Biology content

1. Cell Structure and Organisation

(a) identify cell structures (including organelles) of typical plant and animal cells from diagrams, photomicrographs and as seen under the light microscope using prepared slides and fresh material treated with an appropriate temporary staining technique:

- chloroplasts
- cell membrane
- cell wall
- cytoplasm
- cell vacuoles (large, sap-filled in plant cells, small, temporary in animal cells)
- nucleus

(b) identify the following organelles from diagrams and electron micrographs:

- mitochondria
- ribosomes

(c) state the functions of the organelles identified above

(d) compare the structure of typical animal and plant cells

(e) state, in simple terms, the relationship between cell function and cell structure for the following:

- absorption – root hair cells
- conduction and support – xylem vessels
- transport of oxygen – red blood cells

(f) differentiate cell, tissue, organ and organ system

2. Movement of Substances

(a) define *diffusion* and describe its role in nutrient uptake and gaseous exchange in plants and humans

(b) define *osmosis* and describe the effects of osmosis on plant and animal tissues

3. Biological Molecules

(a) state the roles of water in living organisms

(b) describe and carry out tests for

- starch (iodine in potassium iodide solution)
- reducing sugars (Benedict's solution)
- protein (biuret test)
- fats (ethanol emulsion)

(c) state that large molecules are synthesised from smaller basic units

- glycogen from glucose
- polypeptides and proteins from amino acids
- lipids such as fats from glycerol and fatty acids

(d) explain enzyme action in terms of the 'lock and key' hypothesis (explain the mode of action of enzymes in terms of an active site, enzyme-substrate complex and enzyme specificity)

(e) investigate and explain the effects of temperature and pH on the rate of enzyme catalysed reactions

4. Nutrition in Humans

(a) describe the functions of main regions of the alimentary canal and the associated organs: mouth, salivary glands, oesophagus, stomach, duodenum, pancreas, gall bladder, liver, ileum, colon, rectum, anus, in relation to ingestion, digestion, absorption, assimilation and egestion of food, as appropriate

(b) describe the functions of enzymes (e.g. amylase, maltase, protease, lipase) in digestion, listing the substrates and end-products

(c) state the function of the hepatic portal vein as the transport of blood rich in absorbed nutrients from the small intestine to the liver

(d) state the role of the liver in

- the metabolism of glucose
- the metabolism of amino acids and the formation of urea
- the breakdown of alcohol

5. Nutrition in Plants

(a) identify the cellular and tissue structure of a dicotyledonous leaf, as seen in cross-section under the microscope and state their functions:

- distribution of chloroplasts - photosynthesis
- stomata and mesophyll cells - gaseous exchange
- vascular bundles - transport

(b) state the equation, in words only, for photosynthesis

(c) describe the intake of carbon dioxide and water by plants

(d) state that chlorophyll traps light energy and converts it into chemical energy for the formation of carbohydrates and their subsequent storage

(e) investigate and state the effect of varying light intensity, carbon dioxide concentration and temperature on the rate of photosynthesis (e.g. in submerged aquatic plants)

(f) briefly explain why most forms of life are completely dependent on photosynthesis

6. Transport in Flowering Plants

(a) identify the positions of xylem vessels and phloem in sections of a typical dicotyledonous stem and leaf, under the light microscope, and state their functions

(b) relate the structure and functions of root hairs to their surface area, and to water and ion uptake

(c) state that transpiration is the loss of water vapour from the stomata

(d) briefly explain the movement of water through the stem in terms of transpiration pull

(e) describe
   a. the effects of variation of air movement, temperature, humidity and light intensity on transpiration rate
   b. how wilting occurs

(f) define the term translocation as the transport of food in the phloem tissue

7. Transport in Humans

(a) name the main blood vessels to and from the heart, lungs, liver and kidney

(b) state the functions of blood

- red blood cells – haemoglobin and oxygen transport
- plasma – transport of blood cells, ions, soluble food substances, hormones, carbon dioxide, urea, vitamins, plasma proteins
- white blood cells – phagocytosis, antibody formation and tissue rejection
- platelets – fibrinogen to fibrin, causing clotting

(c) relate the structure of arteries, veins and capillaries to their functions

(d) describe the structure and function of the heart in terms of muscular contraction and the working of valves (histology of the heart muscle, names of nerves and transmitter substances are **not** required)

(e) describe coronary heart disease in terms of the occlusion of coronary arteries and list the possible causes, such as diet, stress and smoking, stating the possible preventative measures

8. Respiration in Humans

(a) identify on diagrams and name the larynx, trachea, bronchi, bronchioles, alveoli and associated capillaries and state their functions in human gas exchange

(b) state the characteristics of, and describe the role of, the exchange surface of the alveoli in gas exchange

(c) describe the effect of tobacco smoke and its major toxic components – nicotine, tar and carbon monoxide, on health

(d) define and state the equation, in words only, for aerobic respiration in humans

(e) define and state the equation, in words only, for anaerobic respiration in humans

(f) describe the effect of lactic acid in muscles during exercise

9. Co-ordination and Response in Humans

(a) state the relationship between receptors, the central nervous system and the effectors

(b) state the principal functions of component parts of the eye in producing a focused image of near and distant objects on the retina

(c) describe the pupil reflex in response to bright and dim light

(d) outline the functions of sensory neurones, relay neurones and motor neurones

(e) define a *hormone* as a chemical substance, produced by a gland, carried by the blood, which alters the activity of one or more specific target organs and is then destroyed by the liver

(f) state what is meant by an endocrine gland, with reference to the islets of Langerhans in the pancreas

(g) outline how the blood glucose level concentration is regulated by insulin and glucagon

10. Reproduction

(a) define *asexual reproduction* as the process resulting in the production of genetically identical offspring from one parent

(b) define *sexual reproduction* as the process involving the fusion of nuclei to form a zygote and the production of genetically dissimilar offspring

(c) state the functions of the sepals, petals, anthers and carpels

(d) outline the process of pollination

(e) describe the growth of the pollen tube and its entry into the ovule followed by fertilisation (production of endosperm and details of development are **not** required)

(f) identify on diagrams, the male reproductive system and give the functions of: testes, scrotum, sperm ducts, prostate gland, urethra and penis

(g) identify on diagrams, the female reproductive system and give the functions of: ovaries, oviducts, uterus, cervix and vagina

(h) briefly describe the menstrual cycle with reference to the alternation of menstruation and ovulation, the natural variation in its length, and the fertile and infertile phases of the cycle, with reference to the roles of progesterone and estrogen only

(i) briefly describe fertilisation and early development of the zygote simply in terms of the formation of a ball of cells which becomes implanted in the wall of the uterus

(j) discuss the spread of human immunodeficiency virus (HIV) and methods by which it may be controlled

11. Molecular Genetics

(a) outline the relationship between genes, chromosomes and DNA

(b) state the structure of DNA in terms of the bases, sugar and phosphate groups found in each of their nucleotides

(c) state the rule of complementary base pairing

(d) state that DNA is used to carry the genetic code, (details of transcription and translation are **not** required)

(e) state that each gene
- is a sequence of nucleotides, as part of a DNA molecule
- controls the production of one polypeptide

12. Inheritance

(a) define a *gene* as a unit of inheritance and distinguish clearly between the terms *gene* and *allele*

(b) describe the difference between continuous and discontinuous variation and give examples of each

(c) explain the terms dominant, recessive, homozygous, heterozygous, phenotype and genotype

(d) predict the results of simple crosses with expected ratios of 3:1 and 1:1, using the terms homozygous, heterozygous, F_1 generation and F_2 generation

(e) state why observed ratios often differ from expected ratios, especially when there are small numbers of progeny

(f) describe the determination of sex in humans – XX and XY chromosomes

(g) describe mutation as a change in the structure of a gene such as in sickle cell anaemia, or in the chromosome number, such as the 47 chromosomes in the condition known as Down's syndrome

(h) name radiation and chemicals as factors which may increase the rate of mutation

13. Organisms and their Environment

(a) briefly describe the non-cyclical nature of energy flow

(b) establish the relationship of the following in food webs: producer, consumer, herbivore, carnivore,
decomposer, food chain, trophic level

(c) describe how energy losses between trophic levels and infer the advantages of short food chains

(d) interpret pyramids of numbers and biomass

(e) explain the importance of the carbon cycle and outline the role of forests and oceans as carbon sinks

(f) evaluate the effects of

- water pollution by sewage
- pollution due to insecticides including bioaccumulation up food chains and impact on top carnivores

(g) outline the roles of microorganisms in sewage treatment as an example of environmental biotechnology

(h) discuss reasons for conservation of species with reference to the maintenance of biodiversity and how this is done, e.g. management of fisheries and management of timber production

Chemistry Content

1. Experimental Chemistry

(a) Experimental design

- name appropriate apparatus for the measurement of time, temperature, mass and volume, including burettes, pipettes, measuring cylinders and gas syringes
- suggest suitable apparatus, given relevant information, for a variety of simple experiments, including collection of gases and measurement of rates of reaction.

(b) Methods of purification and analysis

- describe methods of separation and purification for the components of mixtures, to include:
  - (i) use of a suitable solvent, filtration and crystallisation or evaporation
  - (ii) distillation and fractional distillation
  - (iii) paper chromatography
- suggest suitable separation and purification methods, given information about the substances involved in the following types of mixtures:
  - (i) solid-solid
  - (ii) solid-liquid
  - (iii) liquid-liquid (miscible)
- interpret paper chromatograms (the use of Rf values is not required)
- deduce from given melting point and boiling point data the identities of substances and their purity

(c) Identification of ions and gases

- describe the use of aqueous sodium hydroxide and aqueous ammonia to identify the following aqueous cations: aluminium, ammonium, calcium, copper(II), iron(II), iron(III), lead(II) and zinc (formulae of complex ions are not required)
- describe tests to identify the following anions: carbonate (by the addition of dilute acid and subsequent use of limewater); chloride (by reaction of an aqueous solution with nitric acid and aqueous silver nitrate); iodide (by reaction of an aqueous solution with nitric acid and aqueous silver nitrate); nitrate (by reduction with aluminium in aqueous sodium hydroxide to ammonia and subsequent use of litmus paper) and sulfate (by reaction of an aqueous solution with nitric acid and aqueous barium nitrate)
- describe tests to identify the following gases: ammonia (using damp red litmus paper); carbon dioxide (using limewater); chlorine (using damp litmus paper); hydrogen (using a burning splint); oxygen (using a glowing splint) and sulfur dioxide (using acidified potassium manganate(VII)).

2. The Particulate Nature of Matter

(a) Kinetic particle theory

- describe the solid, liquid and gaseous states of matter and explain their interconversion in terms of the kinetic particle theory and of the energy changes involved

(b) Atomic structure

- state the relative charges and approximate relative masses of a proton, a neutron and an electron

- describe, with the aid of diagrams, the structure of an atom as containing protons and neutrons (nucleons) in the nucleus and electrons arranged in shells (energy levels) (knowledge of s, p, d and f classification is not required; a copy of the Periodic Table will be available)
- define proton (atomic) number and nucleon (mass) number
- interpret and use symbols such as $^{11}_{6}C$
- define the term isotopes
- deduce the numbers of protons, neutrons and electrons in atoms and ions given proton and nucleon numbers.

(c) Structure and properties of materials

- describe the differences between elements, compounds and mixtures

(d) Ionic bonding

- describe the formation of ions by electron loss/gain in order to obtain the electronic configuration of a noble gas
- describe the formation of ionic bonds between metals and non-metals, e.g. NaCl; $MgCl_2$
- relate the physical properties (including electrical property) of ionic compounds to their lattice structure.

(e) Covalent bonding

- describe the formation of a covalent bond by the sharing of a pair of electrons in order to gain the electronic configuration of a noble gas
- describe, using 'dot-and-cross' diagrams, the formation of covalent bonds between non-metallic elements, e.g. H_2; O_2; H_2O; CH_4; CO_2
- deduce the arrangement of electrons in other covalent molecules
- relate the physical properties (including electrical property) of covalent substances to their structure and bonding.

3. Formulae, Stoichiometry and the Mole Concept

- state the symbols of the elements and formulae of the compounds mentioned in the syllabus
- deduce the formulae of simple compounds from the relative numbers of atoms present and vice versa
- deduce the formulae of ionic compounds from the charges on the ions present and vice versa
- interpret chemical equations with state symbols
- construct chemical equations, with state symbols, including ionic equations
- define relative atomic mass, Ar
- define relative molecular mass, Mr, and calculate relative molecular mass (and relative formula mass) as the sum of relative atomic masses
- calculate stoichiometric reacting masses and volumes of gases (one mole of gas occupies 24 dm^3 at room temperature and pressure); calculations involving the idea of limiting reactants may be set (Knowledge of the gas laws and the calculations of gaseous volumes at different temperatures and pressures are not required.)
- apply the concept of solution concentration (in mol / dm^3 or g / dm^3) to process the results of volumetric experiments and to solve simple problems (Appropriate guidance will be provided where unfamiliar reactions are involved. Calculation on % yield and % purity)

4. Energy Changes

- describe the term exothermic as a process or chemical reaction which transfers energy, often in the form of heat, to the surroundings and may be detected by an increase in temperature, e.g. the reaction between sodium hydroxide and hydrochloric acid
- describe the term endothermic as a process or chemical reaction which takes in energy, often in the form of heat, from the surroundings and may be detected by a decrease in temperature, e.g. the dissolving of ammonium nitrate in water

5. Chemical Reactions

(a) Speed of reaction

- describe the effect of concentration, pressure, particle size and temperature on the speeds of reactions and explain these effects in terms of collisions between reacting particles
- interpret data obtained from experiments concerned with speed of reaction.

(b) Redox

- define oxidation and reduction (redox) in terms of oxygen/hydrogen gain/loss
- define redox in terms of electron transfer and changes in oxidation state
- describe the use of aqueous potassium iodide and acidified potassium manganate(VII) in testing for oxidising and reducing agents from the resulting colour changes.

6. Acids, Bases and Salts

(a) Acids and bases

- describe the meanings of the terms acid and alkali in terms of the ions they produce in aqueous solution and their effects on Universal Indicator
- describe how to test hydrogen ion concentration and hence relative acidity using Universal Indicator and the pH scale
- describe the characteristic properties of acids as in reactions with metals, bases and carbonates
- describe the reaction between hydrogen ions and hydroxide ions to produce water, $H^+ + OH^- \rightarrow H2O$, as neutralization
- describe the importance of controlling the pH in soils and how excess acidity can be treated using calcium hydroxide
- describe the characteristic properties of bases in reactions with acids and with ammonium salts
- classify oxides as acidic, basic, amphoteric or neutral based on metallic/non-metallic character.

(b) Salts

- describe the techniques used in the preparation, separation and purification of salts (methods for preparation should include precipitation and titration together with reactions of acids with metals, insoluble bases and insoluble carbonates)
- suggest a method of preparing a given salt from suitable starting materials, given appropriate information.

7. The Periodic Table

(a) Periodic trends

- describe the Periodic Table as an arrangement of the elements in the order of increasing proton (atomic) number
- describe how the position of an element in the Periodic Table is related to proton number and electronic structure
- explain the similarities between the elements in the same group of the Periodic Table in terms of their electronic structure
- describe the change from metallic to non-metallic character from left to right across a period of the Period Table
- describe the relationship between group number, number of valency electrons and metallic/ non-metallic character
- predict the properties of elements in Group I and Group VII using the Periodic Table.

(b) Group properties

- describe lithium, sodium and potassium in Group I (the alkali metals) as a collection of relatively soft, low-density metals showing a trend in melting point and in their reaction with water
- describe chlorine, bromine and iodine in Group VII (the halogens) as a collection of diatomic, nonmetals showing a trend in colour, state and their displacement reactions with solutions of other halide ions
- describe the lack of reactivity of the noble gases in terms of their electronic structures.

8. Metals

(a) Properties of metals

- describe the general physical properties of metals as solids having high melting and boiling points, malleable, good conductors of heat and electricity in terms of their structure
- describe alloys as a mixture of a metal with another element, e.g. brass; stainless steel
- identify representations of metals and alloys from diagrams of structures

(b) Reactivity series

- place in order of reactivity calcium, copper, (hydrogen), iron, lead, magnesium, potassium, silver, sodium and zinc by reference to the reactions, if any, of the metals with water, steam and dilute hydrochloric acid
- deduce the order of reactivity from a given set of experimental results

(c) Extraction of metals

- describe the ease of obtaining metals from their ores by relating the elements to their positions in the reactivity series.

(d) Recycling of metals

- describe metal ores as a finite resource and hence the need to recycle metals, e.g. recycling of iron
- discuss the social, economic and environmental issues of recycling metals.

(e) Iron

- describe and explain the essential reactions in the extraction of iron using haematite, limestone and coke in the blast furnace
- describe the essential conditions for the corrosion (rusting) of iron as the presence of oxygen and water; prevention of rusting can be achieved by placing a barrier around the metal, e.g. painting; greasing; plastic coating;

9. Air

- describe the volume composition of gases present in dry air as being approximately 78% nitrogen, 21% oxygen and the remainder being noble gases (with argon as the main constituent) and carbon dioxide
- name some common atmospheric pollutants, e.g. carbon monoxide; methane; nitrogen oxides (NO and NO_2); ozone; sulfur dioxide; unburned hydrocarbons
- state the sources of these pollutants as
  - (i) carbon monoxide from incomplete combustion of carbon-containing substances
  - (ii) nitrogen oxides from lightning activity and internal combustion engines
  - (iii) sulfur dioxide from volcanoes and combustion of fossil fuels
- discuss some of the effects of these pollutants on health and on the environment
  - (i) the poisonous nature of carbon monoxide
  - (ii) the role of nitrogen dioxide and sulfur dioxide in the formation of 'acid rain' and its effects on respiration and buildings

10. Organic Chemistry

(a) Fuels and crude oil

- name natural gas, mainly methane, and petroleum as sources of energy
- describe petroleum as a mixture of hydrocarbons and its separation into useful fractions by fractional distillation
- name the following fractions and state their uses
  - (i) petrol (gasoline) as a fuel in cars
  - (ii) naphtha as the feedstock and main source of hydrocarbons used for the production of a wide range of organic compounds in the petrochemical industry
  - (iii) paraffin (kerosene) as a fuel for heating and cooking and for aircraft engines
  - (iv) diesel as a fuel for diesel engines
  - (v) lubricating oils as lubricants and as a source of polishes and waxes
  - (vi) bitumen for making road surfaces

(b) Alkanes

- describe a homologous series as a group of compounds with a general formula, similar chemical properties and showing a gradation in physical properties as a result of increase in the size and mass of the molecules, e.g. melting and boiling points; viscosity; flammability
- describe the alkanes as a homologous series of saturated hydrocarbons with the general formula C_nH_{2n+2}
- draw the structures of branched and unbranched alkanes, C_1 to C_3, and name the unbranched alkanes methane to propane

- describe the properties of alkanes (exemplified by methane) as being generally unreactive except in terms of combustion and substitution by chlorine.

(c) Alkenes

- describe the alkenes as a homologous series of unsaturated hydrocarbons with the general formula C_nH_{2n}
- draw the structures of branched and unbranched alkenes, C2 to C3, and name the unbranched alkenes ethene to propene
- describe the manufacture of alkenes and hydrogen by cracking hydrocarbons and recognise that cracking is essential to match the demand for fractions containing smaller molecules from the refinery process
- describe the difference between saturated and unsaturated hydrocarbons from their molecular structures and by using aqueous bromine
- describe the properties of alkenes (exemplified by ethene) in terms of combustion, polymerization and the addition reactions with bromine, steam and hydrogen
- state the meaning of polyunsaturated when applied to food products
- describe the manufacture of margarine by the addition of hydrogen to unsaturated vegetable oils to form a solid product
- describe the formation of poly(ethene) as an example of addition polymerisation of ethene as the monomer
- state some uses of poly(ethene) as a typical plastic, e.g. plastic bags; clingfilm
- deduce the structure of the addition polymer product from a given monomer and vice versa
- describe the pollution problems caused by the disposal of non-biodegradable plastics.

(d) Alcohols

- describe the alcohols as a homologous series containing the –OH group
- draw the structures of alcohols, C1 to C3, and name the unbranched alcohols methanol to propanol
- describe the properties of alcohols in terms of combustion and oxidation to carboxylic acids
- describe the formation of ethanol by fermentation of glucose.

(e) Carboxylic acids

- describe the carboxylic acids as a homologous series containing the $–CO_2H$ group
- describe the formation of ethanoic acid by the oxidation of ethanol by atmospheric oxygen or acidified potassium manganate(VII).