Comparison between 0654 Co-ordinated Sciences and individual science IGCSE syllabuses

This document has been prepared to allow teachers to compare the content of the IGCSE Co-ordinated Sciences syllabus (0654) with each of the companion separate science IGCSE syllabuses (Biology, 0610, page 2; Chemistry, 0620, page 23; Physics, 0625, page 37).

The syllabus content of the Co-ordinated Sciences (double award) is largely a subset of each of the separate sciences. The syllabus content is designed to enable the co-teaching of CIE's science courses. The following minor differences, however, should be noted:

1. The content of the Co-ordinated Sciences syllabus is set out in topic areas within Biology, Chemistry and Physics. While the content takes the content of each of the separate sciences as a guide for organisation, the topic areas given in Co-ordinated Sciences are not identical to the content areas of the separate sciences, often reducing two or more of the separate science content areas into one.

2. Some of the assessment objectives given in the Co-ordinated Sciences syllabus are worded slightly differently to the similar objectives given in the separate science syllabuses. These differences make more explicit the detail of the content referred to in the separate science syllabuses.

The assessment objectives highlighted in pink refer to the core content of the Co-ordinated Sciences syllabus, and those objectives highlighted in yellow refer to the supplement content. Double asterixes indicate areas where the syllabuses are expressed slightly differently in the various syllabuses.

Section I: Characteristics and classification of living organisms (5% of teaching time)

1. Characteristics of living organisms

Core

- List and describe the characteristics of living organisms
- Define the terms:
  - *nutrition* as taking in of nutrients which are organic substances and mineral ions, containing raw materials or energy for growth and tissue repair, absorbing and assimilating them
  - *excretion* as removal from organisms of toxic materials, the waste products of metabolism (chemical reactions in cells including respiration) and substances in excess of requirements
  - *respiration* as the chemical reactions that break down nutrient molecules in living cells to release energy
  - *sensitivity* as the ability to detect or sense changes in the environment (stimuli) and to make responses
  - *reproduction* as the processes that make more of the same kind of organism
  - *growth* as a permanent increase in size and dry mass by an increase in cell number or cell size or both
  - *movement* as an action by an organism or part of an organism causing a change of position or place

2. Classification and diversity of living organisms

2.1 Concept and use of a classificatory system

Core

- Define and describe the *binomial system* of naming species as a system in which the scientific name of an organism is made up of two parts showing the genus and species
- List the main features of the following vertebrates: bony fish, amphibians, reptiles, birds and mammals

Supplement

- Know that there are other classification systems e.g. cladistics (based on RNA/ DNA sequencing data)
- List the main features used in the classification of the following groups: viruses, bacteria and fungi, and their adaptation to the environment, as appropriate

2.2Adaptations of organisms to their environment *(to be illustrated by examples wherever possible)* **Core** • List the main features used in the classification of the following groups: flowering plants (monocotyledons and eudicotyledons (dicotyledons)), arthropods (insects, crustaceans, arachnids and myriapods), annelids, nematodes and molluscs	
3. Simple keys	
Core • Use simple dichotomous keys based on easily identifiable features	
Section II: Organisation and maintenance of the organism (50% of teaching time)	
1. Cell structure and organisation	
Core • State that living organisms are made of cells • Identify and describe the structure of a plant cell (palisade cell) and an animal cell (liver cell), as seen under a light microscope • Describe the differences in structure between typical animal and plant cells	**Supplement** • Relate the structures seen under the light microscope in the plant cell and in the animal cell to their functions
2. Levels of organisation	

Core
• Relate the structure of the following to their functions:
  • ciliated cells – in respiratory tract
  • root hair cells – absorption
  • xylem vessels – conduction and support
  • muscle cells – contraction
  • red blood cells – transport
• Define:
  • *tissue* as a group of cells with similar structures, working together to perform a shared function
  • *organ* as a structure made up of a group of tissues, working together to perform specific functions
  • *organ system* as a group of organs with related functions, working together to perform body functions using examples covered in Sections II and III	

3. Size of specimens	
Core • Calculate magnification and size of biological specimens using millimetres as units	
4. Movement in and out of cells	
4.1 Diffusion **Core** • Define *diffusion* as the net movement of molecules from a region of their higher concentration to a region of their lower concentration down a concentration gradient, as a result of their random movement • Describe the importance of diffusion of gases and solutes and of water as a solvent	
4.2 Active Transport	**Supplement** • Define *active transport* as movement of ions in or out of a cell through the cell membrane, from a region of their lower concentration to a region of their higher concentration against a concentration gradient, using energy released during respiration • Discuss the importance of active transport as an energy-consuming process by which substances are transported against a concentration gradient, e.g. ion uptake by root hairs and uptake of glucose by epithelial cells of villi
4.3 Osmosis **Core** • Define *osmosis* as the diffusion of water molecules from a region of their higher concentration (dilute solution) to a region of their lower concentration (concentrated solution), through a partially permeable membrane • Describe the importance of osmosis in the uptake of water by plants, and its effects on plant and animal tissues	**Supplement** • Describe and explain the importance of a water potential gradient in the uptake of water by plants

5. Enzymes	
Core • Define the term *catalyst* as a substance that speeds up a chemical reaction and is not changed by the reaction • Define *enzymes* as proteins that function as biological catalysts • Investigate and describe the effect of changes in temperature and pH on enzyme activity	**Supplement** • Explain enzyme action in terms of the 'lock and key' model • Explain the effect of changes in temperature and pH on enzyme activity • Describe the role of enzymes in the germination of seeds, and their uses in biological washing products and in the food industry (including pectinase and fruit juice) • Outline the use of microorganisms and fermenters to manufacture the antibiotic penicillin and enzymes for use in biological washing powders • Describe the role of the fungus *Penicillium* in the production of antibiotic penicillin
6. Nutrition	
Core • Define *nutrition* as taking in of nutrients which are organic substances and mineral ions, containing raw materials or energy for growth and tissue repair, absorbing and assimilating them	

6.1 Nutrients
Core
• List the chemical elements that make up:
  • carbohydrates
  • fats
  • proteins
• Describe the synthesis of large molecules from smaller basic units, i.e.
  • simple sugars to starch and glycogen
  • amino acids to proteins
  • fatty acids and glycerol to fats and oils
• Describe tests for:
  • starch (iodine solution)
  • reducing sugars (Benedict's solution)
  • protein (biuret test)
  • fats (ethanol)	

• List the principal sources of, and describe the importance of:
  • carbohydrates
  • fats
  • proteins
  • vitamins (C and D only)
  • mineral salts (calcium and iron only) • fibre (roughage)
  • water
• Describe the deficiency symptoms for:
  • vitamins (C and D only)
  • mineral salts (calcium and iron only)
	• Describe the use of microorganisms in the food industry, with reference to yoghurt and single cell protein
	**
	• Describe the uses, benefits and health hazards associated with food additives, including colourings

6.2 Plant nutrition	
6.2.1 Photosynthesis **Core** • Define *photosynthesis* as the fundamental process by which plants manufacture carbohydrates from raw materials using energy from light • State the word equation for the production of simple sugars and oxygen • Investigate the necessity for chlorophyll, light and carbon dioxide for photosynthesis, using appropriate controls • Describe the intake of carbon dioxide and water by plants • Explain that chlorophyll traps light energy and converts it into chemical energy for the formation of carbohydrates and their subsequent storage	**Supplement** • State the balanced equation for photosynthesis in symbols (symbols as in printed syllabus) • Investigate and state the effect of varying light intensity, carbon dioxide concentration and temperature on the rate of photosynthesis (e.g. in submerged aquatic plants) • Define the term *limiting* factor as something present in the environment in such short supply that it restricts life processes • Explain the concept of limiting factors in photosynthesis • Explain the use of carbon dioxide enrichment, optimum light and optimum temperatures in glasshouse systems
6.2.2 Leaf structure **Core** • Identify and label the cuticle, cellular and tissue structure of a dicotyledonous leaf, as seen in cross-section under the light microscope, and describe the significance of these features in terms of functions, to include: • distribution of chloroplasts – photosynthesis • stomata and mesophyll cells – gas exchange • vascular bundles (xylem and phloem) – transport and support	

6.2.3 Mineral requirements
Core
• Describe the importance of:
  • nitrate ions for protein synthesis
  • magnesium ions for chlorophyll synthesis
• Describe the uses, and the dangers of overuse, of nitrogen fertilisers
	Supplement
	• Explain the effects of nitrate ion and magnesium ion deficiency on plant growth

6.3 Animal nutrition	
6.3.1 Diet **Core** • State what is meant by the term balanced diet and describe a balanced diet related to age, sex and activity of an individual • Describe the effects of malnutrition in relation to starvation, coronary heart disease, constipation and obesity	
6.3.2 Food supply **Core** • Discuss ways in which the use of modern technology has resulted in increased food production (to include modern agricultural machinery, chemical fertilisers, pesticides and herbicides, artificial selection)	**Supplement** • Discuss the problems of world food supplies • Discuss the problems which contribute to famine (unequal distribution of food, drought and flooding and increasing population)
6.3.3 Human alimentary canal **Core** • Define *ingestion* as taking substances (e.g. food, drink) into the body through the mouth • Define *egestion* as passing out of food that has not been digested, as faeces, through the anus • Identify the main regions of the alimentary canal and associated organs including mouth, salivary glands, oesophagus, stomach, small intestine: duodenum and ileum, pancreas, liver, gall bladder, large intestine: colon and rectum, anus • Describe the functions of the regions of the alimentary canal listed above, in relation to ingestion, digestion, absorption, assimilation and egestion of food (cross reference 6.3.4, 6.3.5, 6.3.6 and 6.3.7)	

6.3.4 Mechanical and physical digestion **Core** • Define *digestion* as the break-down of large, insoluble food molecules into small, water-soluble molecules using mechanical and chemical processes • Identify the types of human teeth and describe their structure and functions • State the causes of dental decay and describe the proper care of teeth • Describe the process of chewing • Describe the role of longitudinal and circular muscles in peristalsis • Outline the role of bile in emulsifying fats, to increase the surface area for the action of enzymes	**Supplement** • Describe how fluoride reduces tooth decay and the proper care of teeth explain arguments for and against the addition of fluoride to public water supplies
6.3.5 Chemical digestion **Core** • State the significance of chemical digestion in the alimentary canal in producing small, soluble molecules that can be absorbed • State where, in the alimentary canal, amylase, protease and lipase enzymes are secreted • State the functions of a typical amylase, a protease and a lipase, listing the substrate and end-products	
6.3.6 Absorption **Core** • Define *absorption* as movement of digested food molecules through the wall of the intestine into the blood or lymph • Identify the small intestine as the region for the absorption of digested food • Describe the significance of villi in increasing the internal surface area of the small intestine	**Supplement** • Describe the structure of a villus, including the role of capillaries and lacteals • State the role of the hepatic portal vein in the transport of absorbed food to the liver • Identify the role of the small intestine and colon in absorption of water (the small intestine absorbs 5–10 dm^3 per day, the colon 0.3–0.5 dm^3 per day)
6.3.7 Assimilation **Core** • Define *assimilation* as movement of digested food molecules into the cells of the body where they are used, becoming part of the cells • Describe the role of the liver in the metabolism of glucose (glucose → glycogen) and amino acids (amino acids → proteins and destruction of excess amino acids) • Describe the role of fat as an energy storage substance	**Supplement** • Define *deamination* as removal of the nitrogen-containing part of amino acids to form urea, followed by release of energy from the remainder of the amino acid • State that the liver is the site of breakdown of alcohol and other toxins

7. Transportation	
7.1 Transport in plants **Core** • State the functions of xylem and phloem • Identify the positions of xylem and phloem tissues as seen in transverse sections of unthickened, herbaceous, dicotyledonous roots, stems and leaves	
7.1.1 Water uptake **Core** • Identify root hair cells, as seen under the light microscope, and state their functions • State the pathway taken by water through root, stem and leaf (root hair, root cortex cells, xylem, mesophyll cells) • Investigate, using a suitable stain, the pathway of water through the above-ground parts of a plant	**Supplement** • Relate the structure and functions of root hairs to their surface area and to water and ion uptake
7.1.2 Transpiration **Core** • Define *transpiration* as evaporation of water at the surfaces of the mesophyll cells followed by loss of water vapour from plant leaves, through the stomata • Describe how water vapour loss is related to cell surfaces, air spaces and stomata • Describe the effects of variation of temperature, humidity and light intensity on transpiration rate • Describe how wilting occurs	**Supplement** • Explain the mechanism of water uptake and movement in terms of transpiration producing a tension ('pull') from above, creating a water potential gradient in the xylem, drawing cohesive water molecules up the plant. • Discuss the adaptations of the leaf, stem and root to **three** contrasting environments, to include pond, garden and desert, with emphasis on local examples (where appropriate) and the factors described in the core

7.1.3 Translocation
Core
• Define *translocation* in terms of the movement of sucrose and amino acids in phloem;
  • from regions of production
  • to regions of storage OR to regions of utilisation in respiration or growth
	Supplement
	• Describe translocation throughout the plant of applied chemicals, including systemic pesticides
	• Compare the role of transpiration and translocation in the transport of materials from sources to sinks, within plants at different seasons

7.2 Transport in humans **Core** • Describe the circulatory system as a system of tubes with a pump and valves to ensure one-way flow of blood • Describe the double circulation in terms of a low pressure circulation to the lungs and a high pressure circulation to the body tissues and relate these differences to the different functions of the two circuits	

7.2.1 Heart **Core** • Describe the structure of the heart including the muscular wall and septum, chambers, valves and associated blood vessels • Describe the function of the heart in terms of muscular contraction and the working of the valves • Investigate, state and explain the effect of physical activity on pulse rate • Describe coronary heart disease in terms of the blockage of coronary arteries and state the possible causes (diet, stress and smoking) and preventive measures	
7.2.2 Arteries, veins and capillaries **Core** • Name the main blood vessels to and from the heart, lungs, liver and kidney • Describe the structure and functions of arteries, veins and capillaries	**Supplement** • Explain how structure and function are related in arteries, veins and capillaries • Describe the transfer of materials between capillaries and tissue fluid

7.2.3 Blood
Core
• Identify red and white blood cells as seen under the light microscope on prepared slides, and in diagrams and photomicrographs
• List the components of blood as red blood cells, white blood cells, platelets and plasma
• State the functions of blood:
  • red blood cells – haemoglobin and oxygen transport
  • white blood cells – phagocytosis and antibody formation
  • platelets – causing clotting (no details)
  • plasma – transport of blood cells, ions, soluble nutrients, hormones, carbon dioxide, urea and plasma proteins
	Supplement
	• Describe the immune system in terms of antibody production, tissue rejection and phagocytosis
	• Describe the function of the lymphatic system in circulation of body fluids, and the production of lymphocytes
	• Describe the process of clotting (fibrinogen to fibrin only)

8. Respiration	
Core • Define *respiration* as the chemical reactions that break down nutrient molecules in living cells to release energy • State the uses of energy in the body of humans: muscle contraction, protein synthesis, cell division, active transport, growth, the passage of nerve impulses and the maintenance of a constant body temperature	

8.1 Aerobic respiration **Core** • Define *aerobic respiration* as the release of a relatively large amount of energy in cells by the breakdown of food substances in the presence of oxygen • State the word equation for aerobic respiration	**Supplement** • State the equation for aerobic respiration using symbols ($C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$)
8.2 Anaerobic respiration **Core** • Define *anaerobic respiration* as the release of a relatively small amount of energy by the breakdown of food substances in the absence of oxygen • State the word equation for anaerobic respiration in muscles during hard exercise (glucose → lactic acid) and the microorganism yeast (glucose → alcohol + carbon dioxide) • Describe the role of anaerobic respiration in yeast during brewing and bread-making • Compare aerobic respiration and anaerobic respiration in terms of relative amounts of energy released	**Supplement** • State the balanced equation for anaerobic respiration in muscles ($C_6H_{12}O_6 \rightarrow 2C_3H_6O_3$) and the microorganism yeast ($C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$), using symbols • Describe the effect of lactic acid in muscles during exercise (include oxygen debt in outline only)
8.3 Gas exchange **Core** • List the features of gas exchange surfaces in animals • Identify on diagrams and name the larynx, trachea, bronchi, bronchioles, alveoli and associated capillaries • State the differences in composition between inspired and expired air • Use lime water as a test for carbon dioxide to investigate the differences in composition between inspired and expired air • Investigate and describe the effects of physical activity on rate and depth of breathing	**Supplement** • Describe the role of the ribs, the internal and external intercostal muscles and the diaphragm in producing volume and pressure changes leading to the ventilation of the lungs • Explain the role of mucus and cilia in protecting the gas exchange system from pathogens and particles • Explain the link between physical activity and rate and depth of breathing in terms of changes in the rate at which tissues respire and therefore of carbon dioxide concentration and pH in tissues and in the blood
9. Excretion in humans	
Core • Define excretion as the removal from organisms of toxic materials, the waste products of metabolism (chemical reactions in cells including respiration) and substances in excess of requirements. Substances should include carbon dioxide, urea and salts	**Supplement**

• Describe the function of the kidney in terms of the removal of urea and excess water and the reabsorption of glucose and some salts (details of kidney structure and nephron are not required)
• State the relative positions of ureters, bladders and urethra in the body
• State that urea is formed in the liver from excess amino acids
• State that alcohol, drugs and hormones are broken down in the liver
	• Outline the structure of a kidney (cortex and medulla, and the start of the ureter) and outline the structure and functioning of a kidney tubule (including:
	  • role of renal capsule in filtration from blood of water, glucose, urea and salts
	  • role of tubule in reabsorption of glucose most of the water and some salts back into the blood, leading to concentration of urea in the urine as well as loss of excess water and salts
	• Explain dialysis in terms of maintenance of glucose and protein concentration in blood and diffusion of urea from blood to dialysis fluid
	• Discuss the application of dialysis in kidney machines
	• Discuss the advantages and disadvantages of kidney transplants, compared with dialysis

10. Coordination and response	
10.1 Nervous control in humans **Core** • Describe the human nervous system in terms of the central nervous system (brain and spinal cord as areas of coordination) and the peripheral nervous system which together serve to coordinate and regulate body functions • Identify motor (effector), relay (connector) and sensory neurones from diagrams • Describe a simple reflex arc in terms of sensory, relay and motor neurones, and a reflex action as a means of automatically and rapidly integrating and coordinating stimuli with responses • State that muscles and glands can act as effectors • Describe the action of antagonistic muscles to include the biceps and triceps at the elbow joint • Define sense *organs* as groups of receptor cells responding to specific stimuli: light, sound, touch, temperature and chemicals • Describe the structure and function of the eye, including accommodation and pupil reflex	**Supplement** • Distinguish between voluntary and involuntary actions • Distinguish between rods and cones, in terms of function and distribution

10.2 Hormones **Core** • Define a *hormone* as a chemical substance, produced by a gland, carried by the blood, which alters the activity of one or more specific target organs and is then destroyed by the liver • State the role of the hormone adrenaline in chemical control of metabolic activity, including increasing the blood glucose concentration and pulse rate • Give examples of situations in which adrenaline secretion increases • Compare nervous and hormonal control systems	**Supplement** • Discuss the use of hormones in food production
10.3 Tropic responses **Core** • Define and investigate *geotropism* (as a response in which a plant grows towards or away from gravity) and *phototropism* (as a response in which a plant grows towards or away from the direction from which light is coming)	**Supplement** • Explain the chemical control of plant growth by auxins including geotropism and phototropism in terms of auxins regulating differential growth, and the effects of synthetic plant hormones used as weedkillers
10.4 Homeostasis **Core** • Define *homeostasis* as the maintenance of a constant internal environment • Identify, on a diagram of the skin: hairs, sweat glands, temperature receptors, blood vessels and fatty tissue • Describe the maintenance of a constant body temperature in humans in terms of insulation and the role of temperature receptors in the skin, sweating, shivering, vasodilation and vasoconstriction of arterioles supplying skin-surface capillaries and the coordinating role of the brain	**Supplement** • Explain the concept of control by negative feedback • Describe the control of the glucose content of the blood by the liver, and by insulin and glucagon from the pancreas

10.5 Drugs **Core** • Define a drug as any substance taken into the body that modifies or affects chemical reactions in the body • Describe the medicinal use of antibiotics for the treatment of bacterial infection • Describe the effects of the abuse of heroin: a powerful depressant, problems of addiction, severe withdrawal symptoms and associated problems such as crime and infection e.g. HIV/AIDS • Describe the effects of excessive consumption of alcohol: reduced self-control, depressant, effect on reaction times, damage to liver and social implications • Describe the effects of tobacco smoke and its major toxic components (tar, nicotine, carbon monoxide, smoke particles) on the gas exchange system	**Supplement** • Explain why antibiotics kill bacteria but not viruses
Section III: Development of the organism and the continuity of life (25% of teaching time)	
1. Reproduction	
1.1 Asexual reproduction **Core** • Define *asexual reproduction* as the process resulting in the production of genetically identical offspring from one parent • Describe asexual reproduction in bacteria, spore production in fungi and tuber formation in potatoes	**Supplement** • Discuss the advantages and disadvantages to a species of asexual reproduction
1.2 Sexual reproduction **Core** • Define *sexual reproduction* as the process involving the fusion of haploid nuclei to form a diploid zygote and the production of genetically dissimilar offspring	**Supplement** • Discuss the advantages and disadvantages to a species of sexual reproduction

1.2.1 Sexual reproduction in plants **Core**	**Supplement**
• Identify and draw, using a hand lens if necessary, the sepals, petals, stamens, anthers, carpels, ovaries and stigmas of one, locally available, named, insect-pollinated, dicotyledonous flower, and examine the pollen grains under a light microscope or in photomicrographs • State the functions of the sepals, petals, anthers, stigmas and ovaries • Use a hand lens to identify and describe the anthers and stigmas of one, locally available, named, wind-pollinated flower, and examine the pollen grains under a light microscope or in photomicrographs	
• Candidates should expect to apply their understanding of the flowers they have studied to unfamiliar flowers • Define *pollination* as the transfer of pollen grains from the male part of the plant (anther or stamen) to the female part of the plant (stigma) • Name the agents of pollination • Compare the different structural adaptations of insect-pollinated and wind-pollinated flowers • Describe the growth of the pollen tube and its entry into the ovule followed by fertilisation (production of endosperm and details of development are **not** required) • Investigate and describe the structure of a non-endospermic seed in terms of the embryo (radicle, plumule and cotyledons) and testa, protected by the fruit ** • Outline the formation of a seed (limited to embryo, cotyledons, testa and role of mitosis) and fruit (produced from the ovary wall) • State that seed and fruit dispersal by wind and by animals provides a means of colonising new areas • Describe, using named examples, seed and fruit dispersal by wind and by animals	• Distinguish between self-pollination and cross- pollination • Discuss the implications to a species of self-pollination and cross-pollination

1.2.2 Sexual reproduction in humans **Core** • Identify on diagrams of the male reproductive system, the testes, scrotum, sperm ducts, prostate gland, urethra and penis, and state the functions of these parts • Identify on diagrams of the female reproductive system, the ovaries, oviducts, uterus, cervix and vagina, and state the functions of these parts • Describe the menstrual cycle in terms of changes in the uterus and ovaries • Outline sexual intercourse and describe fertilisation in terms of the joining of the nuclei of male gamete (sperm) and the female gamete (egg) • Outline early development of the zygote simply in terms of the formation of a ball of cells that becomes implanted in the wall of the uterus • Outline the development of the fetus • Describe the function of the placenta and umbilical cord in relation to exchange of dissolved nutrients, gases and excretory products (no structural details are required) • Describe the ante-natal care of pregnant women including special dietary needs and maintaining good health • Outline the processes involved in labour and birth	**Supplement** • Compare male and female gametes in terms of size, numbers and mobility • Explain the role of hormones in controlling the menstrual cycle (including FSH, LH, progesterone and oestrogen) • Indicate the functions of the amniotic sac and amniotic fluid • Describe the advantages and disadvantages of breast-feeding compared with bottle-feeding using formula milk
1.3 Sex hormones **Core** • Describe the roles of testosterone and oestrogen in the development and regulation of secondary sexual characteristics at puberty	**Supplement** • Describe the sites of production and the roles of oestrogen and progesterone in the menstrual cycle and in pregnancy (cross reference 1.2.2)

1.4 Methods of birth control
Core
• Outline the following methods of birth control:
  • natural (abstinence, rhythm method)
  • chemical (contraceptive pill, spermicide)
  • mechanical (condom, diaphragm, femidom, IUD)
  • surgical (vasectomy, female sterilisation)
	Supplement
	• Outline artificial insemination and the use of hormones in fertility drugs, and discuss their social implications

1.5 Sexually transmissible diseases **Core** • Describe the symptoms, signs, effects and treatment of gonorrhoea • Describe the methods of transmission of human immunodeficiency virus (HIV), and the ways in which HIV/AIDS can be prevented from spreading	**Supplement** • Outline how HIV affects the immune system in a person with HIV/AIDS

2. Growth and development	
Core • Define *growth* in terms of a permanent increase in size and dry mass by an increase in cell number or cell size or both • Define *development* in terms of increase in complexity • Investigate and state the environmental conditions that affect germination of seeds: requirement for water and oxygen, suitable temperature	
3. Inheritance	
Core • Define *inheritance* as the transmission of genetic information from generation to generation	

3.1 Chromosomes
Core
• Define the terms:
  • *chromosome* as a thread of DNA, made up of a string of genes
  • *gene* as a length of DNA that is the unit of heredity and codes for a specific protein. A gene may be copied and passed on to the next generation
  • *allele* as any of two or more alternative forms of a gene
  • *haploid nucleus* as a nucleus containing a single set of unpaired chromosomes (e.g. sperm and egg)
  • *diploid nucleus* as a nucleus containing two sets of chromosomes (e.g. in body cells)
• Describe the inheritance of sex in humans (XX and XY chromosomes)	

3.2 Mitosis **Core** • Define *mitosis* as nuclear division giving rise to genetically identical cells in which the chromosome number is maintained by the exact duplication of chromosomes (details of stages are **not** required) • State the role of mitosis in growth, repair of damaged tissues, replacement of worn out cells and asexual reproduction	

3.3 Meiosis Core • Define meiosis as reduction division in which the chromosome number is halved from diploid to haploid (details of stages are not required) • State that gametes are the result of meiosis • State that meiosis results in genetic variation so the cells produced are not all genetically identical	

3.4 Monohybrid inheritance
Core
• Define the terms:
  • *genotype* as genetic makeup of an organism in terms of the alleles present (e.g. Tt or GG)
  • *phenotype* as the physical or other features of an organism due to both its genotype and its environment (e.g. tall plant or green seed)
  • *homozygous* as having two identical alleles of a particular gene (e.g. TT or gg). Two identical homozygous individuals that breed together will be pure-breeding
  • *heterozygous* as having two different alleles of a particular gene (e.g. Tt or Gg), not pure-breeding
  • *dominant* as an allele that is expressed if it is present (e.g. T or G)
  • *recessive* as an allele that is only expressed when there is no dominant allele of the gene present (e.g. t or g)
• Calculate and predict the results of monohybrid crosses involving 1 : 1 and 3 : 1 ratios
	Supplement
	• Explain codominance by reference to the inheritance of ABO blood groups – phenotypes, A, B, AB and O blood groups and genotypes I^A, I^B, and I^O

3.5 Variation **Core** • State that continuous variation is influenced by genes and environment, resulting in a range of phenotypes between two extremes, e.g. height in humans • State that discontinuous variation is caused by genes alone and results in a limited number of distinct phenotypes with no intermediates e.g. A, B, AB and O blood groups in humans • Define *mutation* as a change in a gene or chromosome • Describe mutation as a source of variation, as shown by Down's syndrome • Outline the effects of ionising radiation and chemicals on the rate of mutation	**Supplement** • Describe sickle cell anaemia, and explain its incidence in relation to that of malaria

3.6 Selection **Core** • Describe the role of artificial selection in the production of varieties of animals and plants with increased economic importance • Define *natural selection* as the greater chance of passing on of genes by the best adapted organisms	**Supplement** • Describe variation and state that competition leads to differential survival of, and reproduction by, those organisms best fitted to the environment • Assess the importance of natural selection as a possible mechanism for evolution ** • Describe the development of strains of antibiotic resistant bacteria as an example of natural selection
3.7 Genetic Engineering **Core** • Define *genetic engineering* as taking a gene from one species and putting it into another species	**Supplement** • Explain why, and outline how, human insulin genes were put into bacteria using genetic engineering
Section IV: Relationships of organisms with one another and with their environment (20% of teaching time)	
1. Energy flow	
Core • State that the Sun is the principal source of energy input to biological systems • Describe the non-cyclical nature of energy flow	

2. Food chains and food webs (emphasis on examples occurring locally)	

Core
• Define the terms:
  • *food chain* as a chart showing the flow of energy (food) from one organism to the next beginning with a producer (e.g. mahogany tree → caterpillar → song bird → hawk)
  • *food web* as a network of interconnected food chains showing the energy flow through part of an ecosystem
  • *producer* as an organism that makes its own organic nutrients, usually using energy from sunlight, through photosynthesis
  • *consumer* as an organism that gets its energy by feeding on other organisms
  • *herbivore* as an animal that gets its energy by eating plants
  • *carnivore* as an animal that gets its energy by eating other animals
  • *decomposer* as an organism that gets its energy from dead or waste organic matter
  • *ecosystem* as a unit containing all of the organisms and their environment, interacting together, in a given area e.g. decomposing log or a lake
  • *trophic level* as the position of an organism in a food chain, food web or pyramid of biomass, numbers or energy
	Supplement
	• Explain why food chains usually have fewer than five trophic levels
	• Explain why there is an increased efficiency in supplying green plants as human food and that there is a relative inefficiency, in terms of energy loss, in feeding crop plants to animals

• Describe energy losses between trophic levels • Draw, describe and interpret pyramids of biomass and numbers	

3. Nutrient cycles	

Core
• Describe the carbon and the water cycles
	Supplement
	• Describe the nitrogen cycle in terms of:
	  • the role of microorganisms in providing usable nitrogen-containing substances by decomposition and by nitrogen fixation in roots
	  • the absorption of these substances by plants and their conversion to protein
	  • followed by passage through food chains, death, decay
	  • nitrification and denitrification and the return of nitrogen to the soil or the atmosphere
	(names of individual bacteria are not required)
	• Discuss the effects of the combustion of fossil fuels and the cutting down of forests on the oxygen and carbon dioxide concentrations in the atmosphere

4. Population size	
Core • Define *population* as a group of organisms of one species, living in the same area at the same time • State the factors affecting the rate of population growth for a population of an organism (limited to food supply, predation and disease), and describe their importance • Identify the lag, exponential (log), stationary and death phases in the sigmoid population growth curve for a population growing in an environment with limited resources • Describe the increase in human population size and its social implications • Interpret graphs and diagrams of human population growth	**Supplement** • Explain the factors that lead to the lag phase, exponential (log) phase and stationary phase in the sigmoid curve of population growth making reference, where appropriate, to the role of limiting factors
5. Human influences on the ecosystem	
Core • Outline the effects of humans on ecosystems, with emphasis on examples of international importance (tropical rain forests, oceans and important rivers)	

5.1 Agriculture **Core** • List the undesirable effects of deforestation (to include extinction, loss of soil, flooding, carbon dioxide build up) • Describe the undesirable effects of overuse of fertilisers (to include eutrophication of lakes and rivers)	

5.2 Pollution
Core
• Describe the undesirable effects of pollution to include:
  • water pollution by sewage and chemical waste
  • air pollution by sulfur dioxide
  • air pollution by greenhouse gases (carbon dioxide and methane) contributing to global warming
  • pollution due to pesticides including insecticides and herbicides
  • pollution due to nuclear fall-out
	Supplement
	• Discuss the effects of non-biodegradable plastics in the environment
	• Discuss the causes and effects on the environment of acid rain, and the measures that might be taken to reduce its incidence
	• Explain how increases in greenhouse gases (carbon dioxide and methane) are thought to contributing to cause global warming

5.3 Conservation
Core
• Describe the need for conservation of:
  • species and their habitats
  • natural resources (limited to water and non-renewable materials including fossil fuels)
	Supplement
	• Explain how limited and non-renewable resources can be recycled (including recycling of paper and treatment of sewage to make the water that it contains safe to return to the environment or for human use)

1. The particulate nature of matter	
Core • Describe the states of matter and explain their interconversion in terms of the kinetic particle theory • Describe and explain diffusion • Describe evidence for the movement of particles in gases and liquids (a treatment of Brownian motion is **not** required)	**Supplement** • Describe dependence of rate of diffusion on molecular mass (treated qualitatively)
2. Experimental techniques	
2.1 Measurement **Core** • Name appropriate apparatus for the measurement of time, temperature, mass and volume, including burettes, pipettes and measuring cylinders	
2.2 (a) Criteria of purity **Core** • Describe paper chromatography • Interpret simple chromatograms • Identify substances and assess their purity from melting point and boiling point information • Understand the importance of purity in substances in everyday life, e.g. foodstuffs and drugs	**Supplement** • Interpret simple chromatograms, including the use of *R*f values • Outline how chromatography techniques can be applied to colourless substances by exposing chromatograms to substances called locating agents (knowledge of *specific* locating agents is **not** required)
2.2 (b) Methods of purification **Core** • Describe methods of purification by the use of a suitable solvent, filtration, crystallisation, distillation (including use of fractionating column). (Refer to the fractional distillation of crude oil in section 14.2 and products of fermentation in section 14.6.) ** • Suggest suitable purification techniques, given information about the substances involved	

3. Atoms, elements and compounds	
** 3.1 Atomic structure and the Periodic Table **Core** ** • State the relative charges and approximate relative masses of protons, neutrons and electrons • Define *proton number* and *nucleon number* • Use proton number and the simple structure of atoms to explain the basis of the Periodic Table (see section 9), with special reference to the elements of proton number 1 to 20 • Define *isotopes* • State the two types of isotopes as being radioactive and non-radioactive • State one medical and one industrial use of radioactive isotopes • Describe the build-up of electrons in 'shells' and understand the significance of the noble gas electronic structures and of valency electrons (the ideas of the distribution of electrons in s and p orbitals and in d block elements are **not** required.) (Note: a copy of the Periodic Table, as shown in the Appendix, will be available in Papers 1, 2 and 3)	
3.2 Bonding: the structure of matter **Core** • Describe the differences between elements, mixtures and compounds, and between metals and non-metals • Describe an alloy, such as brass, as a mixture of a metal with other elements	
3.2 (a) Ions and ionic bonds **Core** • Describe the formation of ions by electron loss or gain • Describe the formation of ionic bonds between elements from Groups I and VII **	**Supplement** • Describe the formation of ionic bonds between metallic and non-metallic elements • Describe the lattice structure of ionic compounds as a regular arrangement of alternating positive and negative ions **

3.2 (b) Molecules and covalent bonds **Core** ** • Describe the formation of single covalent bonds in H_2, Cl_2 , H_2O, CH_4 and HCl as the sharing of pairs of electrons leading to the noble gas configuration • Describe the differences in volatility, solubility and electrical conductivity between ionic and covalent compounds	**Supplement** • Describe the electron arrangement in more complex covalent molecules such as N_2, C_2H_4, CH_3OH and CO_2
3.2 (c) Macromolecules **Core** • Describe the giant covalent structures of graphite and diamond • Relate their structures to the use of graphite as a lubricant and of diamond in cutting	**Supplement** • Describe the macromolecular structure of silicon(IV) oxide (silicon dioxide) • Describe the similarity in properties between diamond and silicon(IV) oxide, related to their structures
3.2 (d) Metallic bonding	**Supplement** • Describe metallic bonding as a lattice of positive ions in a 'sea of electrons' and use this to describe the electrical conductivity and malleability of metals
4. Stoichiometry	
Core • Use the symbols of the elements and write the formulae of simple compounds • Deduce the formula of a simple compound from the relative numbers of atoms present • Deduce the formula of a simple compound from a model or a diagrammatic representation • Construct word equations and simple balanced chemical equations • Define *relative atomic mass*, A_r • Define *relative molecular mass*, M_r , as the sum of the relative atomic masses (*relative formula mass* or *M*r will be used for ionic compounds) (Calculations involving reacting masses in simple proportions may be set. Calculations will **not** involve the mole concept.)	**Supplement** • Determine the formula of an ionic compound from the charges on the ions present • Construct equations with state symbols, including ionic equations ** • Deduce the balanced equation for a chemical reaction, given relevant information

4.1 The mole concept	**Supplement** • Define the *mole* and the *Avogadro constant* ** • Use the molar gas volume, taken as 24 dm3 at room temperature and pressure • Calculate stoichiometric reacting masses and volumes of gases and solutions, solution concentrations expressed in g/dm^3 and mol/dm^3 . (Calculations involving the idea of limiting reactants may be set. Questions on the gas laws and the conversion of gaseous volumes to different temperatures and pressures will **not** be set.) • Calculate empirical formulae and molecular formulae • Calculate % yield and % purity
5. Electricity and chemistry	
Core ** • Describe the electrode products in the electrolysis of: – molten lead(II) bromide ** – concentrated hydrochloric acid – concentrated aqueous sodium chloride between inert electrodes (platinum or carbon) • State the general principle that metals or hydrogen are formed at the negative electrode (cathode), and that non-metals (other than hydrogen) are formed at the positive electrode (anode) • Predict the products of the electrolysis of a specified binary compound in the molten state • Describe the electroplating of metals ** • Name the uses of electroplating • Describe the reasons for the use of copper and (steel-cored) aluminium in cables, and why plastics and ceramics are used as insulators	**Supplement** • Relate the products of electrolysis to the electrolyte and electrodes used, exemplified by the specific examples in the Core together with aqueous copper(II) sulfate using carbon electrodes and using copper electrodes (as used in the refining of copper) • Describe electrolysis in terms of the ions present and reactions at the electrodes in the examples given • Predict the products of electrolysis of a specified halide in dilute or concentrated aqueous solution ** • Describe, in outline, the manufacture of – aluminium from pure aluminium oxide in molten cryolite – chlorine and sodium hydroxide from concentrated aqueous sodium chloride (Starting materials and essential conditions should be given but not technical details or diagrams.)

6. Chemical energetics	
6.1 Energetics of a reaction **Core** • Describe the meaning of *exothermic* and *endothermic* reactions **	**Supplement** • Describe bond breaking as endothermic and bond forming as exothermic **
6.2 Production of energy **Core** • Describe the production of heat energy by burning fuels • Describe hydrogen as a fuel • Describe radioactive isotopes, such as ^{235}U, as a source of energy	**Supplement** • Describe the production of electrical energy from simple cells, i.e. two electrodes in an electrolyte. (This should be linked with the reactivity series in section 10.2 and redox in section 7.3.) • Describe the use of hydrogen as a potential fuel reacting with oxygen to generate electricity in a fuel cell (details of the construction and operation of a fuel cell are **not** required)
7. Chemical reactions	
7.1 Speed of reaction **Core** • Describe the effect of concentration, particle size, catalysts (including enzymes) and temperature on the speeds of reactions • Describe a practical method for investigating the speed of a reaction involving gas evolution • Describe the application of the above factors to the danger of explosive combustion with fine powders (e.g. flour mills) and gases (e.g. mines) **	**Supplement** • Devise a suitable method for investigating the effect of a given variable on the speed of a reaction • Interpret data obtained from experiments concerned with speed of reaction • Describe and explain the effects of temperature and concentration in terms of collisions between reacting particles • Describe the role of light in photochemical reactions and the effect of light on the speed of these reactions • Describe the use of silver salts in photography as a process of reduction of silver ions to silver; and photosynthesis as the reaction between carbon dioxide and water in the presence of chlorophyll and sunlight (energy) to produce glucose and oxygen
7.2 Reversible reactions **Core** • Describe the idea that some chemical reactions can be reversed by changing the reaction conditions (Limited to the effects of heat on hydrated salts. Concept of equilibrium is **not** required.)	**Supplement** • Predict the effect of changing the conditions (concentration, temperature and pressure) on other reversible reactions • Concept of equilibrium

7.3 Redox **Core** • Define *oxidation* and *reduction* in terms of oxygen loss/gain. (Oxidation state limited to its use to name ions, e.g. iron(II), iron(III), copper(II), manganate(VII), dichromate(VI).) **	**Supplement** • Define *redox* in terms of electron transfer ** • Identify redox reactions by changes in oxidation state and by the colour changes involved when using acidified potassium manganate(VII), and potassium iodide. (Recall of equations involving $KMnO_4$ is **not** required.)
8. Acids, bases and salts	
8.1 The characteristic properties of acids and bases **Core** • Describe the characteristic properties of acids as reactions with metals, bases, carbonates and effect on litmus • Describe the characteristic properties of bases as reactions with acids and with ammonium salts and effect on litmus ** • Describe neutrality and relative acidity and alkalinity in terms of pH (whole numbers only) measured using Universal Indicator paper ** • Describe and explain the importance of controlling acidity in soil	**Supplement** • Define *acids* and *bases* in terms of proton transfer, limited to aqueous solutions • Describe the meaning of weak and strong acids and bases
8.2 Types of oxides **Core** • Classify oxides as either acidic or basic, related to metallic and non-metallic character **	**Supplement** • Further classify other oxides as neutral or amphoteric **
8.3 Preparation of salts **Core** • Describe the preparation, separation and purification of salts as examples of some of the techniques specified in section 2.2(b) and the reactions specified in section 8.1	**Supplement** • Describe the preparation of insoluble salts by precipitation • Suggest a method of making a given salt from suitable starting material, given appropriate information

Core • Describe the following tests to identify: *aqueous cations:* aluminium, ammonium, calcium, copper(II), iron(II), iron(III) and zinc (using aqueous sodium hydroxide and aqueous ammonia as appropriate) (Formulae of complex ions are **not** required.) *anions:* carbonate (by reaction with dilute acid and then limewater), chloride (by reaction under acidic conditions with aqueous silver nitrate), iodide (by reaction under acidic conditions with aqueous silver nitrate), nitrate (by reduction with aluminium), sulfate (by reaction under acidic conditions with aqueous barium ions) *gases:* ammonia (using damp red litmus paper), carbon dioxide (using limewater), chlorine (using damp litmus paper), hydrogen (using lighted splint), oxygen (using a glowing splint).	
9. The Periodic Table	
Core • Describe the Periodic Table as a method of classifying elements and its use to predict properties of elements **	
9.1 Periodic trends **Core** • Describe the change from metallic to non-metallic character across a period	**Supplement** • Describe the relationship between Group number, number of valency electrons and metallic/non-metallic character

9.2 Group properties **Core** • Describe lithium, sodium and potassium in Group I as a collection of relatively soft metals showing a trend in melting point, density and reaction with water • Predict the properties of other elements in Group I, given data, where appropriate • Describe chlorine, bromine and iodine in Group VII as a collection of diatomic non-metals showing a trend in colour, and state their reaction with other halide ions ** • Predict the properties of other elements in Group VII, given data where appropriate	**Supplement** • Identify trends in other Groups, given information about the elements concerned
9.3 Transition elements **Core** • Describe the transition elements as a collection of metals having high densities, high melting points and forming coloured compounds, and which, as elements and compounds, often act as catalysts	
9.4 Noble gases **Core** • Describe the noble gases as being unreactive • Describe the uses of the noble gases in providing an inert atmosphere, i.e. argon in lamps, helium for filling balloons	
10. Metals	
10.1 Properties of metals **Core** ** • Describe the general physical and chemical properties of metals • Explain why metals are often used in the form of alloys • Identify representations of alloys from diagrams of structure	

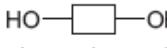
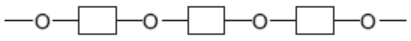
10.2 Reactivity series **Core** • Place in order of reactivity: potassium, sodium, calcium, magnesium, zinc, iron, (hydrogen) and copper, by reference to the reactions, if any, of the metals with – water or steam – dilute hydrochloric acid and the reduction of their oxides with carbon • Deduce an order of reactivity from a given set of experimental results	**Supplement** • Describe the reactivity series as related to the tendency of a metal to form its positive ion, illustrated by its reaction, if any, with – the aqueous ions – the oxides of the other listed metals • Describe the action of heat on the hydroxides and nitrates of the listed metals • Account for the apparent unreactivity of aluminium in terms of the oxide layer which adheres to the metal
10.3 (a) Extraction of metals **Core** ** • Describe the ease in obtaining metals from their ores by relating the elements to the reactivity series • Describe the essential reactions in the extraction of iron from hematite • Describe the conversion of iron into steel using basic oxides and oxygen	**Supplement** • Describe in outline, the extraction of zinc from zinc blende • Name the main ore of aluminium as bauxite (see section 5)
10.3 (b) Uses of metals **Core** • Name the uses of aluminium: – in the manufacture of aircraft because of its strength and low density – in food containers because of its resistance to corrosion • Describe the idea of changing the properties of iron by the controlled use of additives to form steel alloys • Name the uses of mild steel (car bodies and machinery) and stainless steel (chemical plant and cutlery)	**Supplement** • Name the uses of zinc for galvanising and for making brass ** • Name the uses of copper related to its properties (electrical wiring and in cooking utensils)

11. Air and water	
Core • Describe a chemical test for water • Describe, in outline, the treatment of the water supply in terms of filtration and chlorination • Name some of the uses of water in industry and in the home • Describe the composition of clean air as being approximately 79% nitrogen, 20% oxygen and the remainder as being a mixture of noble gases, water vapour and carbon dioxide • Name the common pollutants in the air as being carbon monoxide, sulfur dioxide, oxides of nitrogen and lead compounds • State the source of each of these pollutants: – carbon monoxide from the incomplete combustion of carbon-containing substances – sulfur dioxide from the combustion of fossil fuels which contain sulfur compounds (leading to 'acid rain' – see section 13) – oxides of nitrogen from car exhausts • State the adverse effect of common pollutants on buildings and on health	**Supplement** • Describe the separation of oxygen and nitrogen from liquid air by fractional distillation • Describe and explain the presence of oxides of nitrogen in car exhausts and their catalytic removal
• Describe methods of rust prevention, specifically paint and other coatings to exclude oxygen ** • Describe the need for nitrogen-, phosphorus- and potassium-containing fertilisers • Describe the displacement of ammonia from its salts ** • State that carbon dioxide and methane are greenhouse gases and may contribute to climate change ** • Describe the formation of carbon dioxide: – as a product of complete combustion of carbon-containing substances – as a product of respiration – as a product of the reaction between an acid and a carbonate • State the sources of methane, including decomposition of vegetation and waste gases from digestion in animals	• Describe sacrificial protection in terms of the reactivity series of metals and galvanising as a method of rust prevention • Describe the essential conditions for the manufacture of ammonia by the Haber process including the sources of the hydrogen and nitrogen, i.e. hydrocarbons or steam and air • Describe the carbon cycle, in simple terms, to include the processes of combustion, respiration and photosynthesis **

12. Sulfur	
	Supplement • Name some sources of sulfur • Name the use of sulfur in the manufacture of sulfuric acid • Name the uses of sulfur dioxide as a bleach in the manufacture of wood pulp for paper and as a food preservative (by killing bacteria) • Describe the manufacture of sulfuric acid by the Contact process, including essential conditions • Describe the properties of dilute sulfuric acid as a typical acid
13. Carbonates	
Core • Describe the manufacture of lime (calcium oxide) from calcium carbonate (limestone) in terms of the chemical reactions involved • Name some uses of lime and slaked lime as in treating acidic soil and neutralising acidic industrial waste products, e.g. flue gas desulfurisation • Name the uses of calcium carbonate in the manufacture of iron and of cement	
14. Organic chemistry	
14.1 Names of compounds **Core** • Name and draw the structures of methane, ethane, ethene, ethanol, ethanoic acid and the products of the reactions stated in sections 14.4–14.6 • State the type of compound present, given a chemical name ending in *-ane*, *-ene*, *-ol*, or *-oic acid*, or a molecular structure	**Supplement** ** • Name and draw the structures of the unbranched alkanes, alkenes (not *cis-trans*), alcohols and acids containing up to four carbon atoms per molecule

14.2 Fuels **Core** ** • Name the fuels coal, natural gas and petroleum • Name methane as the main constituent of natural gas • Describe petroleum as a mixture of hydrocarbons and its separation into useful fractions by fractional distillation • Name the uses of the fractions as: – refinery gas for bottled gas for heating and cooking – gasoline fraction for fuel (petrol) in cars – naphtha fraction for making chemicals – kerosene/paraffin fraction for jet fuel – diesel oil/gas oil for fuel in diesel engines – fuel oil fraction for fuel for ships and home heating systems – lubricating fraction for lubricants, waxes and polishes – bitumen for making roads	**
14.3 Homologous series **Core** • Describe the concept of homologous series as a 'family' of similar compounds with similar properties due to the presence of the same functional group	**Supplement** • Describe the general characteristics of an homologous series • Describe and identify structural isomerism
14.4 Alkanes **Core** • Describe the properties of alkanes (exemplified by methane) as being generally unreactive, except in terms of burning ** • Describe the bonding in alkanes	**Supplement** • Describe substitution reactions of alkanes with chlorine

14.5 Alkenes **Core** • Describe the manufacture of alkenes and of hydrogen by cracking ** • Distinguish between saturated and unsaturated hydrocarbons – from molecular structures – by reaction with aqueous bromine • Describe the formation of poly(ethene) as an example of addition polymerisation of monomer units	**Supplement** • Describe the properties of alkenes in terms of addition reactions with bromine, hydrogen and steam
14.6 Alcohols **Core** ** • Describe the formation of ethanol by fermentation and by the catalytic addition of steam to ethene • Describe the properties of ethanol in terms of burning • Name the uses of ethanol as a solvent and as a fuel	
14.7 Acids	**Supplement** • Describe the formation of ethanoic acid by the oxidation of ethanol by fermentation and with acidified potassium manganate(VII) • Describe ethanoic acid as a typical weak acid • Describe the reaction of ethanoic acid with ethanol to give an ester (ethyl ethanoate)
14.8 Macromolecules	**Supplement** • Describe macromolecules in terms of large molecules built up from small units (monomers), different macromolecules having different units and/or different linkages

14.8 (a) Synthetic polymers	**Supplement** • Name some typical uses of plastics and of man-made fibres • Describe the pollution problems caused by non-biodegradable plastics • Deduce the structure of the polymer product from a given alkene and vice versa • Describe the formation of nylon (a polyamide) and *Terylene* (a polyester) by condensation polymerisation, the structure of nylon being represented as: (Details of structure as shown in syllabus) (Details of manufacture and mechanisms of these polymerisations are **not** required.)
14.8 (b) Natural macromolecules	**Supplement** • Name proteins, fats and carbohydrates as the main constituents of food • Describe proteins as possessing the same (amide) linkages as nylon but with different units • Describe the structure of proteins as: (Structure defined as in syllabus) • Describe the hydrolysis of proteins to amino acids (Structures and names are **not** required.) ** • Describe fats as esters possessing the same linkage as *Terylene* but with different units • Describe soap as a product of hydrolysis of fats • Describe complex carbohydrates in terms of a large number of sugar units, considered as  , joined together by condensation polymerisation, e.g.  • Describe the acid hydrolysis of complex carbohydrates (e.g. starch) to give simple sugars • Describe the fermentation of simple sugars to produce ethanol (and carbon dioxide) (Candidates will **not** be expected to give the molecular formulae of sugars.) • Describe, in outline, the usefulness of chromatography in separating and identifying the products of hydrolysis of carbohydrates and proteins

1. General physics	
1.1 Length and time **Core** • Use and describe the use of rules and measuring cylinders to calculate a length or a volume • Use and describe the use of clocks and devices for measuring an interval of time	**Supplement** • Use and describe the use of a mechanical method for the measurement of a small distance (including use of a micrometer screw gauge) • Measure and describe how to measure a short interval of time (including the period of a pendulum)
1.2 Speed, velocity and acceleration **Core** • Define speed and calculate speed from total distance / total time • Plot and interpret a speed/time graph or a distance/ time graph • Recognise from the shape of a speed/time graph when a body is – at rest – moving with constant speed – moving with changing speed • Calculate the area under a speed/time graph to work out the distance travelled for motion with constant acceleration • Demonstrate some understanding that acceleration is related to changing speed	**Supplement** • Distinguish between speed and velocity • Recognise linear motion for which the acceleration is constant and calculate the acceleration • Recognise motion for which the acceleration is not constant
• State that the acceleration of free fall for a body near to the Earth is constant	• Describe qualitatively the motion of bodies falling in a uniform gravitational field with and without air resistance (including reference to terminal velocity)
1.3 Mass and weight **Core** • Show familiarity with the idea of the mass of a body • State that weight is a force ** • Demonstrate understanding that weights (and hence masses) may be compared using a balance	**Supplement** • Demonstrate an understanding that mass is a property that 'resists' change in motion • Describe, and use the concept of, weight as the effect of a gravitational field on a mass
1.4 Density **Core** • Describe an experiment to determine the density of a liquid and of a regularly shaped solid and make the necessary calculation **	**Supplement** • Describe the determination of the density of an irregularly shaped solid by the method of displacement, and make the necessary calculation

1.5 Forces	
1.5 (a) Effects of forces **Core** ** • State that a force may produce a change in size and shape of a body • Plot extension/load graphs and describe the associated experimental procedure • Describe the ways in which a force may change the motion of a body • Find the resultant of two or more forces acting along the same line	**Supplement** • Interpret extension/load graphs • State Hooke's Law and recall and use the expression $F = kx$ • Recognise the significance of the term 'limit of proportionality' for an extension/load graph • Recall and use the relation between force, mass and acceleration (including the direction) • Describe qualitatively motion in a curved path due to a perpendicular force ($F = mv^2/r$ is *not* required)
1.5 (b) Turning effect **Core** • Describe the moment of a force as a measure of its turning effect and give everyday examples • Describe qualitatively the balancing of a beam about a pivot	**Supplement** • Perform and describe an experiment (involving vertical forces) to show that there is no net moment on a body in equilibrium • Apply the idea of opposing moments to simple systems in equilibrium
1.5 (c) Conditions for equilibrium **Core** • State that, when there is no resultant force and no resultant turning effect, a system is in equilibrium **	
1.5 (d) Centre of mass **Core** • Perform and describe an experiment to determine the position of the centre of mass of a plane lamina • Describe qualitatively the effect of the position of the centre of mass on the stability of simple objects	
1.5 (e) Scalars and vectors	**Supplement** • Demonstrate an understanding of the difference between scalars and vectors and give common examples • Add vectors by graphical representation to determine a resultant • Determine graphically the resultant of two vectors

1.6 Energy, work and power	
1.6 (a) Energy **Core** ** • Demonstrate an understanding that an object may have energy due to its motion or its position, and that energy may be transferred and stored • Give examples of energy in different forms, including kinetic, gravitational, chemical, strain, nuclear, internal, electrical, light and sound • Give examples of the conversion of energy from one form to another, and of its transfer from one place to another ** • Apply the principle of energy conservation to simple examples	**Supplement** • Recall and use the expressions k.e. = ½ mv^2 and p.e. = mgh
1.6 (b) Energy resources **Core** • Distinguish between renewable and non-renewable sources of energy ** • Describe how electricity or other useful forms of energy may be obtained from: – chemical energy stored in fuel – water, including the energy stored in waves, in tides, and in water behind hydroelectric dams – geothermal resources – nuclear fission – heat and light from the Sun (solar cells and panels) • Give advantages and disadvantages of each method in terms of cost, reliability, scale and environmental impact • Show a qualitative understanding of efficiency	**Supplement** • Show an understanding that energy is released by nuclear fusion in the Sun • Recall and use the equation: $\text{efficiency} = \frac{\text{useful energy output}}{\text{energy input}} \times 100\%$
1.6 (c) Work **Core** • Relate (without calculation) work done to the magnitude of a force and the distance moved	**Supplement** • Describe energy changes in terms of work done • Recall and use $\Delta W = Fd = \Delta E$
1.6 (d) Power **Core** • Relate (without calculation) power to work done and time taken, using appropriate examples	**Supplement** • Recall and use the equation $P = E/t$ in simple systems

1.7 Pressure **Core** • Relate (without calculation) pressure to force and area, using appropriate examples • Describe the simple mercury barometer and its use in measuring atmospheric pressure • Relate (without calculation) the pressure beneath a liquid surface to depth and to density, using appropriate examples • Use and describe the use of a manometer	• Recall and use the equation $p = F/A$ • Recall and use the equation $p = h\rho g$
2. Thermal physics	
2.1 Simple kinetic molecular model of matter	
2.1 (a) States of matter **Core** • State the distinguishing properties of solids, liquids and gases	
2.1 (b) Molecular model **Core** • Describe qualitatively the molecular structure of solids, liquids and gases • Interpret the temperature of a gas in terms of the motion of its molecules • Describe qualitatively the pressure of a gas in terms of the motion of its molecules • Describe qualitatively the effect of a change of temperature on the pressure of a gas at constant volume • Show an understanding of the random motion of particles in a suspension as evidence for the kinetic molecular model of matter • Describe this motion (sometimes known as Brownian motion) in terms of random molecular bombardment	**Supplement** • Relate the properties of solids, liquids and gases to the forces and distances between molecules and to the motion of the molecules • Show an appreciation that massive particles may be moved by light, fast-moving molecules
2.1 (c) Evaporation **Core** • Describe evaporation in terms of the escape of more-energetic molecules from the surface of a liquid • Relate evaporation to the consequent cooling	**Supplement** • Demonstrate an understanding of how temperature, surface area and draught over a surface influence evaporation
2.1 (d) Pressure changes **Core** • Relate the change in volume of a gas to change in pressure applied to the gas at constant temperature	**Supplement** • Recall and use the equation pV = constant at constant temperature

2.2 Thermal properties	
2.2 (a) Thermal expansion of solids, liquids and gases **Core** • Describe qualitatively the thermal expansion of solids, liquids and gases • Identify and explain some of the everyday applications and consequences of thermal expansion • Describe qualitatively the effect of a change of temperature on the volume of a gas at constant pressure	**Supplement** • Show an appreciation of the relative order of magnitude of the expansion of solids, liquids and gases
2.2 (b) Measurement of temperature **Core** • Appreciate how a physical property that varies with temperature may be used for the measurement of temperature, and state examples of such properties • Recognise the need for and identify fixed points • Describe the structure and action of liquid-in-glass thermometers	**Supplement** • Demonstrate understanding of sensitivity, range and linearity • Describe the structure of a thermocouple and show understanding of its use for measuring high temperatures and those that vary rapidly
2.2 (c) Thermal capacity **Core** • Relate a rise in the temperature of a body to an increase in internal energy • Show an understanding of the term thermal capacity	**Supplement** • Describe an experiment to measure the specific heat capacity of a substance **
2.2 (d) Melting and boiling **Core** • Describe melting and boiling in terms of energy input without a change in temperature • State the meaning of melting point and boiling point • Describe condensation and solidification	**Supplement** • Distinguish between boiling and evaporation • Use the terms latent heat of vaporisation and latent heat of fusion and give a molecular interpretation of latent heat • Describe an experiment to measure specific latent heats for steam and for ice
2.3 Transfer of thermal energy	
2.3 (a) Conduction **Core** • Describe experiments to demonstrate the properties of good and bad conductors of heat	**Supplement** • Give a simple molecular account of heat transfer in solids
2.3 (b) Convection **Core** ** • Relate convection in fluids to density changes and describe experiments to illustrate convection	

2.3 (c) Radiation **Core** • Identify infra-red radiation as part of the electromagnetic spectrum **	**Supplement** • Describe experiments to show the properties of good and bad emitters and good and bad absorbers of infra-red radiation
2.3 (d) Consequences of energy transfer **Core** • Identify and explain some of the everyday applications and consequences of conduction, convection and radiation	
3. Properties of waves	
3.1 General wave properties **Core** ** • Describe what is meant by wave motion as illustrated by vibration in ropes and springs and by experiments using water waves • Use the term wavefront • Give the meaning of speed, frequency, wavelength and amplitude • Distinguish between transverse and longitudinal waves and give suitable examples ** • Describe the use of water waves to show: – reflection at a plane surface – refraction due to a change of speed – diffraction produced by wide and narrow gaps	**Supplement** • Recall and use the equation $v = f\lambda$ • Interpret reflection, refraction and diffraction using wave theory
3.2 Light	
3.2 (a) Reflection of light **Core** • Describe the formation of an optical image by a plane mirror, and give its characteristics • Use the law angle of incidence = angle of reflection	**Supplement** • Perform simple constructions, measurements and calculations **
3.2 (b) Refraction of light **Core** • Describe an experimental demonstration of the refraction of light • Use the terminology for the angle of incidence *i* and angle of refraction *r* and describe the passage of light through parallel-sided transparent material ** • Give the meaning of critical angle • Describe internal and total internal reflection	**Supplement** • Recall and use the definition of refractive index *n* in terms of speed • Recall and use the equation sin *i* /sin *r* = *n* • Describe the action of optical fibres particularly in medicine and communications technology

3.2 (c) Thin converging lens **Core** • Describe the action of a thin converging lens on a beam of light • Use the term principal focus and focal length • Draw ray diagrams to illustrate the formation of a real image by a single lens	**Supplement** • Draw ray diagrams to illustrate the formation of a virtual image by a single lens ** • Use and describe the use of a single lens as a magnifying glass
3.2 (d) Dispersion of light **Core** • Give a qualitative account of the dispersion of light as shown by the action on light of a glass prism	
3.2 (e) Electromagnetic spectrum **Core** • Describe the main features of the electromagnetic spectrum and state that all e.m. waves travel with the same high speed *in vacuo* • Describe the role of electromagnetic waves in: – radio and television communications (radio waves) – satellite television and telephones (microwaves) – electrical appliances, remote controllers for televisions and intruder alarms (infrared) – medicine and security (X-rays) • Demonstrate an awareness of safety issues regarding the use of microwaves and X-rays	**Supplement** • State the approximate value of the speed of electromagnetic waves ** • Use the term monochromatic
3.3 Sound **Core** • Describe the production of sound by vibrating sources • Describe the longitudinal nature of sound waves • State the approximate range of audible frequencies • Show an understanding that a medium is needed to transmit sound waves • Describe an experiment to determine the speed of sound in air • Relate the loudness and pitch of sound waves to amplitude and frequency • Describe how the reflection of sound may produce an echo	**Supplement** • Describe compression and rarefaction ** • State the order of magnitude of the speed of sound in air, liquids and solids

4. Electricity and magnetism	
4.1 Simple phenomena of magnetism **Core** • State the properties of magnets • Give an account of induced magnetism • Distinguish between ferrous and non-ferrous materials • Describe methods of magnetisation and of demagnetisation • Describe an experiment to identify the pattern of field lines round a bar magnet ** • Distinguish between the magnetic properties of iron and steel • Distinguish between the design and use of permanent magnets and electromagnets	
4.2 Electrical quantities	
4.2 (a) Electric charge **Core** • Describe simple experiments to show the production and detection of electrostatic charges • State that there are positive and negative charges • State that unlike charges attract and that like charges repel • Describe an electric field as a region in which an electric charge experiences a force • Distinguish between electrical conductors and insulators and give typical examples	**Supplement** • State that charge is measured in coulombs ** • State the direction of lines of force and describe simple field patterns, including the field around a point charge and the field between two parallel plates • Give an account of charging by induction • Recall and use the simple electron model to distinguish between conductors and insulators
4.2 (b) Current **Core** • State that current is related to the flow of charge • Use and describe the use of an ammeter	**Supplement** • Show understanding that a current is a rate of flow of charge and recall and use the equation $I = Q/t$ • Distinguish between the direction of flow of electrons and conventional current
4.2 (c) Electro-motive force **Core** • State that the e.m.f. of a source of electrical energy is measured in volts	**Supplement** • Show understanding that e.m.f. is defined in terms of energy supplied by a source in driving charge round a complete circuit

4.2 (d) Potential difference **Core** • State that the potential difference across a circuit component is measured in volts • Use and describe the use of a voltmeter	
4.2 (e) Resistance **Core** • State that resistance = p.d./current and understand qualitatively how changes in p.d. or resistance affect current • Recall and use the equation $R = V/I$ • Describe an experiment to determine resistance using a voltmeter and an ammeter • Relate (without calculation) the resistance of a wire to its length and to its diameter	**Supplement** • Recall and use quantitatively the proportionality between resistance and length, and the inverse proportionality between resistance and cross-sectional area of a wire
4.2 (f) Electrical energy	**Supplement** • Recall and use the equations $P = IV$ and $E = IVt$
4.3 Electric circuits	
4.3 (a) Circuit diagrams **Core** • Draw and interpret circuit diagrams containing sources, switches, resistors (fixed and variable), lamps, ammeters voltmeters, magnetising coils, transformers, bells, fuses and relays	**Supplement** • Draw and interpret circuit diagrams containing diodes and transistors
4.3 (b) Series and parallel circuits **Core** • Understand that the current at every point in a series circuit is the same • Give the combined resistance of two or more resistors in series • State that, for a parallel circuit, the current from the source is larger than the current in each branch • State that the combined resistance of two resistors in parallel is less than that of either resistor by itself • State the advantages of connecting lamps in parallel in a lighting circuit	**Supplement** • Recall and use the fact that the sum of the p.d.s across the components in a series circuit is equal to the total p.d. across the supply • Recall and use the fact that the current from the source is the sum of the currents in the separate branches of a parallel circuit • Calculate the effective resistance of two resistors in parallel

4.3 (c) Action and use of circuit components	
Core • Describe the action of a variable potential divider (potentiometer) • Describe the action of thermistors and light-dependent resistors and show understanding of their use as input transducers • Describe the action of a capacitor as an energy store and show understanding of its use in time-delay circuits • Describe the action of a relay and show understanding of its use in switching circuits	**Supplement** • Describe the action of a diode and show understanding of its use as a rectifier • Describe the action of a transistor as an electrically operated switch and show understanding of its use in switching circuits • Recognise and show understanding of circuits operating as light sensitive switches and temperature-operated alarms (using a relay or a transistor)
4.3 (d) Digital electronics	
	Supplement • Explain and use the terms digital and analogue • State that logic gates are circuits containing transistors and other components • Describe the action of NOT, AND, OR, NAND and NOR gates • Design and understand simple digital circuits combining several logic gates • State and use the symbols for logic gates (candidates should use the American ANSI#Y32.14 symbols)
4.4 Dangers of electricity **Core** • state the hazards of – damaged insulation – overheating of cables – damp conditions • Show an understanding of the use of fuses and circuit-breakers	
4.5 Electromagnetic effects	
4.5 (a) Electromagnetic induction **Core** • Describe an experiment that shows that a changing magnetic field can induce an e.m.f. in a circuit	**Supplement** • State the factors affecting the magnitude of an induced e.m.f. • Show understanding that the direction of an induced e.m.f. opposes the change causing it

4.5 (b) a.c. generator **Core** • Describe a rotating-coil generator and the use of slip rings • Sketch a graph of voltage output against time for a simple a.c. generator	
4.5 (c) Transformer **Core** • Describe the construction of a basic iron-cored transformer as used for voltage transformations • Recall and use the equation $(V_p/V_s) = (N_p/N_s)$ • Describe the use of the transformer in high-voltage transmission of electricity • Give the advantages of high-voltage transmission	**Supplement** • Describe the principle of operation of a transformer • Recall and use the equation $V_pI_p = V_sI_s$ (for 100% efficiency) • Explain why energy losses in cables are lower when the voltage is high
4.5 (d) The magnetic effect of a current **Core** • Describe the pattern of the magnetic field due to currents in straight wires and in solenoids • Describe applications of the magnetic effect of current, including the action of a relay	**Supplement** • State the qualitative variation of the strength of the magnetic field over salient parts of the pattern • Describe the effect on the magnetic field of changing the magnitude and direction of the current
4.5 (e) Force on a current-carrying conductor **Core** • Describe an experiment to show that a force acts on a current-carrying conductor in a magnetic field, including the effect of reversing: (i) the current (ii) the direction of the field	**Supplement** • Describe an experiment to show the corresponding force on beams of charged particles • State and use the relative directions of force, field and current
4.5 (f) d.c. motor **Core** • State that a current-carrying coil in a magnetic field experiences a turning effect and that the effect is increased by increasing the number of turns on the coil ** • Relate this turning effect to the action of an electric motor	**Supplement** • Describe the effect of increasing the current
4.6 Cathode-ray oscilloscopes	
4.6 (a) Cathode rays **Core** • Describe the production and detection of cathode rays • Describe their deflection in electric fields • State that the particles emitted in thermionic emission are electrons	

4.6 (b) Simple treatment of cathode-ray oscilloscope	**Supplement** • Describe (in outline) the basic structure and action of a cathode-ray oscilloscope (detailed circuits are **not** required) • Use and describe the use of a cathode-ray oscilloscope to display waveforms
5. Atomic physics	
5.1 Radioactivity	
5.1 (a) Detection of radioactivity **Core** • Show awareness of the existence of background radiation • Describe the detection of α-particles, β-particles and γ-rays (β^+ are not included: β-particles will be taken to refer to β^-)	
5.1 (b) Characteristics of the three kinds of emission **Core** • State that radioactive emissions occur randomly over space and time	
• State, for radioactive emissions: – their nature – their relative ionising effects – their relative penetrating abilities	• Describe their deflection in electric fields and magnetic fields ** • Interpret their relative ionising effects
5.1 (c) Radioactive decay **Core** • State the meaning of radioactive decay, using equations (involving words or symbols) to represent changes in the composition of the nucleus when particles are emitted	
5.1 (d) Half-life **Core** • Use the term half-life in simple calculations, which might involve information in tables or decay curves	
5.1 (e) Safety precautions **Core** ** • Describe how radioactive materials are handled, used and stored in a safe way	
5.2 The nuclear atom	
5.2 (a) Atomic model **Core** • Describe the structure of an atom in terms of a nucleus and electrons	**Supplement** • Describe how the scattering of α-particles by thin metal foils provides evidence for the nuclear atom

5.2 (b) Nucleus **Core** • Describe the composition of the nucleus in terms of protons and neutrons • Use the term proton number *Z* • Use the term nucleon number *A* Use the term nuclide and use the nuclide notation ${}^{A}_{Z}X$	
5.2 (c) Isotopes	**Supplement** • Use the term isotope • Give and explain examples of practical applications of isotopes