges of sub-atomic particles		
1.16	know what is meant by the terms atomic number, mass number, isotopes and relative atomic mass (A_r)		
1.17	be able to calculate the relative atomic mass of an element (A_r) from isotopic abundances		
	(d) The Periodic Table		
1.18	understand how elements are arranged in the Periodic Table: • in order of atomic number • in groups and periods.		
1.19	understand how to deduce the electronic configurations of the first 20 elements from their positions in the Periodic Table		
1.20	understand how to use electrical conductivity and the acid-base character of oxides to classify elements as metals or non-metals		
1.21	identify an element as a metal or a non-metal according to its position in the Periodic Table		
1.22	understand how the electronic configuration of a main group element is related to its position in the Periodic Table		

1.23	understand why elements in the same group of the Periodic Table have similar chemical properties		
1.24	understand why the noble gases (Group 0) do not readily react		
	(e) Chemical formulae and equations		
1.25	write word equations and balanced chemical equations (including state symbols): • for reactions studied in this specification • for unfamiliar reactions where suitable information is provided.		
1.26	calculate relative formula masses (including relative molecular masses) (M_r) from relative atomic masses (A_r)		
1.27		know that the mole (mol) is the unit for the amount of a substance	
1.28		understand how to carry out calculations involving amount of substance, relative atomic mass (A_r) and relative formula mass (M_r)	
1.29		calculate reacting masses using experimental data and chemical equations	
1.30		calculate percentage yield	
1.31		understand how the formulae of simple compounds can be obtained experimentally, including metal oxides, water and salts containing water of crystallisation	
1.32		know what is meant by the terms empirical formula and molecular formula	
1.33		calculate empirical and molecular formulae from experimental data	
1.34C			**understand how to carry out calculations involving amount of substance, volume and concentration (in mol/dm^3) of solution**
1.35C			**understand how to carry out calculations involving gas volumes and the molar volume of a gas (24 dm^3 and 24 000 cm^3 at room temperature and pressure (rtp))**
1.36		*Practical: know how to determine the formula of a metal oxide by combustion (e.g. magnesium oxide) or by reduction (e.g. copper(II) oxide)*	
	(f) Ionic bonding		
1.37	understand how ions are formed by electron loss or gain		
1.38	know the charges of these ions:	know the charges of these ions:	

	• metals in Groups 1, 2 and 3 • non-metals in Groups 5, 6 and 7 • hydrogen (H^+), hydroxide (OH^-), ammonium (NH_4^+), carbonate (CO_3^{2-}), nitrate (NO_3^-), sulfate (SO_4^{2-}). 3 4	• metals in Groups 1, 2 and 3 • non-metals in Groups 5, 6 and 7 • Ag^+, Cu^{2+}, Fe^{2+}, Fe^{3+}, Pb^{2+}, Zn^{2+} • hydrogen (H^+), hydroxide (OH^-), ammonium (NH_4^+), carbonate (CO_3^{2-}), nitrate (NO_3^-), sulfate (SO_4^{2-}).
1.39	write formulae for compounds formed between the ions listed above	
1.40		draw dot-and-cross diagrams to show the formation of ionic compounds by electron transfer, limited to combinations of elements from Groups 1, 2, 3 and 5, 6, 7 *only outer electrons need be shown*
1.41	understand ionic bonding in terms of electrostatic attractions	
1.42	understand why compounds with giant ionic lattices have high melting and boiling points	
1.43		know that ionic compounds do not conduct electricity when solid, but do conduct electricity when molten and in aqueous solution
	(g) Covalent bonding	
1.44	know that a covalent bond is formed between atoms by the sharing of a pair of electrons	
1.45		understand covalent bonds in terms of electrostatic attractions
1.46		understand how to use dot-and-cross diagrams to represent covalent bonds in: • diatomic molecules, including hydrogen, oxygen, nitrogen, halogens and hydrogen halides • inorganic molecules including water, ammonia and carbon dioxide • organic molecules containing up to two carbon atoms, including methane, ethane, ethene and those containing halogen atoms.
1.47	explain why substances with a simple molecular structure are gases or liquids, or solids with low melting and boiling points *the term intermolecular forces of attraction can be used to represent all forces between molecules*	
1.48		explain why the melting and boiling points of substances with simple molecular structures increase, in general, with increasing relative molecular mass
1.49	explain why substances with giant covalent structures are solids with high melting and boiling points	
1.50		explain how the structures of diamond, graphite and C_{60} fullerene influence their physical properties, including electrical conductivity and hardness
1.51		know that covalent compounds do not usually conduct electricity

	(h) Metallic bonding		
1.52C			**know how to represent a metallic lattice by a 2-D diagram**
1.53C			**understand metallic bonding in terms of electrostatic attractions**
1.54C			**explain typical physical properties of metals, including electrical conductivity and malleability**
	(i) Electrolysis		
1.55C			**understand why covalent compounds do not conduct electricity**
1.56C			**understand why ionic compounds conduct electricity only when molten or in aqueous solution**
1.57C			**know that anion and cation are terms used to refer to negative and positive ions respectively**
1.58C			**describe experiments to investigate electrolysis, using inert electrodes, of molten compounds (including lead(II) bromide) and aqueous solutions (including sodium chloride, dilute sulfuric acid and copper(II) sulfate) and to predict the products**
1.59C			**write ionic half-equations representing the reactions at the electrodes during electrolysis and understand why these reactions are classified as oxidation or reduction**
1.60C			***Practical: investigate the electrolysis of aqueous solutions***

2 Inorganic chemistry

The following sub-topics are covered in this section.

(a) Group 1 (alkali metals) – lithium, sodium and potassium

(b) Group 7 (halogens) – chlorine, bromine and iodine

(c) Gases in the atmosphere

(d) Reactivity series

(e) Extraction and uses of metals

(f) Acids, alkalis and titrations

(g) Acids, bases and salt preparations

(h) Chemical tests

	(a) Group 1 (alkali metals) – lithium, sodium and potassium		
2.1	understand how the similarities in the reactions of these elements with water provide evidence for their recognition as a family of elements		
2.2	understand how the differences between the reactions of these elements with air and water provide evidence for the trend in reactivity in Group 1		
2.3	use knowledge of trends in Group 1 to predict the properties of other alkali metals		
2.4C			**explain the trend in reactivity in Group 1 in terms of electronic configurations**
	(b) Group 7 (halogens) – chlorine, bromine and iodine		
2.5	know the colours, physical states (at room temperature) and trends in physical properties of these elements		
2.6	use knowledge of trends in Group 7 to predict the properties of other halogens		
2.7		understand how displacement reactions involving halogens and halides provide evidence for the trend in reactivity in Group 7	
2.8C			**explain the trend in reactivity in Group 7 in terms of electronic configurations**

	(c) Gases in the atmosphere		
2.9	know the approximate percentages by volume of the four most abundant gases in dry air		
2.10	understand how to determine the percentage by volume of oxygen in air using experiments involving the reactions of metals (e.g. iron) and non-metals (e.g. phosphorus) with air		
2.11	describe the combustion of elements in oxygen, including magnesium, hydrogen and sulfur		
2.12		describe the formation of carbon dioxide from the thermal decomposition of metal carbonates, including copper(II) carbonate	
2.13	know that carbon dioxide is a greenhouse gas and that increasing amounts in the atmosphere may contribute to climate change		
2.14	*Practical: determine the approximate percentage by volume of oxygen in air using a metal or a non-metal*		
	(d) Reactivity series		
2.15	understand how metals can be arranged in a reactivity series based on their reactions with: • water • dilute hydrochloric or sulfuric acid.		
2.16		understand how metals can be arranged in a reactivity series based on their displacement reactions between: • metals and metal oxides • metals and aqueous solutions of metal salts.	
2.17	know the order of reactivity of these metals: potassium, sodium, lithium, calcium, magnesium, aluminium, zinc, iron, copper, silver, gold		
2.18	know the conditions under which iron rusts		
2.19	understand how the rusting of iron may be prevented by: • barrier methods • galvanising.	understand how the rusting of iron may be prevented by: • barrier methods • galvanizing • sacrificial protection.	
2.20		in terms of gain or loss of oxygen and loss or gain of electrons, understand the terms: • oxidation • reduction • redox • oxidising agent • reducing agent, in terms of gain or loss of oxygen and loss or gain of electrons.	

2.21		*Practical: investigate reactions between dilute hydrochloric and sulfuric acids and metals (e.g. magnesium, zinc and iron)*	
	(e) Extraction and uses of metals		
2.22C			**know that most metals are extracted from ores found in the Earth's crust and that unreactive metals are often found as the uncombined element**
2.23C			**explain how the method of extraction of a metal is related to its position in the reactivity series, illustrated by carbon extraction for iron and electrolysis for aluminium**
2.24C			**be able to comment on a metal extraction process, given appropriate information** ***detailed knowledge of the processes used in the extraction of a specific metal is not required***
2.25C			**explain the uses of aluminium, copper, iron & steel in terms of their properties** ***the types of steel will be limited to low-carbon (mild), high-carbon and stainless***
2.26C			**know that an alloy is a mixture of a metal and one or more elements, usually other metals or carbon**
2.27C			**explain why alloys are harder than pure metals**
	(f) Acids and alkalis	**Acids, alkalis and titrations**	
2.28	describe the use of litmus to distinguish between acidic and alkaline solutions	describe the use of litmus, phenolphthalein and methyl orange to distinguish between acidic and alkaline solutions	
2.29	understand how the pH scale, from 0–14, can be used to classify solutions as strongly acidic (0–3), weakly acidic (4–6), neutral (7),		

	weakly alkaline (8–10) and strongly alkaline (11–14)		
2.30	describe the use of universal indicator to measure the approximate pH value of an aqueous solution		
2.31	know that acids in aqueous solution are a source of hydrogen ions and alkalis in a aqueous solution are a source of hydroxide ions		
2.32	know that alkalis can neutralise acids		
2.33C			**describe how to carry out an acid-alkali titration**
	(g) Acids, bases and salt preparations		
2.34		know the general rules for predicting the solubility of ionic compounds in water: • common sodium, potassium and ammonium compounds are soluble • all nitrates are soluble • common chlorides are soluble, except those of silver and lead(II) • common sulfates are soluble, except for those of barium, calcium and lead(II) • common carbonates are insoluble, except for those of sodium, potassium and ammonium • common hydroxides are insoluble except for those of sodium, potassium and calcium (calcium hydroxide is slightly soluble).	
2.35		understand acids and bases in terms of proton transfer	
2.36		understand that an acid is a proton donor and a base is a proton acceptor	
2.37		describe the reactions of hydrochloric acid, sulfuric acid and nitric acid with metals, bases and metal carbonates (excluding the reactions between nitric acid and metals) to form salts	
2.38		know that metal oxides, metal hydroxides and ammonia can act as bases, and that alkalis are bases that are soluble in water	
2.39		describe an experiment to prepare a pure, dry sample of a soluble salt, starting from an insoluble reactant	
2.40C			**describe an experiment to prepare a pure, dry sample of a soluble salt, starting from an acid and alkali**
2.41C			**describe an experiment to prepare a pure, dry sample of an insoluble salt, starting from two soluble reactants**
2.42		*Practical: prepare a sample of pure, dry hydrated copper(II) sulfate crystals starting from copper(II) oxide*	

2.43C			***Practical: prepare a sample of pure, dry lead(II) sulfate***
	(h) Chemical tests		
2.44	describe tests for these gases: • hydrogen • oxygen • carbon dioxide • ammonia • chlorine.		
2.45	describe how to carry out a flame test		
2.46	know the colours formed in flame tests for these cations: • Li^+ is red • Na^+ is yellow • K^+ is lilac • Ca^{2+} is orange-red • Cu^{2+} is blue-green.		
2.47		describe tests for these cations: • NH_4^+ using sodium hydroxide solution and identifying the gas evolved • Cu^{2+}, Fe^{2+} and Fe^{3+} using sodium hydroxide solution.	
2.48	describe a test for CO_3^{2-} using hydrochloric acid and identifying the gas evolved	describe tests for these anions: • Cl^-, Br^- and I^- using acidified silver nitrate solution • SO_4^{2-} using acidified barium chloride solution • CO_3^{2-} using hydrochloric acid and identifying the gas evolved.	
2.49	describe a test for the presence of water using anhydrous copper(II) sulfate		
2.50		describe a physical test to show whether a sample of water is pure	

3 Physical chemistry

The following sub-topics are covered in this section.

(a) Energetics

(b) Rates of reaction

	(a) Energetics		
3.1	know that chemical reactions in which heat energy is given out are described as exothermic, and those in which heat energy is taken in are described as endothermic		
3.2	describe simple calorimetry experiments for reactions such as combustion, displacement, dissolving and neutralisation		
3.3	calculate the heat energy change from a measured temperature change using the expression $Q = mc\Delta T$		
3.4		calculate the molar enthalpy change (ΔH) from the heat energy change, Q	
3.5C			**draw and explain energy level diagrams to represent exothermic and endothermic reactions**
3.6C			**know that bond-breaking is an endothermic process and that bond-making is an exothermic process**
3.7C			**use bond energies to calculate the enthalpy change during a chemical reaction**
3.8	*Practical: investigate temperature changes accompanying some of the following types of change:* • *salts dissolving in water* • *neutralisation reactions* • *displacement reactions* • *combustion reactions.*		
	(b) Rates of reaction		
3.9	describe experiments to investigate the effects of changes in surface area of a solid, concentration of a solution, temperature and the use of a catalyst on the rate of a reaction		
3.10	describe the effects of changes in surface area of a solid, concentration of a solution, pressure of a gas, temperature and the use of a catalyst on the rate of a reaction		

3.11		explain the effects of changes in surface area of a solid, concentration of a solution, pressure of a gas and temperature on the rate of a reaction in terms of particle collision theory	
3.12	know that a catalyst is a substance that increases the rate of a reaction but is chemically unchanged at the end of the reaction		
3.13		know that a catalyst works by providing an alternative pathway with lower activation energy	
3.14C			**draw and explain reaction profile diagrams showing Δ*H* and activation energy**
3.15	*Practical: investigate the effect of changing the surface area of marble chips and of changing the concentration of hydrochloric acid on the rate of reaction between marble chips and dilute hydrochloric acid*		
3.16		*Practical: investigate the effect of different solids on the catalytic decomposition of hydrogen peroxide solution*	
	(c) Reversible reactions and equilibria		
3.17		know that some reactions are reversible and this is indicated by the symbol ⇌ in equations	
3.18		describe reversible reactions such as the dehydration of hydrated copper(II) sulfate and the effect of heat on ammonium chloride	
3.19C			**know that a reversible reaction can reach dynamic equilibrium in a sealed container**
3.20C			**know that the characteristics of a reaction at dynamic equilibrium are:** • **the forward and reverse reactions occur at the same rate** • **the concentrations of reactants and products remain constant.**
3.21C			**understand why a catalyst does not affect the position of equilibrium in a reversible reaction**
3.22C			**know the effect of changing either temperature or pressure on the position of equilibrium in a reversible reaction:**

			• **an increase (or decrease) in temperature shifts the position of equilibrium in the direction of the endothermic (or exothermic) reaction** • **an increase (or decrease) in pressure shifts the position of equilibrium in the direction that produces fewer (or more) moles of gas** ***References to Le Chatelier's principle are not required***

4 Organic chemistry

The following sub-topics are covered in this section.

(a) Introduction

(b) Crude oil

(c) Alkanes

(d) Alkenes

(e) Alcohols

(f) Carboxylic acids

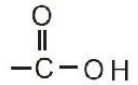
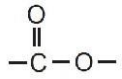
(g) Esters

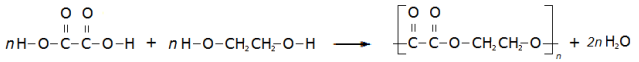
(h) Synthetic polymers

	(a) Introduction	
4.1	know that a hydrocarbon is a compound of hydrogen and carbon only	
4.2	understand how to represent organic molecules using molecular formulae, general formulae, structural formulae and displayed formulae	understand how to represent organic molecules using empirical formulae, molecular formulae, general formulae, structural formulae and displayed formulae
4.3		know what is meant by the terms homologous series, functional group and isomerism
4.4		understand how to name compounds relevant to this specification using the rules of International Union of Pure and Applied Chemistry (IUPAC) nomenclature *students will be expected to name compounds containing up to six carbon atoms*
4.5		understand how to write the possible structural and displayed formulae of an organic molecule given its molecular formula
4.6		understand how to classify reactions of organic compounds as substitution, addition and combustion *knowledge of reaction mechanisms is not required*

	(b) Crude oil		
4.7	know that crude oil is a mixture of hydrocarbons		
4.8		describe how the industrial process of fractional distillation separates crude oil into fractions	
4.9	know the names and uses of the main fractions obtained from crude oil: refinery gases, gasoline, kerosene, diesel, fuel oil and bitumen		
4.10	know the trend in colour, boiling point and viscosity of the main fractions		
4.11	know that a fuel is a substance that, when burned, releases heat energy		
4.12	know the possible products of complete and incomplete combustion of hydrocarbons with oxygen in the air		
4.13	understand why carbon monoxide is poisonous, in terms of its effect on the capacity of blood to transport oxygen *references to haemoglobin are not required*		
4.14	know that, in car engines, the temperature reached is high enough to allow nitrogen and oxygen from air to react, forming oxides of nitrogen		
4.15	explain how the combustion of some impurities in hydrocarbon fuels result in the formation of sulfur dioxide		
4.16	understand how sulfur dioxide and oxides of nitrogen oxides contribute to acid rain		
4.17		describe how long-chain alkanes are converted to alkenes and shorter-chain alkanes by catalytic cracking (using silica or alumina as the catalyst and a temperature in the range of 600–700 ºC)	
4.18		explain why cracking is necessary, in terms of the balance between supply and demand for different fractions	
	(c) Alkanes		
4.19	know the general formula for alkanes		
4.20	explain why alkanes are classified as saturated hydrocarbons		
4.21	understand how to draw the structural and displayed formulae for alkanes with up to five carbon atoms in the molecule, and to name the unbranched-chain isomers		
4.22		describe the reactions of alkanes with halogens in the presence of ultraviolet radiation, limited to mono-substitution *knowledge of reaction mechanisms is not required*	
	(d) Alkenes		
4.23	know that alkenes contain the functional group >C=C<		

4.24	know the general formula for alkenes		
4.25	explain why alkenes are classified as unsaturated hydrocarbons		
4.26	understand how to draw the structural and displayed formulae for alkenes with up to four carbon atoms in the molecule, and name the unbranched-chain isomers *knowledge of cis/trans or E/Z notation is not required*		
4.27		describe the reactions of alkenes with bromine to produce dibromoalkanes	
4.28	describe how bromine water can be used to distinguish between an alkane and an alkene		
	(e) Alcohols		
4.29C			**know that alcohols contain the functional group −OH**
4.30C			**understand how to draw structural and displayed formulae for methanol, ethanol, propanol (*propan-1-ol only*) and butanol (*butan-1-ol only*), and name each compound** ***the names propanol and butanol are acceptable***
4.31C			**know that ethanol can be oxidised by:** • **burning in air or oxygen (complete combustion)** • **reaction with oxygen in the air to form ethanoic acid (microbial oxidation)** • **heating with potassium dichromate(VI) in dilute sulfuric acid to form ethanoic acid**
4.32C			**know that ethanol can be manufactured by:** • **reacting ethene with steam in the presence of a phosphoric acid catalyst at a temperature of about 300 °C and a pressure**

			of about 60–70 atm • **the fermentation of glucose, in the absence of air, an optimum temperature of about 30 °C and using the enzymes in yeast**
4.33C			**understand the reasons for fermentation, in the absence of air, and at an optimum temperature**
	(f) Carboxylic acids		
4.34C			**know that carboxylic acids contain the functional group** 
4.35C			**understand how to draw structural and displayed formulae for unbranched-chain carboxylic acids with up to four carbon atoms in the molecule, and name each compound**
4.36C			**describe the reactions of aqueous solutions of carboxylic acids with metals and metal carbonates**
4.37C			**know that vinegar is an aqueous solution containing ethanoic acid**
	(g) Esters		
4.38C			**know that esters contain the functional group** 
4.39C			**know that ethyl ethanoate is the ester produced when ethanol and ethanoic acid react in the presence of an acid catalyst**

4.40C			**understand how to write the structural and displayed formulae of ethyl ethanoate**
4.41C			**understand how to write the structural and displayed formulae of an ester, given the name or formula of the alcohol and carboxylic acid from which it is formed and vice versa**
4.42C			**know that esters are volatile compounds with distinctive smells and are used as food flavourings and in perfumes**
4.43C			***Practical: prepare a sample of an ester such as ethyl ethanoate***
	(h) Synthetic polymers		
4.44	know that an addition polymer is formed by joining up many small molecules called monomers		
4.45	understand how to draw the repeat unit of the addition polymer poly(ethene)	understand how to draw the repeat unit of an addition polymer, including poly(ethene), poly(propene), poly(chloroethene) and (poly)tetrafluoroethene	
4.46	understand how to deduce the structure of a monomer from the repeat unit of an addition polymer and vice versa		
4.47	explain problems in the disposal of addition polymers, including: • their inertness and inability to biodegrade • the production of toxic gases when they are burned.		
4.48C			**know that condensation polymerisation, in which a dicarboxylic acid reacts with a diol, produces a polyester and water**
4.49C			**understand how to write the structural and displayed formula of a polyester, showing the repeat unit, given the formulae of the monomers from which it is formed including the reaction of ethanedioic acid and ethanediol:** 
4.50C			**know that some polyesters, known as biopolyesters, are biodegradable**

INTERNATIONAL GCSE PHYSICS

1 Forces and motion

The following sub-topics are covered in this section.

(a) Units

(b) Movement and position

(c) Forces and movement

	(a) Units		
1.1	use the following units: kilogram (kg), metre (m), metre/second (m/s), metre/second^2 (m/s^2), newton (N), second (s) and newton/kilogram (N/kg)		
1.2P			**use the following units: newton metre (Nm), kilogram metre/second (kg m/s)**
	(b) Movement and position		
1.3	plot and explain distance–time graphs		
1.4	know and use the relationship between average speed, distance moved and time taken: $\text{average speed} = \frac{\text{distance moved}}{\text{time taken}}$		
1.5	*Practical: investigate the motion of everyday objects such as toy cars or tennis balls*		
1.6	know and use the relationship between acceleration, change in velocity and time taken: $\text{acceleration} = \frac{\text{change in velocity}}{\text{time taken}}$ $a = \frac{(v-u)}{t}$		
1.7	plot and explain velocity-time graphs		
1.8	determine acceleration from the gradient of a velocity–time graph		
1.9	determine the distance travelled from the area between a velocity–time graph and the time axis		

1.10		use the relationship between final speed, initial speed, acceleration and distance moved: (final speed)^2 = (initial speed)^2 + (2 × acceleration × distance moved) $v^2 = u^2 + (2 \times a \times s)$	
	(c) Forces and movement		
1.11	describe the effects of forces between bodies such as changes in speed, shape or direction		
1.12	identify different types of force such as gravitational or electrostatic		
1.13		understand how vector quantities differ from scalar quantities	
1.14		understand that force is a vector quantity	
1.15		calculate the resultant force of forces that act along a line	
1.16	know that friction is a force that opposes motion		
1.17	know and use the relationship between unbalanced force, mass and acceleration: force = mass × acceleration $F = m \times a$		
1.18	know and use the relationship between weight, mass and gravitational field strength: weight = mass × gravitational field strength $W = m \times g$		
1.19	know that the stopping distance of a vehicle is made up of the sum of the thinking distance and the braking distance		
1.20	describe the factors affecting vehicle stopping distance, including speed, mass, road condition and reaction time		
1.21		describe the forces acting on falling objects (and explain why falling objects reach a terminal velocity)	
1.22		*Practical: investigate how extension varies with applied force for helical springs, metal wires and rubber bands*	
1.23		know that the initial linear region of a force-extension graph is associated with Hooke's law	
1.24		describe elastic behaviour as the ability of a material to recover its original shape after the forces causing deformation have been removed	
1.25P			**know and use the relationship between momentum, mass and velocity:** **momentum = mass × velocity** $\boldsymbol{p = m \times v}$

1.26P			**use the idea of momentum to explain safety features**
1.27P			**use the conservation of momentum to calculate the mass, velocity or momentum of objects**
1.28P			**use the relationship between force, change in momentum and time taken:** $\text{force} = \frac{\text{change in momentum}}{\text{time taken}}$ $F = \frac{(mv - mu)}{t}$
1.29P			**demonstrate an understanding of Newton's third law**
1.30P			**know and use the relationship between the moment of a force and its perpendicular distance from the pivot:** **moment = force × perpendicular distance from the pivot**
1.31P			**know that the weight of a body acts through its centre of gravity**
1.32P			**use the principle of moments for a simple system of parallel forces acting in one plane**
1.33P			**understand how the upward forces on a light beam, supported at its ends, vary with the position of a heavy object placed on the beam**

2 Electricity

The following sub-topics are covered in this section.

(a) Units

(b) Mains electricity

(c) Energy and voltage in circuits

(d) Electric charge

	(a) Units	
2.1	use the following units: ampere (A), coulomb (C), joule (J), ohm (Ω), second (s), volt (V) and watt (W)	
	(b) Mains electricity	
2.2		understand how the use of insulation, double insulation, earthing, fuses and circuit breakers protects the device or user in a range of domestic appliances
2.3		understand why a current in a resistor results in the electrical transfer of energy and an increase in temperature, and how this can be used in a variety of domestic contexts
2.4	know and use the relationship between power, current and voltage: power = current × voltage $P = I \times V$	know and use the relationship between power, current and voltage: power = current × voltage $P = I \times V$ and apply the relationship to the selection of appropriate fuses
2.5		use the relationship between energy transferred, current, voltage and time: energy transferred = current × voltage × time $E = I \times V \times t$
2.6	know the difference between mains electricity being alternating current (a.c.) and direct current (d.c.) being supplied by a cell or battery	
	(c) Energy and voltage in circuits	
2.7		explain why a series or parallel circuit is more appropriate for particular applications, including domestic lighting
2.8	understand how the current in a series circuit depends on the applied voltage and the number and nature of other components	

2.9	describe how current varies with voltage in wires, resistors and metal filament lamps, and how to investigate this experimentally	describe how current varies with voltage in wires, resistors, metal filament lamps and diodes, and how to investigate this experimentally	
2.10	describe the qualitative effect of changing resistance on the current in a circuit		
2.11		describe the qualitative variation of resistance of light-dependent resistors (LDRs) with illumination and thermistors with temperature	
2.12	know that lamps and LEDs can be used to indicate the presence of a current in a circuit		
2.13	know and use the relationship between voltage, current and resistance: voltage = current × resistance $V = I \times R$		
2.14	know that current is the rate of flow of charge		
2.15		know and use the relationship between charge, current and time: charge = current × time $Q = I \times t$	
2.16	know that electric current in solid metallic conductors is a flow of negatively charged electrons		
2.17		understand why current is conserved at a junction in a circuit	
2.18		know that the voltage across two components connected in parallel is the same	
2.19	calculate the currents, voltages and resistances of two resistive components connected in a series circuit		
2.20		know that: • voltage is the energy transferred per unit charge passed • the volt is a joule per coulomb.	
2.21		know and use the relationship between energy transferred, charge and voltage: energy transferred = charge × voltage $E = Q \times V$	
	(d) Electric charge		
2.22P			**identify common materials which are electrical conductors or insulators, including metals and plastics**

2.23P			***Practical: investigate how insulating materials can be charged by friction***
2.24P			**explain how positive and negative electrostatic charges are produced on materials by the loss and gain of electrons**
2.25P			**know that there are forces of attraction between unlike charges and forces of repulsion between like charges**
2.26P			**explain electrostatic phenomena in terms of the movement of electrons**
2.27P			**explain the potential dangers of electrostatic charges, e.g. when fuelling aircraft and tankers**
2.28P			**explain some uses of electrostatic charges, e.g. in photocopiers and inkjet printers**

3 Waves

The following sub-topics are covered in this section.

(a) Units

(b) Properties of waves

(c) The electromagnetic spectrum

(d) Light and sound

	(a) Units	
3.1	use the following units: degree (°), hertz (Hz), metre (m), metre/second (m/s) and second (s)	
	(b) Properties of waves	
3.2		explain the difference between longitudinal and transverse waves
3.3	know the definitions of amplitude, wavefront, frequency, wavelength and period of a wave	
3.4	know that waves transfer energy and information without transferring matter	
3.5	know and use the relationship between the speed, frequency and wavelength of a wave: wave speed = frequency × wavelength $v = f \times \lambda$	
3.6		use the relationship between frequency and time period: $\text{frequency} = \frac{1}{\text{time period}}$ $f = \frac{1}{T}$
3.7	use the above relationships in different contexts including sound waves and electromagnetic waves	
3.8		explain why there is a change in the observed frequency and wavelength of a wave when its source is moving relative to an observer, and that this is known as the Doppler effect
3.9	explain that all waves can be reflected and refracted	

	(c) The electromagnetic spectrum		
3.10	know that light is part of a continuous electromagnetic spectrum that includes radio, microwave, infrared, visible, ultraviolet, x-ray and gamma ray radiations and that all these waves travel at the same speed in free space		
3.11	know the order of the electromagnetic spectrum in terms of decreasing wavelength and increasing frequency, including the colours of the visible spectrum		
3.12	explain some of the uses of electromagnetic radiations, including: • radio waves: broadcasting and communications • microwaves: cooking and satellite transmissions • infrared: heaters and night vision equipment • visible light: optical fibres and photography • ultraviolet: fluorescent lamps • x-rays: observing the internal structure of objects and materials, including for medical applications • gamma rays: sterilising food and medical equipment.		
3.13	explain the detrimental effects of excessive exposure of the human body to electromagnetic waves, including: • microwaves: internal heating of body tissue • infrared: skin burns • ultraviolet: damage to surface cells and blindness • gamma rays: cancer, mutation and describe simple protective measures against the risks		
	(d) Light and sound		
3.14	know that light waves can be reflected and refracted	know that light waves are transverse waves and that they can be reflected and refracted	
3.15	use the law of reflection (the angle of incidence equals the angle of reflection)		
3.16		draw ray diagrams to illustrate reflection and refraction	
3.17	*Practical: investigate the refraction of light, using rectangular blocks, semi-circular blocks and triangular prisms*		
3.18		know and use the relationship between refractive index, angle of incidence and angle of refraction: $n = \frac{\sin i}{\sin r}$	
3.19		*Practical: investigate the refractive index of glass, using a glass block*	

3.20	describe the role of total internal reflection in transmitting information along optical fibres and in prisms		
3.21	explain what is meant by critical angle c	explain the meaning of critical angle c	
3.22		know and use the relationship between critical angle and refractive index: $\sin c = \frac{1}{n}$	
3.23	know that sound waves can be reflected and refracted	know that sound waves are longitudinal waves which can be reflected and refracted	
3.24P			**know that the frequency range for human hearing is 20–20 000 Hz**
3.25P			***Practical: investigate the speed of sound in air***
3.26P			**understand how an oscilloscope and microphone can be used to display a sound wave**
3.27P			***Practical: investigate the frequency of a sound wave using an oscilloscope***
3.28P			**understand how the pitch of a sound relates to the frequency of vibration of the source**
3.29P			**understand how the loudness of a sound relates to the amplitude of vibration of the source**

4 Energy resources and energy transfers

The following sub-topics are covered in this section.

(a) Units

(b) Energy transfers

(c) Work and power

	(a) Units		
4.1	use the following units: kilogram (kg), joule (J), metre (m), metre/second (m/s), metre/second^2 (m/s^2), newton (N), second (s), watt (W)		
	(b) Energy transfers		
4.2	describe energy transfers involving energy stores: • energy stores: chemical, kinetic, gravitational, elastic, thermal, magnetic, electrostatic, nuclear • energy transfers: mechanically, electrically, by heating, by radiation (light and sound)		
4.3	use the principle of conservation of energy		
4.4	know and use the relationship between efficiency, useful energy output and total energy output: $\text{efficiency} = \frac{\text{useful energy output}}{\text{total enerrgy output}} \times 100\%$		
4.5	describe a variety of everyday and scientific devices and situations, explaining the transfer of the input energy in terms of the above relationship, including their representation by Sankey diagrams		
4.6		describe how thermal energy transfer may take place by conduction, convection and radiation	
4.7		explain the role of convection in everyday phenomena	
4.8		explain how emission and absorption of radiation are related to surface and temperature	
4.9		*Practical: investigate thermal energy transfer by conduction, convection and radiation*	
4.10		explain ways of reducing unwanted energy transfer, such as insulation	
	(c) Work and power		
4.11	know and use the relationship between work done, force and distance moved in the direction of the force:		

	work done = force × distance moved $W = F \times d$		
4.12	know that work done is equal to energy transferred		
4.13	know and use the relationship between gravitational potential energy, mass, gravitational field strength and height: gravitational potential energy = mass × gravitational field strength × height $GPE = m \times g \times h$		
4.14	know and use the relationship: kinetic energy = ½ × mass × speed^2 $KE = ½ \times m \times v^2$		
4.15	understand how conservation of energy produces a link between gravitational potential energy, kinetic energy and work		
4.16	describe power as the rate of transfer of energy or the rate of doing work		
4.17	use the relationship between power, work done (energy transferred) and time taken: $\text{power} = \frac{\text{work done}}{\text{time taken}}$ $P = \frac{W}{t}$		
	(d) Energy resources and electricity generation		
4.18P			**describe the energy transfers involved in generating electricity using:** • **wind** • **water** • **geothermal resources** • **solar heating systems** • **solar cells** • **fossil fuels** • **nuclear power**
4.19P			**describe the advantages and disadvantages of methods of large-scale electricity production from various renewable and non-renewable resources**

5 Solids, liquids and gases

The following sub-topics are covered in this section.

(a) Units

(b) Density and pressure

(c) Changes of state

(d) Ideal gas molecules

	(a) Units	
5.1	use the following units: degree Celsius (°C), Kelvin (K), joule (J), kilogram (kg), metre (m), metre^2 (m^2), metre^3 (m^3), metre/second (m/s), metre/second^2 (m/s^2), newton (N) and pascal (Pa)	use the following units: degree Celsius (°C), Kelvin (K), joule (J), kilogram (kg), kilogram/metre^3 (kg/m^3), metre (m), metre^2 (m^2), metre^3 (m^3), metre/second (m/s), metre/second^2 (m/s^2), newton (N) and pascal (Pa)
5.2	use the following unit: joules/kilogram degree Celsius (J/kg °C)	
	(b) Density and pressure	
5.3		use the relationship between density, mass and volume: $\text{density} = \frac{\text{mass}}{\text{volume}}$ $\rho = \frac{m}{V}$
5.4		*Practical: investigate density using direct measurements of mass and volume*
5.5	use the relationship between pressure, force and area: $\text{pressure} = \frac{\text{force}}{\text{area}}$ $p = \frac{F}{A}$	
5.6	understand how the pressure at a point in a gas or liquid at rest acts equally in all directions	
5.7		know and use the relationship for pressure difference:

		pressure difference = height × density × gravitational field strength $p = h \times \rho \times g$	
	(c) Changes of state		
5.8P			**explain why heating a system will change the energy stored within the system and raise its temperature or produce changes of state**
5.9P			**describe the changes that occur when a solid melts to form a liquid, and when a liquid evaporates or boils to form a gas**
5.10P			**describe the arrangement and motion of particles in solids, liquids and gases**
5.11P			***Practical: obtain a temperature–time graph to show the constant temperature during a change of state***
5.12P			**know that specific heat capacity is the energy required to change the temperature of an object by one degree Celsius per kilogram of mass (J/kg °C)**
5.13P			**use the equation:** **change in thermal energy = mass × specific heat capacity × change in temperature** $\Delta Q = m \times c \times \Delta T$
5.14P			***Practical: investigate the specific heat capacity of materials including water and some solids***
	(d) Ideal gas molecules		
5.15	explain how molecules in a gas have random motion and that they exert a force and hence a pressure on the walls of a container		
5.16	understand why there is an absolute zero of temperature which is −273 °C		
5.17	describe the Kelvin scale of temperature and be able to convert between the Kelvin and Celsius scales		

5.18	understand why an increase in temperature results in an increase in the average speed of gas molecules	
5.19	know that the Kelvin temperature of a gas is proportional to the average kinetic energy of its molecules	
5.20	explain, for a fixed amount of gas, the qualitative relationship between: • pressure and volume at constant temperature • pressure and Kelvin temperature at constant volume.	
5.21		use the relationship between the pressure and Kelvin temperature of a fixed mass of gas at constant volume: $\frac{p_1}{T_1} = \frac{p_2}{T_2}$
5.22		use the relationship between the pressure and volume of a fixed mass of gas at constant temperature: $p_1V_1 = p_2V_2$

6 Magnetism and electromagnetism

The following sub-topics are covered in this section.

(a) Units

(b) Magnetism

(c) Electromagnetism

(d) Electromagnetic induction

	(a) Units		
6.1	use the following units: ampere (A), volt (V) and watt (W)		
	(b) Magnetism		
6.2		know that magnets repel and attract other magnets and attract magnetic substances	
6.3		describe the properties of magnetically hard and soft materials	
6.4	understand the term magnetic field line		
6.5		know that magnetism is induced in some materials when they are placed in a magnetic field	
6.6	*Practical: investigate the magnetic field pattern for a permanent bar magnet and between two bar magnets*		
6.7	describe how to use two permanent magnets to produce a uniform magnetic field pattern		
	(c) Electromagnetism		
6.8	know that an electric current in a conductor produces a magnetic field around it		
6.9P			**describe the construction of electromagnets**
6.10P			**draw magnetic field patterns for a straight wire, a flat circular coil and a solenoid when each is carrying a current**
6.11P			**know that there is a force on a charged particle when it moves in a magnetic field as long as its motion is not parallel**

			to the field
6.12	understand why a force is exerted on a current-carrying wire in a magnetic field, and how this effect is applied in simple d.c. electric motors and loudspeakers		
6.13	use the left-hand rule to predict the direction of the resulting force when a wire carries a current perpendicular to a magnetic field		
6.14	describe how the force on a current-carrying conductor in a magnetic field changes with the magnitude and direction of the field and current		
	(d) Electromagnetic induction		
6.15		know that a voltage is induced in a conductor or a coil when it moves through a magnetic field or when a magnetic field changes through it and describe the factors that affect the size of the induced voltage	
6.16		describe the generation of electricity by the rotation of a magnet within a coil of wire and of a coil of wire within a magnetic field, and describe the factors that affect the size of the induced voltage	
6.17P			**describe the structure of a transformer, and understand that a transformer changes the size of an alternating voltage by having different numbers of turns on the input and output sides**
6.18P			**explain the use of step-up and step-down transformers in the large-scale generation and transmission of electrical energy**
6.19P			**know and use the relationship between input (primary) and output (secondary) voltages and the turns ratio for a transformer:** $\frac{\text{initial (primary) voltage}}{\text{output (secondary) voltage}} = \frac{\text{primary turns}}{\text{secondary turns}}$
6.20P			**know and use the relationship:** **input power = output power** $V_p I_p = V_s I_s$ **for 100% efficiency**

7 Radioactivity and particles

The following sub-topics are covered in this section.

(a) Units

(b) Radioactivity

(c) Fission and fusion

	(a) Units	
7.1	use the following units: becquerel (Bq), centimetre (cm), hour (h), minute (min) and second (s)	
	(b) Radioactivity	
7.2	describe the structure of an atom in terms of protons, neutrons and electrons and use symbols such as $^{14}_{6}C$ to describe particular nuclei	
7.3	know the terms atomic (proton) number, mass (nucleon) number and isotope	
7.4	know that alpha (α) particles, beta (β^-) particles and gamma (γ) rays are ionising radiations emitted from unstable nuclei in a random process	
7.5	describe the nature of alpha (α) particles, beta (β^-) particles and gamma (γ) rays, and recall that they may be distinguished in terms of penetrating power and ability to ionize	
7.6	*Practical: investigate the penetration powers of different types of radiation using either radioactive sources or simulations*	
7.7		describe the effects on the atomic and mass numbers of a nucleus of the emission of each of the four main types of radiation (alpha, beta, gamma and neutron radiation)
7.8		understand how to balance nuclear equations in terms of mass and charge
7.9		know that photographic film or a Geiger–Müller detector can detect ionising radiations
7.10	explain the sources of background (ionising) radiation from Earth and space	
7.11		know that the activity of a radioactive source decreases over a period of time and is measured in becquerels
7.12	know the definition of the term half-life and understand that it is different for different radioactive isotopes	
7.13		use the concept of the half-life to carry out simple calculations on activity, including graphical methods
7.14	describe uses of radioactivity in industry and medicine	

7.15	describe the difference between contamination and irradiation	
7.16	describe the dangers of ionising radiations, including: • that radiation can cause mutations in living organisms • that radiation can damage cells and tissue • the problems arising from the disposal of radioactive waste and how the associated risks can be reduced.	
	(c) Fission and fusion	
7.17	know that nuclear reactions, including fission, fusion and radioactive decay can be a source of energy	
7.18	understand how a nucleus of U-235 can be split (the process of fission) by collision with a neutron, and that this process releases energy as kinetic energy of the fission products	
7.19	know that the fission of U-235 produces two radioactive daughter nuclei and a small number of neutrons	
7.20		describe how a chain reaction can be set up if the neutrons produced by one fission strike other U-235 nuclei
7.21		describe the role played by the control rods and moderator in the fission process
7.22	understand the role of shielding around a nuclear reactor	
7.23		explain the difference between nuclear fusion and nuclear fission
7.24		describe nuclear fusion as the creation of larger nuclei resulting in a loss of mass from smaller nuclei, accompanied by a release of energy
7.25	know that fusion is the energy source for stars	
7.26		explain why nuclear fusion does not happen at low temperatures and pressures, due to electrostatic repulsion of protons

8 Astrophysics

The following sub-topics are covered in this section:

(a) Units

(b) Motion in the universe

(c) Stellar evolution

(d) Cosmology

	(a) Units		
8.1	use the following units: kilogram (kg), metre (m), metre/second (m/s), metre/second^2 (m/s^2), newton (N), second (s), newton/kilogram (N/kg) kilogram metre/second (kg m/s)		
	(b) Motion in the universe		
8.2	know that: • the universe is a large collection of billions of galaxies • a galaxy is a large collection of billions of stars • our solar system is in the Milky Way galaxy.		
8.3	understand why gravitational field strength, g, varies and know that it is different on other planets and the Moon from that on the Earth.		
8.4	explain that gravitational force: • causes moons to orbit planets • causes the planets to orbit the Sun • causes artificial satellites to orbit the Earth • causes comets to orbit the Sun.		
8.5	describe the differences in the orbits of comets, moons and planets		
8.6		use the relationship between orbital speed, orbital radius and time period: $\text{orbital speed} = \frac{2 \times \pi \times \text{orbital radius}}{\text{time period}}$ $v = \frac{2 \times \pi \times r}{T}$	

	(c) Stellar evolution		
8.7	understand how stars can be classified according to their colour		
8.8	know that a star's colour is related to its surface temperature		
8.9	describe the evolution of stars of similar mass to the Sun through the following stages: • nebula • star (main sequence) • red giant • white dwarf.		
8.10		describe the evolution of stars with a mass larger than the Sun	
8.11P			**understand how the brightness of a star at a standard distance can be represented using absolute magnitude**
8.12P			**draw the main components of the Hertzsprung–Russell diagram (HR diagram)**
	(d) Cosmology		
8.13P			**describe the past evolution of the universe and the main arguments in favour of the Big Bang**
8.14P			**describe evidence that supports the Big Bang theory (red-shift and cosmic microwave background (CMB) radiation)**
8.15P			**describe that if a wave source is moving relative to an observer there will be a change in the observed frequency and wavelength**
8.16P			**use the equation relating change in wavelength, wavelength, velocity of a galaxy and the speed of light:** $\frac{\text{change in wavelength}}{\text{reference wavelength}} = \frac{\text{velocity of a galaxy}}{\text{speed of light}}$

			$\frac{\lambda - \lambda_0}{\lambda_0} = \frac{\Delta\lambda}{\lambda_0} = \frac{v}{c}$
8.17P			**describe the red-shift in light received from galaxies at different distances away from the Earth**
8.18P			**explain why the red-shift of galaxies provides evidence for the expansion of the universe**