IGCSE Co-ordinated Sciences

Syllabus Checklist · 大纲自查表

Tick one box per statement: ☐ not yet ☐ nearly ☐ confident. 每条打一个勾：尚未掌握 / 快会了 / 有把握。 **[S]** = Supplement 拓展内容。

B1. Characteristics of living organisms 生物的特征

B1.1 Characteristics of living organisms 生物的特征

☐☐☐ Describe the characteristics of living organisms by defining: (a) movement as an action by an organism or part of an organism causing a change of position or place (b) respiration as the chemical reactions in cells that break down nutrient molecules and release energy for metabolism (c) sensitivity as the ability to detect and respond to changes in the internal or external environment (d) growth as a permanent increase in size and dry mass (e) reproduction as the processes that make more of the same kind of organism (f) excretion as the removal of waste products of metabolism and substances in excess of requirements (g) nutrition as the taking in of materials for energy, growth and development

B2. Cells 细胞

B2.1 Cell structure 细胞结构

☐☐☐ Describe and compare the structure of a plant cell with an animal cell, limited to: cell wall, cell membrane, nucleus, cytoplasm, chloroplasts, ribosomes, mitochondria, vacuoles

☐☐☐ Describe the structure of a bacterial cell, limited to: cell wall, cell membrane, cytoplasm, ribosomes, circular DNA, plasmids

☐☐☐ Identify the cell structures listed in 2.1.1 and 2.1.2 in diagrams and images of plant, animal and bacterial cells

☐☐☐ Describe the functions of the structures listed in 2.1.1 and 2.1.2 in plant, animal and bacterial cells

☐☐☐ State that new cells are produced by division of existing cells

☐☐☐ State that specialised cells have specific functions, limited to: (a) ciliated cells – movement of mucus in the trachea and bronchi (b) root hair cells – absorption (c) palisade mesophyll cells – photosynthesis (d) neurones – conduction of electrical impulses (e) red blood cells – transport of oxygen (f) sperm and egg cells (gametes) – reproduction

☐☐☐ Describe the meaning of the terms: cell, tissue, organ, organ system and organism as illustrated by examples given in the syllabus

B2.2 Size of specimens 标本的大小

☐☐☐ State and use the formula: magnification $= \frac{\text{image size}}{\text{actual size}}$

☐☐☐ Calculate magnification and size of biological specimens using millimetres as units

☐☐☐ **[S]** Convert measurements between millimetres (mm) and micrometres (µm)

B3. Movement into and out of cells 物质进出细胞

B3.1 Diffusion 扩散

☐☐☐ Describe diffusion as the net movement of particles from a region of their higher concentration to a region of their lower concentration (i.e. down a concentration gradient), as a result of their random movement

☐☐☐ State that some substances move into and out of cells by diffusion through the cell membrane

☐☐☐ Describe the importance of diffusion of gases and solutes in living organisms

☐☐☐ **[S]** Investigate the factors that influence diffusion, limited to: surface area, temperature, concentration gradient and distance

B3.2 Osmosis 渗透

☐☐☐ State that water diffuses through partially permeable membranes by osmosis

☐☐☐ **[S]** Describe osmosis as the net movement of water molecules from a region of higher water potential (dilute solution) to a region of lower water potential (concentrated solution), through a partially permeable membrane

☐☐☐ State that water moves into and out of cells by osmosis through the cell membrane

☐☐☐ Investigate and describe the effects on plant tissues of immersing them in solutions of different concentrations

☐☐☐ **[S]** Explain the effects on plant cells of immersing them in solutions of different concentrations by using the terms: turgid, turgor pressure, plasmolysis, flaccid

☐☐☐ **[S]** Explain the importance of water potential and osmosis in the uptake and loss of water by organisms

B3.3 Active transport 主动运输

☐☐☐ Describe active transport as the movement of particles through a cell membrane from a region of lower concentration to a region of higher concentration (i.e. against a concentration gradient), using energy from respiration

☐☐☐ **[S]** Explain the importance of active transport as a process for movement of molecules or ions across membranes, including ion uptake by root hairs

B4. Biological molecules 生物分子

B4.1 Biological molecules 生物分子

☐☐☐ List the chemical elements that make up: carbohydrates, fats and proteins

☐☐☐ State that large molecules are made from smaller molecules, limited to: (a) starch, glycogen and cellulose from glucose (b) proteins from amino acids (c) fats and oils from fatty acids and glycerol

☐☐☐ Describe the use of: (a) iodine solution test for starch (b) Benedict's solution test for reducing sugars (c) biuret test for proteins (d) ethanol emulsion test for fats and oils

B5. Enzymes 酶

B5.1 Enzymes 酶

☐☐☐ Describe enzymes as proteins that are involved in all metabolic reactions, where they function as biological catalysts

☐☐☐ **[S]** Describe and explain enzyme action with reference to: the active site, enzyme–substrate complex, substrate and product

☐☐☐ **[S]** Describe and explain the specificity of enzymes in terms of the complementary shape and fit of the active site with the substrate

☐☐☐ Investigate and describe the effect of changes in temperature and pH on enzyme activity

☐☐☐ **[S]** Explain the effect of changes in temperature on enzyme activity in terms of kinetic energy, shape and fit, frequency of effective collisions and denaturation

☐☐☐ **[S]** Explain the effect of changes in pH on enzyme activity in terms of shape and fit and

denaturation

B6. Plant nutrition 植物营养

B6.1 Photosynthesis 光合作用

- ☐☐☐ Describe photosynthesis as the process by which plants synthesise carbohydrates from raw materials using energy from light
- ☐☐☐ State the word equation for photosynthesis as: carbon dioxide + water → glucose + oxygen in the presence of light and chlorophyll
- ☐☐☐ **[S]** State the balanced symbol equation for photosynthesis as: $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$
- ☐☐☐ State that chlorophyll is a green pigment that is found in chloroplasts
- ☐☐☐ **[S]** State that chlorophyll transfers energy from light into energy in chemicals, for the synthesis of carbohydrates
- ☐☐☐ **[S]** Outline the subsequent use and storage of the carbohydrates made in photosynthesis: (a) starch as an energy store (b) cellulose to build cell walls (c) glucose used in respiration to provide energy (d) sucrose for transport in the phloem (e) nectar to attract insects for pollination
- ☐☐☐ **[S]** Explain the importance of: (a) nitrate ions for making amino acids (b) magnesium ions for making chlorophyll
- ☐☐☐ Investigate and understand the need for chlorophyll, light and carbon dioxide for photosynthesis
- ☐☐☐ **[S]** Understand and describe the effects of varying light intensity, carbon dioxide concentration and temperature on the rate of photosynthesis
- ☐☐☐ **[S]** Understand and describe the effect of light and dark conditions on gas exchange in an aquatic plant using hydrogencarbonate indicator solution

B6.2 Leaf structure 叶片结构

- ☐☐☐ State that most leaves have a large surface area and are thin, and explain how these features are adaptations for photosynthesis
- ☐☐☐ Identify in diagrams and images the following structures in the leaf of a dicotyledonous plant: chloroplasts, cuticle, guard cells and stomata, upper and lower epidermis, palisade mesophyll, spongy mesophyll, air spaces, vascular bundles, xylem and phloem
- ☐☐☐ **[S]** Explain how the structures listed in 6.2.2 adapt leaves for photosynthesis

B7. Human nutrition 人体营养

B7.1 Diet 膳食

- ☐☐☐ Describe what is meant by a balanced diet
- ☐☐☐ State the principal dietary sources and describe the importance of: (a) carbohydrates (b) fats and oils (c) proteins (d) vitamins, limited to C and D (e) mineral ions, limited to calcium and iron (f) fibre (roughage) (g) water
- ☐☐☐ State the causes of scurvy and rickets

B7.2 Digestive system 消化系统

- ☐☐☐ Identify in diagrams and images the main organs of the digestive system, limited to: (a) alimentary canal: mouth, oesophagus, stomach, small intestine (duodenum and ileum) and large intestine (colon, rectum and anus) (b) associated organs: salivary glands, pancreas, liver and gall bladder
- ☐☐☐ Describe the functions of the organs of the digestive system listed in 7.2.1, in relation to: (a) ingestion – the taking of substances, e.g. food and drink, into the body (b) digestion – the

breakdown of food (c) absorption – the movement of nutrients from the intestines into the blood (d) assimilation – uptake and use of nutrients by cells (e) egestion – the removal of undigested food from the body as faeces

B7.3 Digestion 消化

- ☐☐☐ Describe physical digestion as the breakdown of food into smaller pieces without chemical change to the food molecules
- ☐☐☐ State that physical digestion increases the surface area of food for the action of enzymes in chemical digestion
- ☐☐☐ Describe chemical digestion as the breakdown of large insoluble molecules into small soluble molecules
- ☐☐☐ State the role of chemical digestion in producing small soluble molecules that can be absorbed
- ☐☐☐ **[S]** Describe the functions of enzymes as follows: (a) amylase breaks down starch to simple reducing sugars (b) proteases break down protein to amino acids (c) lipase breaks down fats and oils to fatty acids and glycerol
- ☐☐☐ **[S]** State where, in the digestive system, amylase, protease and lipase are secreted and where they act
- ☐☐☐ **[S]** Describe the functions of hydrochloric acid in gastric juice, limited to killing harmful microorganisms in food and providing an acidic pH for optimum enzyme activity of proteases in the stomach
- ☐☐☐ **[S]** Explain that bile is an alkaline mixture that neutralises the acidic mixture of food and gastric juices entering the duodenum from the stomach, to provide a suitable pH for enzyme action in the small intestine
- ☐☐☐ **[S]** Outline the role of bile in emulsifying fats and oils to increase the surface area for chemical digestion

B8. Transport in plants 植物体内的运输

B8.1 Xylem and phloem 木质部和韧皮部

- ☐☐☐ State the functions of xylem and phloem: (a) xylem – transport of water and mineral ions, and support (b) phloem – transport of sucrose and amino acids
- ☐☐☐ Identify in diagrams and images the position of xylem and phloem as seen in sections of roots, stems and leaves of non-woody dicotyledonous plants

B8.2 Water uptake 水分吸收

- ☐☐☐ Identify in diagrams and images root hair cells and state their functions
- ☐☐☐ State that the large surface area of root hairs increases the uptake of water and mineral ions
- ☐☐☐ Outline the pathway taken by water through root, stem and leaf as: root hair cells, root cortex cells, xylem, mesophyll cells

B8.3 Transpiration 蒸腾作用

- ☐☐☐ Describe transpiration as the loss of water vapour from leaves
- ☐☐☐ State that water evaporates from the surfaces of the mesophyll cells into the air spaces and then diffuses out of the leaves through the stomata as water vapour
- ☐☐☐ Investigate and describe the effects of variation of temperature and wind speed on transpiration rate
- ☐☐☐ **[S]** Explain the effects on the rate of transpiration of varying the following: temperature, wind speed and humidity

☐☐☐ [S] Explain how and why wilting occurs

B8.4 Translocation 有机物运输

☐☐☐ [S] Describe translocation as the movement of sucrose and amino acids in phloem from sources to sinks

☐☐☐ [S] Describe: (a) sources as the parts of plants that release sucrose or amino acids (b) sinks as the parts of plants that use or store sucrose or amino acids

B9. Transport in animals 动物体内的运输

B9.1 Circulatory systems 循环系统

☐☐☐ Describe the circulatory system as a system of blood vessels with a pump and valves to ensure one-way flow of blood

☐☐☐ [S] Describe the single circulation of a fish

☐☐☐ [S] Describe the double circulation of a mammal

☐☐☐ [S] Explain the advantages of a double circulation

B9.2 Heart 心脏

☐☐☐ Identify in diagrams and images the structures of the mammalian heart, limited to: muscular wall, septum, left and right ventricles, left and right atria, one-way valves and coronary arteries

☐☐☐ [S] Describe the functioning of the heart in terms of the contraction of muscles of the atria and ventricles and the action of the valves

☐☐☐ State that blood is pumped away from the heart in arteries and returns to the heart in veins

☐☐☐ State that the activity of the heart may be monitored by: ECG (electrocardiogram), pulse rate and listening to sounds of valves closing

☐☐☐ Investigate and describe the effect of physical activity on the heart rate

☐☐☐ [S] Explain the effect of physical activity on the heart rate

☐☐☐ Describe coronary heart disease in terms of the blockage of coronary arteries and state the possible risk factors including: diet, lack of exercise, stress, smoking, genetic predisposition, age and sex

☐☐☐ Discuss the roles of diet and exercise in reducing the risk of coronary heart disease

B9.3 Blood vessels 血管

☐☐☐ Describe the structure of arteries, veins and capillaries, limited to: relative thickness of wall, diameter of the lumen and the presence of valves in veins

☐☐☐ [S] Explain how the structure of arteries and veins is related to the pressure of the blood that they transport

☐☐☐ State the functions of capillaries

☐☐☐ [S] Explain how the structure of capillaries is related to their functions

☐☐☐ [S] Identify in diagrams and images the main blood vessels to and from the: (a) heart, limited to: vena cava, aorta, pulmonary artery and pulmonary vein (b) lungs, limited to: pulmonary artery and pulmonary vein

B9.4 Blood 血液

☐☐☐ List the components of blood as: red blood cells, white blood cells, platelets and plasma

☐☐☐ Identify red and white blood cells in photomicrographs and diagrams

- [ ] [S] Identify lymphocytes and phagocytes in photomicrographs and diagrams
- [ ] State the functions of the following components of blood: (a) red blood cells in transporting oxygen, including the role of haemoglobin (b) white blood cells in phagocytosis and antibody production (c) platelets in clotting (details are not required) (d) plasma in the transport of blood cells, ions, nutrients, urea, hormones and carbon dioxide
- [ ] [S] State the functions of: (a) lymphocytes – antibody production (b) phagocytes – engulfing pathogens by phagocytosis
- [ ] [S] State the roles of blood clotting as preventing blood loss and the entry of pathogens

B10. Diseases and immunity 疾病与免疫

B10.1 Diseases and immunity 疾病与免疫

- [ ] Describe a pathogen as a disease-causing organism
- [ ] Describe a transmissible disease as a disease in which the pathogen can be passed from one host to another
- [ ] [S] State the features of viruses, limited to a protein coat and genetic material
- [ ] State that a pathogen is transmitted: (a) by direct contact, including through blood and other body fluids (b) indirectly, including from contaminated surfaces, food, animals and air
- [ ] Describe the body defences against pathogens, limited to: skin, hairs in the nose, mucus, stomach acid and white blood cells
- [ ] Explain the importance of the following in controlling the spread of disease: (a) a clean water supply (b) hygienic food preparation (c) good personal hygiene (d) waste disposal (e) sewage treatment (details of the stages of sewage treatment are not required)
- [ ] [S] Describe active immunity as defence against a pathogen by antibody production in the body
- [ ] [S] State that each pathogen has its own antigens, which have specific shapes
- [ ] [S] Describe antibodies as proteins that bind to antigens leading to direct destruction of pathogens or marking of pathogens for destruction by phagocytes
- [ ] [S] State that specific antibodies have complementary shapes which fit specific antigens
- [ ] [S] Explain that active immunity is gained after an infection by a pathogen or by vaccination
- [ ] [S] Outline the process of vaccination: (a) weakened pathogens or their antigens are put into the body (b) the antigens stimulate an immune response by lymphocytes which produce antibodies (c) memory cells are produced that give long-term immunity
- [ ] State that vaccinations are available for some pathogens to help control the spread of diseases
- [ ] [S] Explain the role of vaccination in controlling the spread of diseases

B11. Gas exchange in humans 人体气体交换

B11.1 Gas exchange in humans 人体气体交换

- ☐☐☐ Identify in diagrams and images the following parts of the breathing system: lungs, diaphragm, ribs, intercostal muscles, larynx, trachea, bronchi, bronchioles, alveoli and associated capillaries
- ☐☐☐ [S] Describe the features of gas exchange surfaces in humans, limited to: large surface area, thin surface, good blood supply and good ventilation with air
- ☐☐☐ Investigate the differences in composition between inspired and expired air using limewater as a test for carbon dioxide
- ☐☐☐ Describe the differences in composition between inspired and expired air, limited to: oxygen, carbon dioxide and water vapour
- ☐☐☐ [S] Explain the differences in composition between inspired and expired air
- ☐☐☐ Investigate and describe the effects of physical activity on the rate and depth of breathing
- ☐☐☐ [S] Explain the link between physical activity and the rate and depth of breathing in terms of: an increased carbon dioxide concentration in the blood, which is detected by the brain, leading to an increased rate and greater depth of breathing

B12. Respiration 呼吸作用

B12.1 Respiration 呼吸作用

- ☐☐☐ State the uses of energy in living organisms, including: muscle contraction, protein synthesis, cell division, growth, the passage of nerve impulses and the maintenance of a constant body temperature
- ☐☐☐ Describe aerobic respiration as the chemical reactions in cells that use oxygen to break down nutrient molecules to release energy
- ☐☐☐ State the word equation for aerobic respiration as: glucose + oxygen → carbon dioxide + water
- ☐☐☐ [S] State the balanced symbol equation for aerobic respiration as: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$
- ☐☐☐ [S] Describe anaerobic respiration as the chemical reactions in cells that break down nutrient molecules to release energy without using oxygen
- ☐☐☐ [S] State that anaerobic respiration releases much less energy per glucose molecule than aerobic respiration
- ☐☐☐ [S] State the word equation for anaerobic respiration in muscles during vigorous exercise as: glucose → lactic acid
- ☐☐☐ [S] State that lactic acid builds up in muscles and blood during vigorous exercise causing an oxygen debt
- ☐☐☐ [S] Outline how the oxygen debt is removed after exercise, limited to: (a) continuation of fast heart rate to transport lactic acid in the blood from the muscles to the liver (b) continuation of deeper and faster breathing to supply oxygen for aerobic respiration of lactic acid (c) aerobic respiration of lactic acid in the liver

B13. Coordination and response 协调与反应

B13.1 Coordination and response 协调与反应

- ☐☐☐ State that electrical impulses travel along neurones
- ☐☐☐ Describe the mammalian nervous system in terms of: (a) the central nervous system (CNS) consisting of the brain and spinal cord (b) the peripheral nervous system (PNS) consisting of the nerves outside of the brain and spinal cord
- ☐☐☐ Describe the role of the nervous system as coordination and regulation of body functions
- ☐☐☐ Identify in diagrams and images sensory, relay and motor neurones
- ☐☐☐ Describe a simple reflex arc in terms of: receptor, sensory neurone, relay neurone, motor neurone and effector
- ☐☐☐ Describe a reflex action as a means of automatically and rapidly integrating and coordinating stimuli with the responses of effectors (muscles and glands)
- ☐☐☐ Describe sense organs as groups of receptor cells responding to specific stimuli: light, sound, touch, temperature and chemicals

B13.2 Hormones 激素

- ☐☐☐ Describe a hormone as a chemical substance, produced by a gland and carried by the blood, which alters the activity of one or more specific target organs
- ☐☐☐ Identify in diagrams and images specific endocrine glands and state the hormones they secrete, limited to: (a) adrenal glands and adrenaline (b) pancreas and insulin (c) testes and testosterone (d) ovaries and oestrogen
- ☐☐☐ **[S]** State that glucagon is secreted by the pancreas
- ☐☐☐ Describe adrenaline as the hormone secreted in 'fight or flight' situations and its effects, limited to: (a) increased breathing rate (b) increased heart rate (c) increased pupil diameter

B13.3 Homeostasis 内环境稳态

- ☐☐☐ **[S]** Describe homeostasis as the maintenance of a constant internal environment
- ☐☐☐ **[S]** Explain the concept of homeostatic control by negative feedback with reference to a set point
- ☐☐☐ **[S]** Describe the control of blood glucose concentration by the liver and the roles of insulin and glucagon
- ☐☐☐ **[S]** Identify in diagrams and images of the skin: hairs, hair erector muscles, sweat glands, receptors, sensory neurones, blood vessels and fatty tissue
- ☐☐☐ **[S]** Describe the maintenance of a constant internal body temperature in mammals in terms of: (a) insulation, sweating, shivering, the role of the brain (b) vasodilation and vasoconstriction of arterioles supplying skin surface capillaries

B14. Drugs 药物

B14.1 Drugs 药物

- ☐☐☐ Describe a drug as any substance taken into the body that modifies or affects chemical reactions in the body
- ☐☐☐ Describe the use of antibiotics for the treatment of bacterial infections
- ☐☐☐ State that some bacteria are resistant to antibiotics which reduces the effectiveness of antibiotics
- ☐☐☐ **[S]** Explain how using antibiotics only when essential can limit the development of resistant bacteria such as MRSA
- ☐☐☐ State that antibiotics kill bacteria but do not affect viruses

B15. Reproduction 生殖

B15.1 Asexual reproduction 无性生殖

- ☐☐☐ Describe asexual reproduction as a process resulting in the production of genetically identical offspring from one parent
- ☐☐☐ [S] Discuss the advantages and disadvantages of asexual reproduction to a population of a species in the wild
- ☐☐☐ Identify examples of asexual reproduction in diagrams, images and information provided

B15.2 Sexual reproduction 有性生殖

- ☐☐☐ Describe sexual reproduction as a process involving the fusion of the nuclei of two gametes to form a zygote and the production of offspring that are genetically different from each other
- ☐☐☐ [S] State that nuclei of gametes are haploid and that the nucleus of a zygote is diploid
- ☐☐☐ [S] Discuss the advantages and disadvantages of sexual reproduction to a population of a species in the wild
- ☐☐☐ Describe a species as a group of organisms that can reproduce to produce fertile offspring

B15.3 Sexual reproduction in plants 植物的有性生殖

- ☐☐☐ Identify in diagrams and images and draw the following parts of an insect-pollinated flower: sepals, petals, stamens, filaments, anthers, carpels, style, stigma, ovary and ovules
- ☐☐☐ [S] Identify in diagrams and images and describe the anthers and stigmas of a wind-pollinated flower
- ☐☐☐ State the functions of the structures listed in 15.3.1
- ☐☐☐ Describe pollination as the transfer of pollen grains from an anther to a stigma
- ☐☐☐ State that fertilisation occurs when a pollen nucleus fuses with a nucleus in an ovule
- ☐☐☐ Describe the structural adaptations of insect-pollinated and wind-pollinated flowers
- ☐☐☐ Investigate and describe the environmental conditions that affect germination of seeds, limited to the requirement for: water, oxygen and a suitable temperature

B15.4 Sexual reproduction in humans 人的有性生殖

- ☐☐☐ Identify on diagrams and state the functions of the following parts of the male reproductive system: testes, scrotum, sperm ducts, prostate gland, urethra and penis
- ☐☐☐ Identify on diagrams and state the functions of the following parts of the female reproductive system: ovaries, oviducts, uterus, cervix and vagina
- ☐☐☐ Describe fertilisation as the fusion of the nuclei from a male gamete (sperm) and a female gamete (egg cell)
- ☐☐☐ [S] Explain the adaptive features of sperm, limited to: flagellum, mitochondria and the presence of enzymes in the acrosome
- ☐☐☐ [S] Explain the adaptive features of egg cells, limited to: energy stores and the jelly coat that changes at fertilisation
- ☐☐☐ [S] Compare male and female gametes in terms of: size, structure, motility and numbers
- ☐☐☐ Describe the roles of testosterone and oestrogen in the development and regulation of secondary sexual characteristics during puberty
- ☐☐☐ Describe the menstrual cycle in terms of changes in the ovaries and in the lining of the uterus (knowledge of sex hormones is not required)

B15.5 Sexually transmitted infections 性传播感染

- ☐☐☐ Describe a sexually transmitted infection (STI) as an infection that is transmitted through sexual contact
- ☐☐☐ State that human immunodeficiency virus (HIV) is a pathogen that causes an STI
- ☐☐☐ State that HIV infection may lead to AIDS
- ☐☐☐ Describe the methods of transmission of HIV
- ☐☐☐ Explain how the spread of STIs is controlled

B16. Inheritance 遗传

B16.1 Chromosomes and genes 染色体和基因

- ☐☐☐ State that chromosomes are made of DNA, which contains genetic information in the form of genes
- ☐☐☐ Define a gene as a length of DNA that codes for a protein
- ☐☐☐ Define an allele as an alternative form of a gene
- ☐☐☐ Describe the inheritance of sex in humans with reference to XX and XY chromosomes
- ☐☐☐ **[S]** Describe a haploid nucleus as a nucleus containing a single set of chromosomes
- ☐☐☐ **[S]** Describe a diploid nucleus as a nucleus containing two sets of chromosomes
- ☐☐☐ **[S]** State that in a diploid cell, there is a pair of each type of chromosome and in a human diploid cell there are 23 pairs

B16.2 Cell division 细胞分裂

- ☐☐☐ **[S]** Describe mitosis as nuclear division giving rise to genetically identical cells (details of the stages of mitosis are not required)
- ☐☐☐ **[S]** State the role of mitosis in growth, repair of damaged tissues, replacement of cells and asexual reproduction
- ☐☐☐ **[S]** State that the exact replication of chromosomes occurs before mitosis
- ☐☐☐ **[S]** State that during mitosis, the copies of chromosomes separate, maintaining the chromosome number in each daughter cell
- ☐☐☐ **[S]** State that meiosis is involved in the production of gametes
- ☐☐☐ **[S]** Describe meiosis as reduction division in which the chromosome number is halved from diploid to haploid resulting in genetically different cells (details of the stages of meiosis are not required)

B16.3 Monohybrid inheritance 单因子遗传

- ☐☐☐ Describe inheritance as the transmission of genetic information from generation to generation
- ☐☐☐ Describe genotype as the genetic make-up of an organism and in terms of the alleles present
- ☐☐☐ Describe phenotype as the observable features of an organism
- ☐☐☐ Describe homozygous as having two identical alleles of a particular gene
- ☐☐☐ State that two identical homozygous individuals that breed together will be pure-breeding
- ☐☐☐ Describe heterozygous as having two different alleles of a particular gene
- ☐☐☐ State that a heterozygous individual will not be pure-breeding
- ☐☐☐ Describe a dominant allele as an allele that is expressed if it is present in the genotype
- ☐☐☐ Describe a recessive allele as an allele that is only expressed when there is no dominant allele of the gene present in the genotype
- ☐☐☐ Interpret pedigree diagrams for the inheritance of a given characteristic
- ☐☐☐ Use genetic diagrams to predict the results of monohybrid crosses and calculate phenotypic ratios, limited to 1 : 1 and 3 : 1 ratios

☐☐☐ Use Punnett squares in crosses which result in more than one genotype to work out and show the possible different genotypes

B17. Variation and selection 变异与选择

B17.1 Variation 变异

☐☐☐ Describe variation as differences between individuals of the same species

☐☐☐ State that continuous variation results in a range of phenotypes between two extremes; examples include body length

☐☐☐ State that discontinuous variation results in a limited number of phenotypes with no intermediates; examples include ABO blood groups

☐☐☐ Describe mutation as a genetic change

☐☐☐ State that mutation is the way in which new alleles are formed

B17.2 Selection 选择

☐☐☐ Describe natural selection with reference to: (a) genetic variation within populations (b) production of many offspring (c) struggle for survival, including competition for resources (d) a greater chance of reproduction by individuals that are better adapted to the environment than others (e) these individuals passing on their alleles to the next generation

☐☐☐ [**S**] Describe the development of strains of antibiotic-resistant bacteria as an example of natural selection

☐☐☐ Describe selective breeding with reference to: (a) selection by humans of individuals with desirable features (b) crossing these individuals to produce the next generation (c) selection of offspring showing the desirable features

☐☐☐ Outline how selective breeding by artificial selection is carried out over many generations to improve crop plants and domesticated animals and apply this to given contexts

B18. Organisms and their environment 生物与环境

B18.1 Energy flow 能量流动

☐☐☐ State that the Sun is the principal source of energy input to biological systems

☐☐☐ Describe the flow of energy through living organisms, including light energy from the Sun and chemical energy in organisms, and its eventual transfer to the environment

B18.2 Food chains and food webs 食物链和食物网

☐☐☐ Describe a food chain as showing the transfer of energy from one organism to the next, beginning with a producer

☐☐☐ Construct and interpret simple food chains

☐☐☐ Describe a food web as a network of interconnected food chains and interpret food webs

☐☐☐ Describe a producer as an organism that makes its own organic nutrients, usually using energy from sunlight, through photosynthesis

☐☐☐ Describe a consumer as an organism that gets its energy by feeding on other organisms

☐☐☐ State that consumers may be classed as primary, secondary and tertiary according to their position in a food chain

☐☐☐ Describe a herbivore as an animal that gets its energy by eating plants

☐☐☐ Describe a carnivore as an animal that gets its energy by eating other animals

☐☐☐ Describe a decomposer as an organism that gets its energy from dead or waste organic material

- ☐☐☐ Use food chains and food webs to describe the impact humans have through overharvesting of food species and through introducing foreign species to a habitat
- ☐☐☐ **[S]** Describe a trophic level as the position of an organism in a food chain and food web
- ☐☐☐ **[S]** Identify the following as the trophic levels in food webs and food chains: producers, primary consumers, secondary consumers, tertiary consumers and quaternary consumers
- ☐☐☐ **[S]** Explain why the transfer of energy from one trophic level to another is often not efficient
- ☐☐☐ **[S]** Explain, in terms of energy loss, why food chains usually have fewer than five trophic levels
- ☐☐☐ **[S]** Explain why it is more energy efficient for humans to eat crop plants than to eat livestock that have been fed on crop plants

B18.3 Carbon cycle 碳循环

- ☐☐☐ Describe the carbon cycle, limited to: photosynthesis, respiration, feeding, decomposition, formation of fossil fuels and combustion

B19. Human influences on ecosystems 人类对生态系统的影响

B19.1 Habitat destruction 栖息地破坏

- ☐☐☐ Describe an ecosystem as a unit containing the community of organisms and their environment, interacting together
- ☐☐☐ Describe biodiversity as the number of different species that live in an area
- ☐☐☐ Describe the reasons for habitat destruction, including: (a) increased area for housing, crop plant production and livestock production (b) extraction of natural resources (c) freshwater and marine pollution (a detailed description of eutrophication is not required)
- ☐☐☐ State the undesirable effects of deforestation as an example of habitat destruction, to include: reducing biodiversity, extinction, loss of soil, flooding and increase of carbon dioxide in the atmosphere
- ☐☐☐ **[S]** Explain the undesirable effects of deforestation as an example of habitat destruction, to include: reducing biodiversity, extinction, loss of soil, flooding and increase of carbon dioxide in the atmosphere

B19.2 Conservation 保护

- ☐☐☐ Explain why organisms become endangered or extinct, including: climate change, habitat destruction, hunting, overharvesting, pollution and introduced species
- ☐☐☐ Describe how endangered species can be conserved, limited to: (a) monitoring and protecting species and habitats (b) education (c) captive breeding programmes (d) seed banks

C1. States of matter 物质的状态

C1.1 Solids, liquids and gases 固体、液体和气体

- ☐☐☐ State the distinguishing properties of solids, liquids and gases
- ☐☐☐ Describe the structure of solids, liquids and gases in terms of particle separation, arrangement and motion
- ☐☐☐ Describe changes of state in terms of melting, boiling, evaporating, freezing and condensing
- ☐☐☐ **[S]** Explain changes of state in terms of kinetic particle theory, including the interpretation of heating and cooling curves
- ☐☐☐ Describe the effects of temperature and pressure on the volume of a gas
- ☐☐☐ **[S]** Explain, in terms of kinetic particle theory, the effects of temperature and pressure on the

volume of a gas

C1.2 Diffusion 扩散

- ☐☐☐ Describe and explain diffusion in terms of kinetic particle theory
- ☐☐☐ [S] Describe and explain the effect of relative molecular mass on the rate of diffusion of gases

C2. Atoms, elements and compounds 原子、元素和化合物

C2.1 Elements, compounds and mixtures 元素、化合物和混合物

- ☐☐☐ Describe the differences between elements, compounds and mixtures

C2.2 Atomic structure and the Periodic Table 原子结构与元素周期表

- ☐☐☐ Describe the structure of the atom as a central nucleus containing neutrons and protons, surrounded by electrons in shells
- ☐☐☐ State the relative charges and relative masses of a proton, a neutron and an electron
- ☐☐☐ Define proton number / atomic number as the number of protons in the nucleus of an atom
- ☐☐☐ Define mass number / nucleon number as the total number of protons and neutrons in the nucleus of an atom
- ☐☐☐ Determine the electronic configuration of elements with proton number 1 to 20, e.g. 2,8,3
- ☐☐☐ State that: (a) Group VIII noble gases have a full outer shell; (b) the number of outer-shell electrons is equal to the group number in Groups I to VII; (c) the number of occupied electron shells is equal to the period number

C2.3 Isotopes 同位素

- ☐☐☐ Define isotopes as different atoms of the same element that have the same number of protons but different numbers of neutrons
- ☐☐☐ [S] State that isotopes of the same element have the same chemical properties because they have the same number of electrons and therefore the same electronic configuration
- ☐☐☐ Interpret and use symbols for atoms, e.g. ${}^{12}_{6}\mathrm{C}$, and ions, e.g. ${}^{35}_{17}\mathrm{Cl}^{-}$

C2.4 Ions and ionic bonds 离子与离子键

- ☐☐☐ Describe the formation of positive ions, known as cations, and negative ions, known as anions
- ☐☐☐ State that an ionic bond is a strong electrostatic attraction between oppositely charged ions
- ☐☐☐ Describe the formation of ionic bonds between elements from Group I and Group VII, including the use of dot-and-cross diagrams
- ☐☐☐ [S] Describe the formation of ionic bonds between ions of metallic and non-metallic elements, including the use of dot-and-cross diagrams
- ☐☐☐ Describe the properties of ionic compounds: (a) high melting points and boiling points; (b) good electrical conductivity when aqueous or molten and poor when solid; (c) generally soluble in water
- ☐☐☐ [S] Explain in terms of structure and bonding the properties of ionic compounds: (a) high melting points and boiling points; (b) good electrical conductivity when aqueous or molten and poor when solid
- ☐☐☐ [S] Describe the giant lattice structure of ionic compounds as a regular arrangement of alternating positive and negative ions, exemplified by sodium chloride

C2.5 Simple molecules and covalent bonds 简单分子与共价键

☐☐☐ State that a covalent bond is formed when a pair of electrons is shared between two atoms leading to noble gas electronic configurations

☐☐☐ Describe the formation of covalent bonds in simple molecules, including H_2, Cl_2, H_2O, CH_4, NH_3 and HCl. Use dot-and-cross diagrams to show the electronic configurations in these molecules

☐☐☐ **[S]** Describe the formation of covalent bonds in simple molecules, including CH_3OH, C_2H_4, O_2, CO_2 and N_2. Use dot-and-cross diagrams to show the electronic configurations in these molecules

☐☐☐ Describe in terms of structure and bonding the properties of simple molecular compounds: (a) low melting points and boiling points; (b) poor electrical conductivity

☐☐☐ **[S]** Explain in terms of structure and bonding the properties of simple molecular compounds: (a) low melting points and boiling points in terms of weak intermolecular forces (specific types of intermolecular forces are not required); (b) poor electrical conductivity

C2.6 Giant covalent structures 巨型共价结构

☐☐☐ Describe the giant covalent structures of graphite and diamond

☐☐☐ **[S]** Relate the structures and bonding of graphite and diamond to their uses, limited to: (a) graphite as a lubricant and as an electrode; (b) diamond in cutting tools

C2.7 Metallic bonding 金属键

☐☐☐ **[S]** Describe metallic bonding as the electrostatic attraction between the positive ions in a giant metallic lattice and a 'sea' of delocalised electrons

☐☐☐ **[S]** Explain in terms of structure and bonding the properties of metals: (a) good electrical conductivity; (b) malleability

C3. Stoichiometry 化学计量

C3.1 Formulas 化学式

☐☐☐ State the formulas of the elements and compounds named in the subject content

☐☐☐ Define the molecular formula of a compound as the number and type of atoms in one molecule

☐☐☐ Deduce the formula of a simple molecular compound from the relative numbers of atoms present in a model or a diagrammatic representation

☐☐☐ **[S]** Deduce the formula of an ionic compound from the relative numbers of the ions present in a model or a diagrammatic representation or from the charges on the ions

☐☐☐ Construct word equations to show how reactants form products

☐☐☐ Balance and interpret simple symbol equations, including state symbols

☐☐☐ **[S]** Construct symbol equations with state symbols, including ionic equations

☐☐☐ **[S]** Deduce the symbol equation with state symbols for a chemical reaction, given relevant information

C3.2 Relative masses of atoms and molecules 原子和分子的相对质量

☐☐☐ Describe relative atomic mass, A_r, as the average mass of the isotopes of an element compared to 1/12th of the mass of an atom of ^{12}C

☐☐☐ Define relative molecular mass, M_r, as the sum of the relative atomic masses. Relative formula mass, M_r, will be used for ionic compounds

☐☐☐ Calculate reacting masses in simple proportions (calculations will not involve the mole concept)

C3.3 The mole and the Avogadro constant 摩尔和阿伏伽德罗常数

☐☐☐ State that concentration can be measured in g/dm^3

☐☐☐ [S] State that the mole, mol, is the unit of amount of substance and that one mole contains 6.02×10^{23} particles, e.g. atoms, ions, molecules; this number is the Avogadro constant

☐☐☐ [S] Use the relationship amount of substance (mol) $= \frac{\text{mass (g)}}{\text{molar mass (g/mol)}}$ to calculate: (a) amount of substance; (b) mass; (c) molar mass; (d) relative atomic mass or relative molecular / formula mass

☐☐☐ [S] Use the molar gas volume, taken as 24 dm^3 at room temperature and pressure, r.t.p., in calculations involving gases

☐☐☐ [S] Calculate stoichiometric reacting masses, limiting reactants, volumes of gases at r.t.p., including conversion between cm^3 and dm^3

C4. Electrochemistry 电化学

C4.1 Electrolysis 电解

☐☐☐ Define electrolysis as the decomposition of an ionic compound, when molten or in aqueous solution, by the passage of an electric current

☐☐☐ Identify in simple electrolytic cells: (a) the anode as the positive electrode; (b) the cathode as the negative electrode; (c) the electrolyte as the molten or aqueous substance that undergoes electrolysis

☐☐☐ Identify the products formed at the electrodes and describe the observations made during the electrolysis of: (a) molten lead(II) bromide; (b) concentrated aqueous sodium chloride; (c) dilute sulfuric acid using inert electrodes made of platinum or carbon / graphite

☐☐☐ [S] Describe the transfer of charge during electrolysis: (a) the movement of electrons in the external circuit; (b) the loss or gain of electrons at the electrodes; (c) the movement of ions in the electrolyte

☐☐☐ [S] Identify the products formed at the electrodes and describe the observations made during the electrolysis of aqueous copper(II) sulfate using carbon / graphite electrodes and when using copper electrodes

☐☐☐ [S] State that metals or hydrogen are formed at the cathode and that non-metals (other than hydrogen) are formed at the anode

☐☐☐ [S] Predict the identity of the products at each electrode for the electrolysis of a binary compound in the molten state

☐☐☐ [S] Construct ionic half-equations for reactions at the cathode (showing gain of electrons as a reduction reaction)

C4.2 Hydrogen–oxygen fuel cells 氢氧燃料电池

☐☐☐ State that a hydrogen–oxygen fuel cell uses hydrogen and oxygen to produce electricity with water as the only chemical product

☐☐☐ [S] Describe the advantages and disadvantages of using hydrogen–oxygen fuel cells in comparison with gasoline / petrol engines in vehicles

C5. Chemical energetics 化学能量变化

C5.1 Exothermic and endothermic reactions 放热反应和吸热反应

☐☐☐ State that an exothermic reaction transfers thermal energy to the surroundings leading to an increase in the temperature of the surroundings

☐☐☐ State that an endothermic reaction takes in thermal energy from the surroundings leading to a decrease in the temperature of the surroundings

☐☐☐ [S] Interpret reaction pathway diagrams showing exothermic and endothermic reactions

☐☐☐ [S] State that the transfer of thermal energy during a reaction is called the enthalpy change, ΔH, of the reaction. ΔH is negative for exothermic reactions and positive for endothermic reactions

☐☐☐ [S] Define activation energy, E_a, as the minimum energy that colliding particles must have to react

☐☐☐ [S] Draw and label reaction pathway diagrams for exothermic and endothermic reactions using information provided, to include: (a) reactants; (b) products; (c) overall energy change of the reaction, ΔH; (d) activation energy, E_a

☐☐☐ [S] State that bond breaking is an endothermic process and bond making is an exothermic process

C6. Chemical reactions 化学反应

C6.1 Physical and chemical changes 物理变化和化学变化

☐☐☐ Identify physical and chemical changes, and understand the differences between them

C6.2 Rate of reaction 化学反应速率

☐☐☐ Describe the effect on the rate of reaction of: (a) changing the concentration of solutions; (b) changing the pressure of gases; (c) changing the surface area of solids; (d) changing the temperature; (e) adding or removing a catalyst

☐☐☐ [S] Explain the effect on the rate of reaction of: (a) changing the concentration of solutions; (b) changing the pressure of gases; (c) changing the surface area of solids; (d) changing the temperature; (e) adding or removing a catalyst using collision theory

☐☐☐ State that a catalyst increases the rate of a reaction and is unchanged at the end of a reaction

☐☐☐ [S] State that a catalyst decreases the activation energy, E_a, of a reaction

☐☐☐ Describe practical methods for investigating the rate of a reaction including change in mass of a reactant or product and the formation of a gas

☐☐☐ Interpret data, including graphs, from rate of reaction experiments

☐☐☐ [S] Describe collision theory in terms of: (a) number of particles per unit volume; (b) frequency of collisions between particles; (c) kinetic energy of particles; (d) activation energy, E_a

C6.3 Redox 氧化还原

☐☐☐ Define redox reactions as involving simultaneous oxidation and reduction

☐☐☐ Define oxidation as gain of oxygen and reduction as loss of oxygen

☐☐☐ [S] Define oxidation in terms of: (a) loss of electrons; (b) an increase in oxidation number (determination of oxidation numbers is not required)

☐☐☐ [S] Define reduction in terms of: (a) gain of electrons; (b) a decrease in oxidation number (determination of oxidation numbers is not required)

☐☐☐ Identify redox reactions as reactions involving gain and loss of oxygen

☐☐☐ Identify oxidation and reduction in redox reactions. (Oxidation number limited to its use to name ions, e.g. iron(II), iron(III), copper(II).)

C7. Acids, bases and salts 酸、碱和盐

C7.1 The characteristic properties of acids and bases 酸和碱的特性

☐☐☐ Describe the characteristic properties of acids in terms of their reactions with: (a) metals; (b) bases; (c) carbonates

☐☐☐ Describe acids in terms of their effect on the indicators: (a) litmus; (b) methyl orange

☐☐☐ State that bases are oxides or hydroxides of metals and that alkalis are soluble bases

- ☐☐☐ Describe the characteristic properties of bases in terms of their reactions with acids
- ☐☐☐ Describe alkalis in terms of their effect on the indicators: (a) litmus; (b) methyl orange
- ☐☐☐ Describe how to compare neutrality, relative acidity and relative alkalinity in terms of colour and pH using universal indicator
- ☐☐☐ Describe the neutralisation reaction between an acid and an alkali to produce a salt and water (the ionic equation for this reaction is not required)

C7.2 Oxides 氧化物

- ☐☐☐ Classify oxides as either acidic, including SO_2 and CO_2, or basic, including CuO and CaO, related to metallic and non-metallic character
- ☐☐☐ **[S]** Describe amphoteric oxides as oxides that react with acids and with bases to produce a salt and water
- ☐☐☐ **[S]** Classify Al_2O_3 and ZnO as amphoteric oxides

C7.3 Preparation of salts 盐的制备

- ☐☐☐ Describe the preparation, separation and purification of soluble salts by reaction of an acid with: (a) an alkali by titration; (b) excess metal; (c) excess insoluble base; (d) excess insoluble carbonate (the general solubility rules for salts are not required)
- ☐☐☐ Define a hydrated substance as a substance that is chemically combined with water and an anhydrous substance as a substance containing no water
- ☐☐☐ **[S]** Describe the preparation of insoluble salts by precipitation (the general solubility rules for salts are not required)

C8. The Periodic Table 元素周期表

C8.1 Arrangement of elements 元素的排列

- ☐☐☐ Describe the Periodic Table as an arrangement of elements in periods and groups and in order of increasing proton number / atomic number
- ☐☐☐ Describe the change from metallic to non-metallic character across a period
- ☐☐☐ Explain similarities in the chemical properties of elements in the same group of the Periodic Table in terms of their electronic configuration
- ☐☐☐ **[S]** Identify trends in groups, given information about the elements

C8.2 Group I properties 第 族元素的性质

- ☐☐☐ Describe the Group I alkali metals, lithium, sodium and potassium, as relatively soft metals with general trends down the group, limited to: (a) decreasing melting point; (b) increasing density; (c) increasing reactivity with water
- ☐☐☐ **[S]** Predict the properties of other elements in Group I, given information about the elements

C8.3 Group VII properties 第 族元素的性质

- ☐☐☐ Describe the Group VII halogens, chlorine, bromine and iodine, as diatomic non-metals with general trends down the group, limited to: (a) increasing density; (b) decreasing reactivity
- ☐☐☐ State the appearance of the halogens at room temperature and pressure, r.t.p., as: (a) chlorine, a pale yellow-green gas; (b) bromine, a red-brown liquid; (c) iodine, a grey-black solid
- ☐☐☐ **[S]** Describe and explain the displacement reactions of halogens with other halide ions
- ☐☐☐ **[S]** Predict the properties of other elements in Group VII, given information about the elements

C8.4 Transition elements 过渡元素

☐☐☐ Describe the transition elements as metals that: (a) have high densities; (b) have high melting points; (c) form coloured compounds; (d) often act as catalysts as elements and in compounds

C8.5 Noble gases 稀有气体

☐☐☐ Describe the Group VIII noble gases as unreactive, monatomic gases and explain this in terms of electronic configuration

C9. Metals 金属

C9.1 Properties of metals 金属的性质

☐☐☐ Compare the general physical properties of metals and non-metals, including: (a) thermal conductivity; (b) electrical conductivity; (c) malleability and ductility; (d) melting points and boiling points

☐☐☐ Describe the general chemical properties of metals, limited to their reactions with: (a) dilute acids; (b) cold water and steam

C9.2 Uses of metals 金属的用途

☐☐☐ Describe the uses of metals in terms of their physical properties, including: (a) aluminium in the manufacture of aircraft because of its low density; (b) aluminium in the manufacture of overhead electrical cables because of its low density and good electrical conductivity; (c) aluminium in food containers because of its resistance to corrosion; (d) copper in electrical wiring because of its good electrical conductivity

C9.3 Alloys and their properties 合金及其性质

☐☐☐ Describe alloys as mixtures of a metal with other elements, including: (a) brass as a mixture of copper and zinc; (b) stainless steel as a mixture of iron and other elements such as chromium, nickel and carbon

☐☐☐ State that alloys can be harder and stronger than the pure metals and are more useful

☐☐☐ Describe the use of alloys in terms of their physical properties, including stainless steel in cutlery because of its hardness and resistance to rusting

☐☐☐ Identify representations of alloys from diagrams of structure

☐☐☐ **[S]** Explain in terms of structure how alloys can be harder and stronger than the pure metals because the different sized atoms in alloys mean the layers can no longer slide over each other

C9.4 Reactivity series 金属活动性顺序

☐☐☐ State the order of the reactivity series as: potassium, sodium, calcium, magnesium, aluminium, carbon, zinc, iron, hydrogen, copper, silver, gold

☐☐☐ **[S]** Describe the relative reactivities of metals in terms of their tendency to form positive ions, by displacement reactions, if any, with the aqueous ions of magnesium, zinc, iron, copper and silver

☐☐☐ Describe the reactions, if any, of: (a) potassium, sodium and calcium with cold water; (b) magnesium with steam; (c) magnesium, zinc, iron, copper, silver and gold with dilute hydrochloric acid and explain these reactions in terms of the position of the metals in the reactivity series

☐☐☐ Deduce an order of reactivity from a given set of experimental results

C9.5 Corrosion of metals 金属的腐蚀

☐☐☐ State the conditions required for the rusting of iron (presence of oxygen and water)

☐☐☐ State some common barrier methods, including painting, greasing and coating with plastic

☐☐☐ Describe how barrier methods prevent rusting by excluding oxygen and water

☐☐☐ **[S]** Describe the use of zinc in galvanising steel as an example of a barrier method and sacrificial protection

☐☐☐ **[S]** Explain sacrificial protection in terms of the reactivity series and in terms of electron loss

C9.6 Extraction of metals 金属的提取

☐☐☐ Describe the ease in obtaining metals from their ores, related to the position of the metal in the reactivity series

☐☐☐ State that iron from hematite is extracted by reduction of iron(III) oxide in the blast furnace

☐☐☐ **[S]** Describe the extraction of iron from hematite in the blast furnace, limited to: (a) the burning of carbon (coke) to provide heat and produce carbon dioxide $C + O_2 \rightarrow CO_2$; (b) the reduction of carbon dioxide to carbon monoxide $C + CO_2 \rightarrow 2CO$; (c) the reduction of iron(III) oxide by carbon monoxide $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$; (d) the thermal decomposition of calcium carbonate / limestone to produce calcium oxide $CaCO_3 \rightarrow CaO + CO_2$; (e) the formation of slag $CaO + SiO_2 \rightarrow CaSiO_3$

☐☐☐ State that main ore of aluminium is bauxite and that aluminium is extracted by electrolysis

C10. Chemistry of the environment 环境化学

C10.1 Water 水

☐☐☐ Describe chemical tests for the presence of water using anhydrous cobalt(II) chloride and anhydrous copper(II) sulfate

☐☐☐ Describe how to test for the purity of water using melting point and boiling point

☐☐☐ State that distilled water is used in practical chemistry rather than tap water because it contains fewer chemical impurities

☐☐☐ Describe the treatment of the domestic water supply in terms of: (a) sedimentation and filtration to remove solids; (b) use of carbon to remove tastes and odours; (c) chlorination to kill microbes (pathogens)

C10.2 Air quality and climate 空气质量与气候

☐☐☐ State the composition of clean, dry air as approximately 78% nitrogen, N_2, 21% oxygen, O_2, and the remainder as a mixture of noble gases and carbon dioxide, CO_2

☐☐☐ State the source of each of these air pollutants, limited to: (a) carbon dioxide from the complete combustion of carbon-containing fuels; (b) carbon monoxide and particulates from the incomplete combustion of carbon-containing fuels; (c) methane from the decomposition of vegetation and waste gases from digestion in animals; (d) oxides of nitrogen from car engines; (e) sulfur dioxide from the combustion of fossil fuels which contain sulfur compounds

☐☐☐ State the adverse effect of these air pollutants, limited to: (a) carbon dioxide: higher levels of carbon dioxide leading to increased global warming, which leads to climate change; (b) carbon monoxide: toxic gas; (c) particulates: increased risk of respiratory problems and cancer; (d) methane: higher levels of methane leading to increased global warming, which leads to climate change; (e) oxides of nitrogen: acid rain and respiratory problems; (f) sulfur dioxide: acid rain

☐☐☐ State and explain strategies to reduce the effects of climate change: (a) planting trees; (b) reduction in livestock farming; (c) decreasing use of fossil fuels; (d) increasing use of hydrogen and renewable energy, e.g. wind, solar

☐☐☐ **[S]** State and explain strategies to reduce the effects of acid rain: reducing emissions of sulfur dioxide by using low-sulfur fuels and flue gas desulfurisation with calcium oxide

☐☐☐ **[S]** Describe how the greenhouse gases carbon dioxide and methane cause global warming, limited

to: (a) the absorption, reflection and emission of thermal energy; (b) reducing thermal energy loss to space

☐☐☐ **[S]** Explain how oxides of nitrogen form in car engines and describe their removal by catalytic converters, limited to: $2CO + 2NO \rightarrow 2CO_2 + N_2$

C11. Organic chemistry 有机化学

C11.1 Formulas and terminology 化学式和术语

☐☐☐ Draw and interpret the displayed formula of a molecule to show all the atoms and all the bonds

☐☐☐ State that a saturated compound has molecules in which all carbon–carbon bonds are single bonds

☐☐☐ State that an unsaturated compound has molecules in which one or more carbon–carbon bonds are not single bonds

☐☐☐ **[S]** State that a homologous series is a family of similar compounds with similar chemical properties

☐☐☐ **[S]** Describe the general characteristics of a homologous series as: (a) having the same general formula (recall of specific general formulas is not required); (b) displaying a trend in physical properties

C11.2 Naming organic compounds 有机化合物的命名

☐☐☐ Name and draw the displayed formulas of: (a) methane and ethane; (b) ethene; (c) ethanol

☐☐☐ State the type of compound present, given a chemical name ending in -ane, -ene or -ol, or from a molecular formula or displayed formula

☐☐☐ **[S]** Name and draw the structural formulas and displayed formulas of unbranched: (a) alkanes; (b) alkenes, including but-1-ene and but-2-ene (not cis/trans) containing up to four carbon atoms per molecule

C11.3 Fuels 燃料

☐☐☐ Name the fossil fuels: coal, natural gas and petroleum

☐☐☐ Name methane as the main constituent of natural gas

☐☐☐ State that hydrocarbons are compounds that contain hydrogen and carbon only

☐☐☐ State that petroleum is a mixture of hydrocarbons

☐☐☐ Describe the separation of petroleum into useful fractions by fractional distillation

☐☐☐ Name the uses of the fractions as: (a) refinery gas fraction for gas used in heating and cooking; (b) gasoline / petrol fraction for fuel used in cars; (c) naphtha fraction as a chemical feedstock; (d) diesel oil / gas oil for fuel used in diesel engines; (e) bitumen for making roads

☐☐☐ **[S]** Describe how the properties of fractions obtained from petroleum change from the bottom to the top of the fractionating column, limited to: (a) decreasing chain length; (b) lower boiling points

C11.4 Alkanes 烷烃

☐☐☐ State that the bonding in alkanes is single covalent and that alkanes are saturated hydrocarbons

☐☐☐ Describe the properties of alkanes as being generally unreactive, except in terms of combustion

C11.5 Alkenes 烯烃

☐☐☐ State that the bonding in alkenes includes a double carbon–carbon covalent bond and that alkenes are unsaturated hydrocarbons

☐☐☐ Describe the test to distinguish between saturated and unsaturated hydrocarbons by their reaction with aqueous bromine

☐☐☐ **[S]** Describe the manufacture of alkenes and hydrogen by the cracking of larger alkane molecules using a high temperature and a catalyst

☐☐☐ **[S]** Describe the properties of alkenes in terms of addition reactions with: (a) bromine; (b) hydrogen in the presence of a nickel catalyst; (c) steam in the presence of an acid catalyst

C11.6 Alcohols 醇

☐☐☐ Describe the complete combustion of ethanol

☐☐☐ State the uses of ethanol as: (a) a solvent; (b) a fuel

C11.7 Polymers 聚合物

☐☐☐ Define polymers as large molecules built up from many smaller molecules called monomers

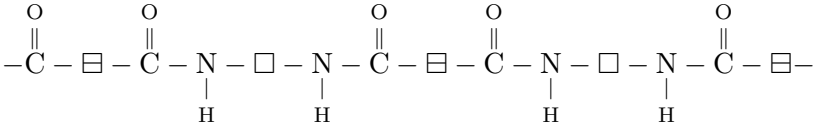
☐☐☐ Describe the formation of poly(ethene) as an example of addition polymerisation using ethene monomers

☐☐☐ **[S]** Identify the repeat units in addition polymers and in condensation polymers

☐☐☐ **[S]** Deduce the structure or repeat unit of an addition polymer from a given alkene and vice versa

☐☐☐ **[S]** Describe the differences between addition and condensation polymerisation

☐☐☐ **[S]** Describe and draw the structure of nylon, a polyamide:



C12. Experimental techniques and chemical analysis 实验技术与化学分析

C12.1 Experimental design 实验设计

☐☐☐ Name appropriate apparatus for the measurement of time, temperature, mass and volume, including: (a) stop-watches; (b) thermometers; (c) balances; (d) burettes; (e) volumetric pipettes; (f) measuring cylinders; (g) gas syringes

☐☐☐ Describe a: (a) solvent as a substance that dissolves a solute; (b) solute as a substance that is dissolved in a solvent; (c) solution as a mixture of one or more solutes dissolved in a solvent; (d) saturated solution as a solution containing the maximum concentration of a solute dissolved in the solvent at a specified temperature; (e) residue as a solid substance that remains after evaporation, distillation, filtration or any similar process; (f) filtrate as a liquid or solution that has passed through a filter

C12.2 Acid-base titrations 酸碱滴定

☐☐☐ Describe an acid–base titration to include the use of a: (a) burette; (b) volumetric pipette; (c) suitable indicator

☐☐☐ Describe how to identify the end-point of a titration using an indicator

C12.3 Chromatography 色谱法

☐☐☐ Describe how paper chromatography is used to separate mixtures of soluble coloured substances, using a suitable solvent

☐☐☐ Interpret simple chromatograms to identify: (a) unknown substances by comparison with known substances; (b) pure and impure substances

☐☐☐ **[S]** State and use the equation for R_f: $R_f = \dfrac{\text{distance travelled by substance}}{\text{distance travelled by solvent}}$

C12.4 Separation and purification 分离与提纯

- ☐☐☐ Describe and explain methods of separation and purification using: (a) a suitable solvent; (b) filtration; (c) crystallisation; (d) simple distillation; (e) fractional distillation
- ☐☐☐ Suggest suitable separation and purification techniques, given information about the substances involved
- ☐☐☐ Identify substances and assess their purity from melting point and boiling point information

C12.5 Identification of ions and gases 离子和气体的鉴定

- ☐☐☐ Describe tests to identify the anions: (a) carbonate, CO_3^{2-}, by reaction with dilute acid and then testing for carbon dioxide gas; (b) chloride, Cl^-, bromide, Br^-, and iodide, I^-, by acidifying with dilute nitric acid then adding aqueous silver nitrate; (c) nitrate, NO_3^-, reduction with aluminium foil and aqueous sodium hydroxide and then testing for ammonia gas; (d) sulfate, SO_4^{2-}, by acidifying with dilute nitric acid and then adding aqueous barium nitrate
- ☐☐☐ Describe tests using aqueous sodium hydroxide and aqueous ammonia to identify the aqueous cations: (a) ammonium, NH_4^+; (b) calcium, Ca^{2+}; (c) copper(II), Cu^{2+}; (d) iron(II), Fe^{2+}; (e) iron(III), Fe^{3+}; (f) zinc, Zn^{2+} (formulas of complex ions are not required)
- ☐☐☐ Describe tests to identify the gases: (a) ammonia, NH_3, using damp red litmus paper; (b) carbon dioxide, CO_2, using limewater; (c) chlorine, Cl_2, using damp litmus paper; (d) hydrogen, H_2, using a lighted splint; (e) oxygen, O_2, using a glowing splint
- ☐☐☐ Describe the use of a flame test to identify the cations: (a) lithium, Li^+; (b) sodium, Na^+; (c) potassium, K^+; (d) copper(II), Cu^{2+}

P1. Motion, forces and energy 运动、力和能量

P1.1 Physical quantities and measurement techniques 物理量与测量技术

- ☐☐☐ Describe the use of rulers and measuring cylinders to find a length or a volume
- ☐☐☐ Describe how to measure a variety of time intervals using clocks and digital timers
- ☐☐☐ Determine an average value for a small distance and for a short interval of time by measuring multiples (including the period of oscillation of a pendulum)
- ☐☐☐ **[S]** Understand that a scalar quantity has magnitude (size) only and that a vector quantity has magnitude and direction
- ☐☐☐ **[S]** Know that the following quantities are scalars: distance, speed, time, mass, energy and temperature
- ☐☐☐ **[S]** Know that the following quantities are vectors: force, weight, velocity, acceleration and gravitational field strength

P1.2 Motion 运动

- ☐☐☐ Define speed as distance travelled per unit time; recall and use the equation $v = \frac{s}{t}$
- ☐☐☐ Recall and use the equation average speed $= \frac{\text{total distance travelled}}{\text{total time taken}}$
- ☐☐☐ **[S]** Define velocity as speed in a given direction
- ☐☐☐ **[S]** Define acceleration as change in velocity per unit time; recall and use the equation $a = \frac{\Delta v}{\Delta t}$
- ☐☐☐ Sketch, plot and interpret distance–time and speed–time graphs
- ☐☐☐ Know that an object moving with increasing speed is accelerating, and that an object moving with decreasing speed is decelerating
- ☐☐☐ Determine, qualitatively, from the shape of a distance–time graph or speed–time graph when an object is: (a) at rest (b) moving with constant speed (c) accelerating (d) decelerating
- ☐☐☐ **[S]** Determine from given data or the shape of a speed–time graph when an object is moving

with: (a) constant acceleration (b) changing acceleration

- ☐☐☐ Calculate speed from the gradient of a straight-line section of a distance–time graph
- ☐☐☐ **[S]** Calculate acceleration from the gradient of a straight-line section of a speed–time graph
- ☐☐☐ Calculate the area under a speed–time graph to work out the distance travelled for motion with: (a) constant speed (b) constant acceleration
- ☐☐☐ **[S]** Know that deceleration is a negative acceleration and use this in calculations
- ☐☐☐ **[S]** Know that the acceleration of free fall g for an object near to the surface of the Earth is approximately constant and is approximately 9.8 m/s^2

P1.3 Mass and weight 质量和重量

- ☐☐☐ State that mass is a measure of the quantity of matter in an object
- ☐☐☐ State that weight is the gravitational force on an object that has mass
- ☐☐☐ **[S]** Describe, and use the concept of, weight as the effect of a gravitational field on a mass
- ☐☐☐ Define gravitational field strength g as the gravitational force per unit mass; recall and use the equation $g = \frac{W}{m}$ and know that near to the surface of the Earth, g is approximately 9.8 N/kg
- ☐☐☐ **[S]** Know that gravitational field strength is equivalent to the acceleration of free fall

P1.4 Density 密度

- ☐☐☐ Define density as mass per unit volume; recall and use the equation $\rho = \frac{m}{V}$
- ☐☐☐ Describe how to determine the density of a liquid, of a regularly shaped solid and of an irregularly shaped solid which sinks in a liquid (volume by displacement), including appropriate calculations
- ☐☐☐ Determine whether an object floats or sinks based on density data

P1.5 Forces 力

- ☐☐☐ Know that forces may produce changes in the size, shape and motion of an object
- ☐☐☐ Determine the resultant of two or more forces acting along the same straight line
- ☐☐☐ Describe friction as the force between two surfaces that may impede relative motion and produce heating
- ☐☐☐ Know that friction (drag) acts on an object moving through a liquid
- ☐☐☐ Know that friction (drag) acts on an object moving through a gas (e.g. air resistance)
- ☐☐☐ Know that an object either remains at rest or continues in a straight line at constant speed unless there is a resultant force on the object
- ☐☐☐ **[S]** Recall and use the equation $F = ma$ and know that the resultant force and the acceleration are in the same direction
- ☐☐☐ **[S]** Sketch, plot and interpret load–extension graphs for an elastic solid and describe the associated experimental procedures
- ☐☐☐ **[S]** Define the spring constant as force per unit extension; recall and use the equation $k = \frac{F}{x}$
- ☐☐☐ **[S]** Define and use the term 'limit of proportionality' for a load–extension graph and identify this point on the graph (an understanding of the elastic limit is not required)
- ☐☐☐ Describe the moment of a force as a measure of its turning effect and give everyday examples
- ☐☐☐ **[S]** Apply the principle of moments to situations with one force each side of the pivot, including balancing of a beam
- ☐☐☐ Define the moment of a force as moment = force × perpendicular distance from the pivot; recall and use this equation
- ☐☐☐ State that, when there is no resultant force and no resultant moment, an object is in equilibrium
- ☐☐☐ Understand what is meant by centre of gravity and know its position for regularly shaped objects

(limited to rectangular blocks, spheres and cylinders)

- ☐☐☐ Describe an experiment to determine the position of the centre of gravity of an irregularly shaped plane lamina
- ☐☐☐ Describe, qualitatively, the effect of the position of the centre of gravity on the stability of simple objects

P1.6 Energy, work and power 能量、功和功率

- ☐☐☐ State that energy may be stored as kinetic, gravitational potential, chemical, elastic (strain), nuclear, electrostatic and internal (thermal)
- ☐☐☐ Describe how energy is transferred between stores during events and processes, including examples of transfer by forces (mechanical work done), electrical currents (electrical work done), heating and by electromagnetic, sound and other waves
- ☐☐☐ **[S]** Recall and use the equation for kinetic energy $E_{\mathrm{k}} = \frac{1}{2}mv^2$
- ☐☐☐ **[S]** Recall and use the equation for the change in gravitational potential energy $\Delta E_{\mathrm{p}} = mg\Delta h$
- ☐☐☐ Know the principle of conservation of energy and apply this principle to simple examples including the interpretation of simple flow diagrams (Sankey diagrams are not required)
- ☐☐☐ Understand that mechanical or electrical work done is equal to the energy transferred
- ☐☐☐ Recall and use the equation for mechanical working $W = Fd = \Delta E$
- ☐☐☐ Describe how useful energy may be obtained, or electrical power generated, from: (a) fossil fuels (b) biofuels (c) water, including waves, tides, and hydroelectric dams (d) geothermal resources (e) nuclear fission (f) light from the Sun (solar cells) (g) infrared and other electromagnetic waves from the Sun to heat water (solar thermal collectors) (h) wind (wind turbines) including references to a boiler, turbine and generator where they are used
- ☐☐☐ **[S]** Know that radiation from the Sun is the main source of energy for all our energy resources except geothermal, nuclear and tidal
- ☐☐☐ Give advantages and disadvantages of each method in terms of renewability, availability, reliability, scale and environmental impact
- ☐☐☐ **[S]** Know that energy is released by nuclear fusion in the Sun (detailed knowledge of the process of fusion is not required)
- ☐☐☐ **[S]** Know that energy is released by nuclear fission in nuclear reactors (detailed knowledge of the process of fission is not required)
- ☐☐☐ Understand, qualitatively, the concept of efficiency of energy transfer
- ☐☐☐ **[S]** Define efficiency as: (a) efficiency $= \frac{\text{useful energy output}}{\text{total energy input}} \times 100\%$ (b) efficiency $= \frac{\text{useful power output}}{\text{total power input}} \times 100\%$ recall and use the equations
- ☐☐☐ Define power as work done per unit time and also as energy transferred per unit time; recall and use the equations (a) $P = \frac{W}{t}$ (b) $P = \frac{\Delta E}{t}$

P1.7 Pressure 压强

- ☐☐☐ Describe how pressure varies with force and area in the context of everyday examples
- ☐☐☐ Define pressure as force per unit area; recall and use the equation $p = \frac{F}{A}$

P2. Thermal physics 热物理

P2.1 Kinetic particle model of matter 物质的粒子运动模型

- ☐☐☐ State the distinguishing properties of solids, liquids and gases
- ☐☐☐ Know the terms for the changes in state between solids, liquids and gases (gas to solid and solid to gas changes are not required)

- ☐☐☐ Describe the structure of solids, liquids and gases in terms of the arrangement, separation and motion of the particles and represent these states using simple particle diagrams
- ☐☐☐ **[S]** Know that the forces and distances between particles and the motion of the particles affect the properties of solids, liquids and gases
- ☐☐☐ Describe the relationship between the motion of particles and temperature
- ☐☐☐ Know that the random motion of particles (e.g. smoke particles or pollen grains, that can be viewed with a light microscope) in a suspension is evidence for the kinetic particle model of matter
- ☐☐☐ **[S]** Describe and explain this motion (sometimes known as Brownian motion) in terms of random collisions between particles in the suspension and the much smaller, fast-moving particles of the gas or liquid
- ☐☐☐ **[S]** Describe the pressure of a gas in terms of the forces exerted by particles colliding with surfaces, creating a force per unit area
- ☐☐☐ **[S]** Describe qualitatively, in terms of particles, the effect on the pressure of a fixed mass of gas of: (a) a change of temperature at constant volume (b) a change of volume at constant temperature

P2.2 Thermal properties and temperature 热性质和温度

- ☐☐☐ Describe, qualitatively, the thermal expansion of solids, liquids and gases at constant pressure
- ☐☐☐ **[S]** Explain some of the everyday applications and consequences of thermal expansion
- ☐☐☐ Know the melting and boiling temperatures for water at standard atmospheric pressure (limited to Celsius only)
- ☐☐☐ **[S]** Describe the differences between boiling and evaporation
- ☐☐☐ Describe condensation and solidification (freezing) in terms of particles
- ☐☐☐ **[S]** Describe how temperature, surface area and air movement over a surface affect evaporation
- ☐☐☐ Describe evaporation in terms of the escape of the more energetic particles from the surface of a liquid
- ☐☐☐ Know that evaporation causes cooling of a liquid
- ☐☐☐ Describe melting and boiling in terms of energy input without a change in temperature

P2.3 Transfer of thermal energy 热能传递

- ☐☐☐ Identify and give examples of typical good thermal conductors and bad thermal conductors (thermal insulators)
- ☐☐☐ **[S]** Describe thermal conduction in solids in terms of atomic or molecular lattice vibrations and also in terms of the movement of delocalised (mobile) electrons in metallic conductors
- ☐☐☐ Know that convection is an important method of energy transfer in liquids and gases
- ☐☐☐ Describe convection in liquids and gases
- ☐☐☐ **[S]** Explain convection in liquid and gases in terms of density changes
- ☐☐☐ Know that thermal energy transfer by thermal radiation does not require a medium and is mainly due to infrared radiation
- ☐☐☐ **[S]** Know that the temperature of the Earth is affected by the radiation absorbed by the Earth and the radiation emitted by the Earth
- ☐☐☐ Describe the effect of surface colour (black or white) and texture (dull or shiny) on the emission, absorption and reflection of thermal radiation
- ☐☐☐ **[S]** Describe experiments to distinguish between good and bad emitters of thermal radiation
- ☐☐☐ **[S]** Describe experiments to distinguish between good and bad absorbers of thermal radiation
- ☐☐☐ Identify and explain some of the basic everyday applications and consequences of conduction, convection and radiation

P3. Waves 波

P3.1 General properties of waves 波的一般性质

- ☐☐☐ Know that waves transfer energy without transferring matter
- ☐☐☐ Describe what is meant by wave motion as illustrated by vibration (oscillation) in ropes and springs and by experiments using water waves
- ☐☐☐ **[S]** Know that for a transverse wave, the direction of vibration is at right angles to the direction of propagation and understand that electromagnetic radiation, water waves and seismic S-waves (secondary) are transverse
- ☐☐☐ **[S]** Know that for a longitudinal wave, the direction of vibration is parallel to the direction of propagation and understand that sound waves and seismic P-waves (primary) are longitudinal
- ☐☐☐ Describe the features of a wave in terms of wavelength, frequency, crest (peak), trough, amplitude and wave speed
- ☐☐☐ Describe how waves can undergo: (a) reflection at a plane surface (b) refraction due to a change of speed
- ☐☐☐ **[S]** Describe how waves undergo diffraction through a narrow gap
- ☐☐☐ Recall and use the equation for wave speed $v = f\lambda$
- ☐☐☐ **[S]** Describe how wavelength and gap size affects diffraction through a gap

P3.2 Light 光

- ☐☐☐ Use ray diagrams to define the terms normal, angle of incidence and angle of reflection
- ☐☐☐ Describe the formation of an optical image by a vertical plane mirror and give its characteristics compared with the object, i.e. same size, same distance from mirror, laterally inverted
- ☐☐☐ **[S]** Describe the formation of an optical image by a plane mirror and explain why it is virtual
- ☐☐☐ State that for reflection, the angle of incidence is equal to the angle of reflection; recall and use this relationship
- ☐☐☐ **[S]** Use simple diagrams, measurements and calculations for reflection by plane mirrors
- ☐☐☐ Define refraction as the change in direction of a light ray passing from one medium to another
- ☐☐☐ Define and use the terms normal, angle of incidence and angle of refraction using ray diagrams
- ☐☐☐ **[S]** Define refractive index, n, as the ratio of the speeds of a wave in two different regions
- ☐☐☐ Describe the passage of light through a transparent material (limited to the boundaries between two media only)
- ☐☐☐ **[S]** Recall and use the equation $n = \frac{\sin i}{\sin r}$
- ☐☐☐ **[S]** Describe total internal reflection using ray diagrams
- ☐☐☐ **[S]** Define the critical angle as the angle of incidence at which the angle of refraction is 90° and above which all light is totally internally reflected
- ☐☐☐ **[S]** Describe total internal reflection in optical fibres and state some common applications of optical fibres
- ☐☐☐ Describe the action of a thin converging lens on a parallel beam of light and know that rays of light from an object at distance can be assumed to be parallel
- ☐☐☐ Define and use the terms principal axis, principal focus (focal point) and focal length
- ☐☐☐ Draw and use ray diagrams for the formation of an image by a thin converging lens, limited to real images
- ☐☐☐ **[S]** Draw and use ray diagrams for the formation of a virtual image by a thin converging lens
- ☐☐☐ Describe the characteristics of an image using the terms enlarged / same size / diminished and upright / inverted

- ☐☐☐ [S] Describe the characteristics of an image using the terms real / virtual
- ☐☐☐ [S] Describe the use of a single lens as a magnifying glass
- ☐☐☐ Describe the dispersion of light as illustrated by the refraction of white light by a glass prism
- ☐☐☐ Know the seven colours (red, orange, yellow, green, blue, indigo, violet) of the visible spectrum in order of frequency and in order of wavelength

P3.3 Electromagnetic spectrum 电磁波谱

- ☐☐☐ Know the main regions of the electromagnetic spectrum (radio, microwave, infrared, visible, ultraviolet, X-ray, gamma) in order of frequency and in order of wavelength
- ☐☐☐ Know that all electromagnetic waves travel at the same high speed in a vacuum
- ☐☐☐ [S] Know that the speed of electromagnetic waves in a vacuum is 3.0×10^8 m/s and is approximately the same in air
- ☐☐☐ Know some applications of the different regions of the electromagnetic spectrum including: (a) radio waves; radio and television transmissions, radar (b) microwaves; satellite television, mobile (cell) phone, microwave ovens (c) infrared; remote controllers for televisions, thermal imaging (d) visible light; vision, photography (e) ultraviolet; detecting fake bank notes (f) X-rays; medical scanning, security scanners (g) gamma rays; detection of cancer and its treatment
- ☐☐☐ Describe the harmful effects on people of excessive exposure to electromagnetic radiation, including: (a) ultraviolet; damage to surface cells and eyes, leading to skin cancer and eye conditions (b) X-rays and gamma rays; mutation or damage to cells in the body

P3.4 Sound 声音

- ☐☐☐ Describe the production of sound by vibrating sources
- ☐☐☐ [S] Describe the longitudinal nature of sound waves in air as a series of compressions and rarefactions
- ☐☐☐ [S] Describe, qualitatively, compressions as regions of higher pressure due to particles being closer together and rarefactions as regions of lower pressure due to particles being spread further apart
- ☐☐☐ State the approximate range of frequencies audible to humans as 20 Hz to 20 kHz
- ☐☐☐ Know that a medium is needed to transmit sound waves
- ☐☐☐ Determine the speed of sound in air using a method involving a measurement of distance and time
- ☐☐☐ [S] Know that, in general, sound travels faster in solids than in liquids and faster in liquids than in gases
- ☐☐☐ Describe how changes in amplitude and frequency affect the loudness and pitch of sound waves
- ☐☐☐ Describe an echo as the reflection of a sound wave
- ☐☐☐ Define ultrasound as sound with a frequency higher than 20 kHz

P4. Electricity and magnetism 电与磁

P4.1 Simple phenomena of magnetism 简单磁现象

- ☐☐☐ Describe the forces between magnetic poles and between magnets and magnetic materials, including the use of the terms north pole (N pole) and south pole (S pole), attraction and repulsion, magnetised and unmagnetised
- ☐☐☐ [S] Describe a magnetic field as a region in which a magnetic pole experiences a force
- ☐☐☐ [S] State that the direction of a magnetic field at a point is the direction of the force on the N pole of a magnet at that point
- ☐☐☐ State the differences between the properties of temporary magnets (made of soft iron) and the properties of permanent magnets (made of steel)

☐☐☐ [S] Describe induced magnetism

☐☐☐ State the difference between magnetic and non-magnetic materials

☐☐☐ Describe how a permanent magnet differs from an electromagnet

P4.2 Electrical quantities 电学量

☐☐☐ State that there are positive and negative charges

☐☐☐ [S] State that charge is measured in coulombs

☐☐☐ State that positive charges repel other positive charges, negative charges repel other negative charges, but positive charges attract negative charges

☐☐☐ [S] Describe an electric field as a region in which an electric charge experiences a force

☐☐☐ Describe electrostatic charging by friction, and simple methods to determine if an object is charged

☐☐☐ [S] State that the direction of an electric field at a point is the direction of the force on a positive charge at that point

☐☐☐ Know that charging of solids by friction involves only a transfer of negative charge (electrons)

☐☐☐ Distinguish between electrical conductors and insulators and give typical examples

☐☐☐ Know that electric current is related to the flow of charge

☐☐☐ [S] Define electric current as the charge passing a point per unit time; recall and use the equation $I = \frac{Q}{t}$

☐☐☐ Know that electric current in metals is related to the flow of electrons

☐☐☐ [S] Describe electrical conduction in metals in terms of the movement of delocalised (mobile) electrons

☐☐☐ Describe the use of ammeters (analogue and digital) with different ranges

☐☐☐ [S] State that conventional current is from positive to negative and that the flow of electrons is from negative to positive

☐☐☐ Know the difference between direct current (d.c.) and alternating current (a.c.)

☐☐☐ Describe the voltage of the source as the cause of current in the circuit

☐☐☐ [S] Define electromotive force (e.m.f.) as the electrical work done by a source in moving a unit charge around a complete circuit

☐☐☐ Know that the voltage of the source is shared between the components in a series circuit

☐☐☐ [S] Know that e.m.f. is measured in volts (V)

☐☐☐ Describe the use of voltmeters (analogue and digital) with different ranges

☐☐☐ [S] Define potential difference (p.d.) as the work done by a unit charge passing between two points in a circuit

☐☐☐ [S] Know that the p.d. between two points is measured in volts (V)

☐☐☐ Recall and use the equation for resistance $R = \frac{V}{I}$

☐☐☐ [S] Sketch and explain the current–voltage graph of a resistor of constant resistance

☐☐☐ Describe an experiment to determine resistance using a voltmeter and an ammeter and do the appropriate calculations

☐☐☐ [S] Recall and use the following relationship for a metallic electrical conductor: (a) resistance is directly proportional to length (b) resistance is inversely proportional to cross-sectional area

☐☐☐ Understand that electric circuits transfer energy from a source of electrical energy, such as an electrical cell or mains supply, to the circuit components and then into the surroundings

☐☐☐ Recall and use the equation for electrical power $P = IV$

☐☐☐ Recall and use the equation for electrical energy $E = IVt$

☐☐☐ Define the kilowatt-hour (kW h) and calculate the cost of using electrical appliances where the

energy unit is the kW h

P4.3 Electrical circuits 电路

- ☐☐☐ Draw and interpret circuit diagrams containing cells, batteries, power supplies, switches, resistors (fixed and variable), heaters, lamps, motors, ammeters, voltmeters and fuses, and know how these components behave in the circuit
- ☐☐☐ **[S]** Draw and interpret circuit diagrams containing generators and light-emitting diodes (LEDs), and know how these components behave in the circuit
- ☐☐☐ Know that the current at every point in a series circuit is the same
- ☐☐☐ Know how to construct and use series and parallel circuits
- ☐☐☐ Calculate the combined resistance of two or more resistors in series
- ☐☐☐ **[S]** Recall and use in calculations, the fact that: (a) the sum of the currents entering a junction in a parallel circuit is equal to the sum of the currents that leave the junction (b) the total p.d. across the components in a series circuit is equal to the sum of the individual p.d.s across each component (c) the p.d. across each branch of a parallel arrangement of components is the p.d. across the whole arrangement
- ☐☐☐ Know the advantages of connecting lamps in parallel in a circuit
- ☐☐☐ Know that, for a parallel circuit, the current from the source is larger than the current in each branch
- ☐☐☐ Know that the combined resistance of two resistors in parallel is less than that of either resistor by itself
- ☐☐☐ **[S]** Calculate the combined resistance of two resistors in parallel

P4.4 Electrical safety 用电安全

- ☐☐☐ Describe the heating effect of current
- ☐☐☐ State the hazards of: (a) damaged insulation (b) overheating cables (c) damp conditions (d) excess current from overloading of plugs, extension leads, single and multiple sockets when using a mains supply
- ☐☐☐ Explain the use and operation of trip switches and fuses and choose appropriate fuse ratings and trip switch settings (knowledge of RCDs (Residual Current Devices) is not required)
- ☐☐☐ Explain why the outer casing of an electrical appliance must be either non-conducting (double-insulated) or earthed

P4.5 Electromagnetic effects 电磁效应

- ☐☐☐ **[S]** Know that a conductor moving across a magnetic field or a changing magnetic field linking with a conductor can induce an e.m.f. across the conductor
- ☐☐☐ **[S]** State the factors affecting the magnitude of an induced e.m.f.
- ☐☐☐ **[S]** Describe a simple form of a.c. generator (rotating coil) and the use of slip rings and brushes where needed
- ☐☐☐ **[S]** Sketch and interpret graphs of e.m.f. against time for simple a.c. generators
- ☐☐☐ **[S]** Describe the pattern and direction of the magnetic field due to currents in straight wires and in solenoids
- ☐☐☐ **[S]** Describe the effect on the magnetic field around straight wires and solenoids of changing the magnitude and direction of the current
- ☐☐☐ **[S]** Know that a force acts on a current-carrying conductor in a magnetic field, including the effect of reversing: (a) the current (b) the direction of the field
- ☐☐☐ **[S]** Recall and use the relative directions of force, magnetic field and current

☐☐☐ **[S]** Know that a current-carrying coil in a magnetic field may experience a turning effect and that the effect is increased by increasing: (a) the number of turns on the coil (b) the current (c) the strength of the magnetic field

☐☐☐ **[S]** Describe the operation of an electric motor, including the action of a split-ring commutator and brushes

☐☐☐ **[S]** Describe the construction of a basic transformer with a soft-iron core, as used for voltage transformations

☐☐☐ **[S]** Use the terms primary, secondary, step-up and step-down

☐☐☐ **[S]** Recall and use the equation $\frac{V_\mathrm{p}}{V_\mathrm{s}} = \frac{N_\mathrm{p}}{N_\mathrm{s}}$ where p and s refer to primary and secondary

☐☐☐ **[S]** Recall and use the equation for 100% efficiency in a transformer $I_\mathrm{p}V_\mathrm{p} = I_\mathrm{s}V_\mathrm{s}$ where p and s refer to primary and secondary

☐☐☐ **[S]** Describe the use of transformers in high-voltage transmission of electricity

☐☐☐ **[S]** Recall and use the equation $P = I^2R$ to explain why power losses in cables are smaller when the voltage is greater

P5. Nuclear physics 核物理

P5.1 The nucleus 原子核

☐☐☐ Describe the composition of the nucleus in terms of protons and neutrons

☐☐☐ **[S]** Know the relationship between the proton number and the relative charge on a nucleus

☐☐☐ State the relative charges of protons, neutrons and electrons as +1, 0 and –1 respectively

☐☐☐ **[S]** Describe the processes of nuclear fission and nuclear fusion as the splitting and joining of nuclei

☐☐☐ Define the terms proton number (atomic number) Z and nucleon number (mass number) A and be able to calculate the number of neutrons in a nucleus

☐☐☐ Use the nuclide notation ${}^{A}_{Z}\mathrm{X}$

☐☐☐ State that an element may have more than one isotope and know that some isotopes are radioactive

P5.2 Radioactivity 放射性

☐☐☐ Know what is meant by the terms ionising nuclear radiation and background radiation

☐☐☐ Know the sources that make a significant contribution to background radiation including: (a) radon gas (in the air) (b) rocks and buildings (c) food and drink (d) cosmic rays

☐☐☐ Know that ionising nuclear radiation can be measured using a detector connected to a counter

☐☐☐ Use count rate measured in counts / s or counts / minute

☐☐☐ Identify alpha (α), beta (β) and gamma (γ) emissions by recalling: (a) their nature (b) their relative ionising effects (c) their relative penetrating abilities (β^+ are not included, β-particles will be taken to refer to β^-)

☐☐☐ Know that radioactive decay is a change in an unstable nucleus that can result in the emission of α-particles or β-particles and / or γ-radiation and know that these changes are spontaneous and random

☐☐☐ **[S]** Use decay equations, using nuclide notation, to show the emission of α-particles, β-particles and γ-radiation

☐☐☐ Know that during α-decay or β-decay, the nucleus changes to that of a different element

☐☐☐ Know the change in the nucleus that occurs during β-emission: neutron $\rightarrow$ proton + electron

☐☐☐ Define the half-life of a particular isotope as the time taken for half the nuclei of that isotope in any sample to decay; recall and use this definition in simple calculations, which might involve

information in tables or decay curves (calculations will not include background radiation)

- ☐☐☐ Know the following applications of radioactivity: (a) household fire (smoke) alarms (b) irradiating food to kill bacteria (c) sterilisation of equipment using gamma rays (d) measuring and controlling thicknesses of materials with the choice of radiations used linked to penetration and absorption (e) diagnosis and treatment of cancer using gamma rays
- ☐☐☐ State the effects of ionising nuclear radiation on living things, including cell death, mutations and cancer
- ☐☐☐ Describe how radioactive materials are moved, used and stored in a safe way in terms of time, distance and shielding

P6. Space physics 空间物理

P6.1 The Solar System 太阳系

- ☐☐☐ Describe the Solar System as containing: (a) one star, the Sun (b) the eight named planets and know their order from the Sun (c) minor planets that orbit the Sun, including dwarf planets such as Pluto and asteroids in the asteroid belt (d) moons, that orbit the planets

P6.2 Stars and the Universe 恒星与宇宙

- ☐☐☐ Know that: (a) the Sun is the closest star to the Earth (b) astronomical distances can be measured in light-years, where one light-year is the distance travelled in (the vacuum of) space by light in one year
- ☐☐☐ Calculate the time it takes light to travel a significant distance such as between objects in the Solar System
- ☐☐☐ Know that the Sun contains most of the mass of the Solar System and this explains why the planets orbit the Sun
- ☐☐☐ **[S]** Define orbital speed from the equation $v = \frac{2\pi r}{T}$ where r is the radius of the orbit and T is the orbital period; recall and use this equation
- ☐☐☐ Know that the force that keeps an object in orbit around the Sun is due to the gravitational attraction of the Sun
- ☐☐☐ **[S]** Know that the strength of the Sun's gravitational field decreases and that the orbital speeds of the planets decrease as the distance from the Sun increases
- ☐☐☐ Know that the Sun is a star of medium size, consisting mostly of hydrogen and helium, and that it radiates most of its energy in the infrared, visible and ultraviolet regions of the electromagnetic spectrum
- ☐☐☐ **[S]** Know that stars are powered by nuclear reactions that release energy and that in stable stars the nuclear reactions involve the fusion of hydrogen into helium
- ☐☐☐ Know that stable stars are formed as protostars from interstellar clouds of gas and dust due to gravitational attraction
- ☐☐☐ **[S]** Know that the nebula from a supernova may form new stars with orbiting planets
- ☐☐☐ Know that the next stages of the life cycle of a star depend on its mass, limited to: (a) a small mass star (about the same mass as the Sun): red giant → white dwarf + planetary nebula (b) a large mass star: red supergiant → supernova → neutron star (c) a very large mass star: red supergiant → supernova → black hole
- ☐☐☐ Know that: (a) galaxies are each made up of many billions of stars (b) the Sun is a star in the galaxy known as the Milky Way (c) other stars that make up the Milky Way are much further away from the Earth than the Sun is from the Earth
- ☐☐☐ **[S]** Know that the Big Bang Theory is supported by many astronomical observations and states that: (a) the Universe expanded from a single point of high density and temperature (b) the Universe is still expanding (c) the Universe is approximately 13.8 billion years old

☐☐☐ Know that the Milky Way is one of many billions of galaxies making up the Universe and that the diameter of the Milky Way is approximately 100 000 light-years