Ngee Ann Polytechnic

Admission for Academic Year 2025 Intake

Entrance Test Subject Syllabus

ENGLISH ENTRANCE TEST SYLLABUS

AIM: To assess the written English Language proficiency of the candidates for placement purpose in the polytechnics. By passing the test, a student is deemed to have the basic foundation in English Language to enrol in a diploma course with English as the medium of instruction.

OBJECTIVES

Candidates should be able to:

(i) Apply the use of grammatical structures correctly in a given context/passage.

(ii) Show understanding of how use of language achieves purpose and impact

(iii) Derive meaning from context and knowledge of vocabulary

(iv) Use varied sentence structures and a wide and appropriate vocabulary with clarity and precision

FORMAT

Students are given 1.5 hours to complete the test which is made up of five sections.

This includes reading time. The five sections will be set as follows:

1) Section I – Grammar (30 marks)

2) Section II – Vocabulary (30 marks)

3) Section III – Cloze Passage (10 marks)

4) Section IV – Editing (20 marks)

5) Section V – Comprehension (10 marks)

Section I consists of multiple-choice questions testing the knowledge of grammatical structures.

Section II consists of multiple-choice questions assessing vocabulary skills.

Section III consists of a cloze passage which requires students to fill in the blanks with the correct words.

Section IV comprises of two passages which require students to edit errors and to fill in the blanks with the correct words.

Section V requires students to read a text and answer multiple-choice questions related to it.

Syllabus for Maths Entrance Test

Arithmetic

1. Use of non-programmable scientific calculators.
2. Factors and multiples, highest common factor, lowest common multiple.
3. Fractions, arithmetical operations on fractions. Decimals. Approximations, decimal places, significant figures and standard form.
4. Applications of averages, percentages, ratios, proportions and rates.

Mensuration

5. Areas and perimeters of square, rectangle, triangle, parallelogram, trapezium, and circle.
6. Surface areas, volumes, weights and densities of cube, cuboid, cylinder, prism, pyramid, cone and sphere.

Algebra

7. The laws of indices and their manipulation.
8. Addition, subtraction, multiplication and division of polynomials.
9. Factorisation, perfect square, difference of two squares, factorisation of quadratic polynomials, factorisation by grouping.
10. Manipulation of formulae: change of subject of a formula and evaluation of formulae.
11. Manipulation of algebraic fractions.
12. Solving linear equations.
13. Solving quadratic equations by (i) factorization, (ii) formula.
14. Solving simultaneous linear equations with two unknowns.

Trigonometry

15. Angular measure in radians.
16. Length of arc and area of sector.
17. Pythagoras Theorem.
18. Trigonometric ratios of acute angles including special angles of $0^\circ, 30^\circ, 45^\circ, 60^\circ$ and 90°.
19. Trigonometric ratios for angles of any magnitude.
20. Problems based on right-angled triangle including angles of elevation and depression, bearings and distances.
21. Solution of triangles including simple three-dimensional problems and use of sine and cosine rules for acute–angled triangles.

Graph

22. Graphs of equations of the linear form $y = mx + c$, graphs of quadratic form $y = ax^2 + bx + c$ and cubic form $y = ax^3 + bx^2 + cx + d$.
23. Interpretation and use of graphs (interpolation and extrapolation).

Geometry

24. Similarity and congruency. Areas of volumes of similar figures.
25. Symmetry and angle properties of circle and polygon.

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SYLLABUS FOR BIOLOGY ENTRANCE TEST

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

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

- endoplasmic reticulum
- mitochondria
- Golgi body
- ribosomes

(c) state the functions of the membrane systems and 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

(c) define *active transport* and discuss its importance as an energy-consuming process by which substances are transported against a concentration gradient, as in ion uptake by root hairs and uptake of glucose by cells in the villi

3. Biological Molecules

(a) state the roles of water in living organisms

(b) list the chemical elements which make up

- carbohydrates
- fats
- proteins

(c) describe and carry out tests for

- starch (iodine in potassium iodide solution)
- reducing sugars (Benedict's solution)

- protein (biuret test)
- fats (ethanol emulsion)

(d) 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

(e) explain enzyme action in terms of the ‘lock and key’ hypothesis

(f) explain the mode of action of enzymes in terms of an active site, enzyme-substrate complex, lowering of activation energy and enzyme specificity

(g) 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 peristalsis in terms of rhythmic wave-like contractions of the muscles to mix and propel the contents of the alimentary canal

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

(d) describe the structure of a villus and its role, including the role of capillaries and lacteals in absorption

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

(f) state the role of the liver in

- carbohydrate metabolism
- fat digestion
- breakdown of red blood cells
- metabolism of amino acids and the formation of urea
- breakdown of alcohol

(g) describe the effects of excessive consumption of alcohol: reduced self-control, depressant, effect on reaction times, damage to liver and social implications

5. Nutrition in Plants

(a) identify and label the cellular and tissue structure of a dicotyledonous leaf, as seen in transverse section using the light microscope and describe the significance of these features in terms of their functions, such as the

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

(b) state the equation, in words and symbols, 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 uses

(e) investigate and discuss the effects of varying light intensity, carbon dioxide concentration and temperature on the rate of photosynthesis (e.g. in submerged aquatic plant)

(f) discuss light intensity, carbon dioxide concentration and temperature as limiting factors on the rate of photosynthesis

6. Transport in Flowering Plants

(a) identify the positions and explain the functions of xylem vessels, phloem (sieve tube elements and companion cells) in sections of a herbaceous dicotyledonous leaf and stem, using the light microscope

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

(c) explain the movement of water between plant cells, and between them and the environment in terms of water potential (calculations on water potential are **not** required)

(d) outline the pathway by which water is transported from the roots to the leaves through the xylem vessels

(e) define the term *transpiration* and explain that transpiration is a consequence of gaseous exchange in plants

(f) describe and explain

- the effects of variation of air movement, temperature, humidity and light intensity on transpiration rate
- how wilting occurs

(g) define the term *translocation* as the transport of food in the phloem tissue and illustrate the process through translocation studies

7. Transport in Humans

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

(b) state the role of blood in transport and defence

- 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) list the different ABO blood groups and all possible combinations for the donor and recipient in blood transfusions

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

(e) describe the transfer of materials between capillaries and tissue fluid

(f) describe the structure and function of the heart in terms of muscular contraction and the working of valves

(g) outline the cardiac cycle in terms of what happens during systole and diastole (histology of the heart muscle, names of nerves and transmitter substances are **not** required)

(h) 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

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

(c) describe the removal of carbon dioxide from the lungs, including the role of the carbonic anhydrase enzyme

(d) describe the role of cilia, diaphragm, ribs and intercostal muscles in breathing

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

(f) define and state the equation, in words and symbols, for aerobic respiration in humans

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

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

9. Excretion in Humans

(a) define *excretion* and explain the importance of removing nitrogenous and other compounds from the body

(b) outline the function of the nephron with reference to ultra-filtration and selective reabsorption in the production of urine

(c) outline the role of anti-diuretic hormone (ADH) in osmoregulation

(d) outline the mechanism of dialysis in the case of kidney failure

10. Homeostasis

(a) define *homeostasis* as the maintenance of a constant internal environment

(b) explain the basic principles of homeostasis in terms of stimulus resulting from a change in the internal environment, a corrective mechanism and negative feedback

(c) identify on a diagram of the skin: hairs, sweat glands, temperature receptors, blood vessels and fatty tissue

(d) describe the maintenance of a constant body temperature in humans in terms of insulation and the role of: temperature receptors in the skin, sweating, shivering, blood vessels near the skin surface and the co-ordinating role of the hypothalamus

11. Co-ordination and Response in Humans

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

(b) describe the structure of the eye as seen in front view and in horizontal section

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

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

(e) state that the nervous system – brain, spinal cord and nerves, serves to co-ordinate and regulate bodily functions

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

(g) discuss the function of the brain and spinal cord in producing a co-ordinated response as a result of a specific stimulus in a reflex action

(h) 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

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

(j) state the role of the hormone adrenaline in boosting blood glucose levels and give examples of situations in which this may occur

(k) explain how the blood glucose concentration is regulated by insulin and glucagon as a homeostatic mechanism

(l) describe the signs, such as an increased blood glucose level and glucose in urine, and the treatment of *diabetes mellitus* using insulin

12. 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) identify and draw, using a hand lens if necessary, the sepals, petals, stamens and carpels of one, locally available, named, insect-pollinated, dicotyledonous flower, and examine the pollen grains using a microscope

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

(e) use a hand lens to identify and describe the stamens and stigmas of one, locally available, named, wind-pollinated flower, and examine the pollen grains using a microscope

(f) outline the process of pollination and distinguish between self-pollination and cross-pollination

(g) compare, using fresh specimens, an insect-pollinated and a wind-pollinated flower

(h) 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)

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

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

(k) 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 effects of progesterone and estrogen only

(l) 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

(m) state the functions of the amniotic sac and the amniotic fluid

(n) describe the function of the placenta and umbilical cord in relation to exchange of dissolved nutrients, gases and excretory products (structural details are **not** required)

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

13. Cell Division

(a) state the importance of mitosis in growth, repair and asexual reproduction

(b) explain the need for the production of genetically identical cells

(c) identify, with the aid of diagrams, the main stages of mitosis

(d) state what is meant by *homologous pairs* of chromosomes

(e) identify, with the aid of diagrams, the main stages of meiosis (names of the sub-divisions of prophase are

not required)

(f) define the terms *haploid* and *diploid*, and explain the need for a reduction division process prior to fertilisation in sexual reproduction

(g) state how meiosis and fertilisation can lead to variation

14. Molecular Genetics

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

(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, which is used to synthesise specific polypeptides (details of transcription and translation are **not** required)

(e) state that each gene is a sequence of nucleotides, as part of a DNA molecule

(f) explain that genes may be transferred between cells. Reference should be made to the transfer of genes between organisms of the same species or different species – transgenic plants or animals

(g) briefly explain how a gene that controls the production of human insulin can be inserted into bacterial DNA to produce human insulin in medical biotechnology

(h) discuss the social and ethical implications of genetic engineering, with reference to a named example

15. Inheritance

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

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

(c) 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

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

(e) use genetic diagrams to solve problems involving monohybrid inheritance (genetic diagrams involving autosomal linkage or epistasis are **not** required)

(f) explain co-dominance and multiple alleles with reference to the inheritance of the ABO blood group phenotypes (A, B, AB and O) and the gene alleles ($\mathbf{I}^A$, $\mathbf{I}^B$ and $\mathbf{I}^o$)

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

(h) 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 syndrome

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

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

(k) state that variation and competition lead to differential survival of, and reproduction by, those organisms best fitted to the environment

(l) give examples of environmental factors that act as forces of natural selection

(m) explain the role of natural selection as a possible mechanism for evolution

(n) give examples of artificial selection such as in the production of economically important plants and animals

16. Organisms and their Environment

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

(b) explain the terms producer, consumer and trophic level in the context of food chains and food webs

(c) explain how energy losses occur along food chains, and discuss the efficiency of energy transfer between trophic levels

(d) describe and interpret pyramids of numbers and biomass

(e) describe how carbon is cycled within an ecosystem and outline the role of forests and oceans as carbon sinks

(f) evaluate the effects of

- water pollution by sewage and by inorganic waste
- 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

END

SYLLABUS FOR CHEMISTRY ENTRANCE TEST

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) sublimation
  (iii) distillation and fractional distillation
  (iv) use of a separating funnel
  (v) 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 and immiscible)
- interpret paper chromatograms including comparison with ‘known’ samples and the use of Rf values
- explain the need to use locating agents in the chromatography of colourless compounds (knowledge of specific locating agents is not required)
- deduce from given melting point and boiling point data the identities of substances and their purity
- explain that the measurement of purity in substances used in everyday life, e.g. foodstuffs and drugs, is important.

(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
- describe and explain evidence for the movement of particles in liquids and gases (the treatment of Brownian motion is not required)
- explain everyday effects of diffusion in terms of particles, e.g. the spread of perfumes and cooking aromas; tea and coffee grains in water
- state qualitatively the effect of molecular mass on the rate of diffusion and explain the dependence of rate of diffusion on temperature.

(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 $^{12}_{6}C$
- 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
- compare the structure of simple molecular substances, e.g. methane; iodine, with those of giant molecular substances, e.g. poly(ethene); sand (silicon dioxide); diamond; graphite in order to deduce their properties
- compare the bonding and structures of diamond and graphite in order to deduce their properties such as electrical conductivity, lubricating or cutting action (candidates will not be required to draw the structures)
- deduce the physical and chemical properties of substances from their structures and bonding and vice versa.

(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. $NaCl$; $MgCl_2$
- state that ionic materials contain a giant lattice in which the ions are held by electrostatic attraction, e.g. $NaCl$ (candidates will not be required to draw diagrams of ionic lattices)
- deduce the formulae of other ionic compounds from diagrams of their lattice structures, limited to binary compounds
- 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.

(f) Metallic bonding

- describe metals as a lattice of positive ions in a 'sea of electrons'
- relate the electrical conductivity of metals to the mobility of the electrons in the structure

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 the percentage mass of an element in a compound when given appropriate information
- calculate empirical and molecular formulae from relevant data
- 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.)
- calculate % yield and % purity.

4. Electrolysis

- describe electrolysis as the conduction of electricity by an ionic compound (an electrolyte), when molten or dissolved in water, leading to the decomposition of the electrolyte
- describe electrolysis as evidence for the existence of ions which are held in a lattice when solid but which are free to move when molten or in solution
- describe, in terms of the mobility of ions present and the electrode products, the electrolysis of molten sodium chloride, using inert electrodes
- predict the likely products of the electrolysis of a molten binary compound
- apply the idea of selective discharge based on

(i) cations: linked to the reactivity series

(ii) anions: halides, hydroxides and sulfates (e.g. aqueous copper(II) sulfate and dilute sodium chloride solution (as essentially the electrolysis of water))

(iii) concentration effects (as in the electrolysis of concentrated and dilute aqueous sodium chloride)

(In all cases above, inert electrodes are used.)

- predict the likely products of the electrolysis of an aqueous electrolyte, given relevant information
- construct ionic equations for the reactions occurring at the electrodes during the electrolysis, given relevant information
- describe the electrolysis of aqueous copper(II) sulfate with copper electrodes as a means of purifying copper (no technical details are required)
- describe the electroplating of metals, e.g. copper plating, and state one use of electroplating
- describe the production of electrical energy from simple cells (i.e. two electrodes in an electrolyte) linked to the reactivity series and redox reactions (in terms of electron transfer).

5. Energy from Chemicals

- describe the meaning of enthalpy change in terms of exothermic (ΔH negative) and endothermic (ΔH positive) reactions
- represent energy changes by energy profile diagrams, including reaction enthalpy changes and activation energies
- describe bond breaking as an endothermic process and bond making as an exothermic process
- explain overall enthalpy changes in terms of the energy changes associated with the breaking and making of covalent bonds
- describe hydrogen, derived from water or hydrocarbons, as a potential fuel, reacting with oxygen to generate electricity directly in a fuel cell (details of the construction and operation of a fuel cell are not required).

6. 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
- define the term catalyst and describe the effect of catalysts (including enzymes) on the speeds of reactions
- explain how pathways with lower activation energies account for the increase in speeds of reactions
- state that some compounds act as catalysts in a range of industrial processes and that enzymes are biological catalysts
- suggest a suitable method for investigating the effect of a given variable on the speed of a reaction
- interpret data obtained from experiments concerned with speed of reaction.

(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
- identify redox reactions in terms of oxygen/hydrogen gain/loss, electron gain/loss 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.

7. 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 qualitatively the difference between strong and weak acids in terms of the extent of ionization
- describe the characteristic properties of acids as in reactions with metals, bases and carbonates
- state the uses of sulfuric acid in the manufacture of detergents and fertilisers; and as a battery acid
- describe the reaction between hydrogen ions and hydroxide ions to produce water, $H^+ + OH^- \rightarrow H_2O$, 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)
- describe the general rules of solubility for common salts to include nitrates, chlorides (including silver and lead), sulfates (including barium, calcium and lead), carbonates, hydroxides, salts of Group I cations and ammonium salts
- suggest a method of preparing a given salt from suitable starting materials, given appropriate information.

(c) Ammonia

- describe the use of nitrogen, from air, and hydrogen, from the cracking of crude oil, in the manufacture of ammonia
- state that some chemical reactions are reversible, e.g. manufacture of ammonia
- describe the essential conditions for the manufacture of ammonia by the Haber process
- describe the displacement of ammonia from its salts.

8. 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
- describe the relationship between group number and the ionic charge of an ion of an element

- 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 elements in Group 0 (the noble gases) as a collection of monatomic elements that are chemically unreactive and hence important in providing an inert atmosphere, e.g. argon and neon in light bulbs; helium in balloons; argon in the manufacture of steel
- describe the lack of reactivity of the noble gases in terms of their electronic structures.

(c) Transition elements

- describe typical transition elements as metals having high melting point, high density, variable oxidation state and forming coloured compounds
- state that the elements and/or their compounds are often able to act as catalysts.

9. 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
- explain why alloys have different physical properties to their constituent elements.

(b) Reactivity series

- place in order of reactivity calcium, copper, (hydrogen), iron, lead, magnesium, potassium, silver, sodium and zinc by reference to
  - (i) the reactions, if any, of the metals with water, steam and dilute hydrochloric acid,
  - (ii) the reduction, if any, of their oxides by carbon and/or by hydrogen
- describe the reactivity series as related to the tendency of a metal to form its positive ion, illustrated by its reaction with
  - (i) the aqueous ions of the other listed metals
  - (ii) the oxides of the other listed metals
- deduce the order of reactivity from a given set of experimental results
- describe the action of heat on the carbonates of the listed metals and relate thermal stability to the reactivity series.

(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 steels as alloys which are a mixture of iron with carbon or other metals and how controlled use of these additives changes the properties of the iron, e.g. high carbon steels are strong but brittle whereas low carbon steels are softer and more easily shaped
- state the uses of mild steel, e.g. car bodies; machinery, and stainless steel, e.g. chemical plants; cutlery; surgical instruments
- 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; galvanizing
- describe the sacrificial protection of iron by a more reactive metal in terms of the reactivity series where the more reactive metal corrodes preferentially, e.g. underwater pipes have a piece of magnesium attached to them.

10. 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
- describe the reactions used in possible solutions to the problems arising from some of the pollutants named above
    - (i) the redox reactions in catalytic converters to remove combustion pollutants
    - (ii) the use of calcium carbonate to reduce the effect of ‘acid rain’ and in flue gas desulfurisation
- 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
- discuss the importance of the ozone layer and the problems involved with the depletion of ozone by reaction with chlorine-containing compounds, chlorofluorocarbons (CFCs)

- describe the carbon cycle in simple terms, to include
  (i) the processes of combustion, respiration and photosynthesis
  (ii) how the carbon cycle regulates the amount of carbon dioxide in the atmosphere
- state that carbon dioxide and methane are greenhouse gases and may contribute to global warming, give the sources of these gases and discuss the possible consequences of an increase in global warming.

11. 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
- describe the issues relating to the competing uses of oil as an energy source and as a chemical feedstock.

(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_4, and name the unbranched alkanes methane to butane
- define isomerism and identify isomers
- 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, C_2 to C_4, and name the unbranched alkenes ethene to butene
- 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.

(d) Alcohols

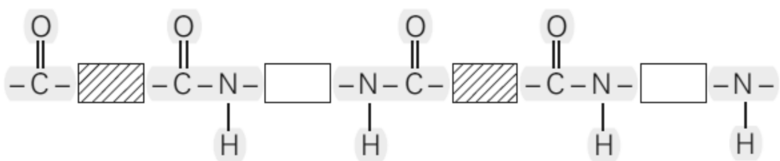
- describe the alcohols as a homologous series containing the –OH group
- draw the structures of alcohols, C_1 to C_4, and name the unbranched alcohols methanol to butanol
- describe the properties of alcohols in terms of combustion and oxidation to carboxylic acids
- describe the formation of ethanol by the catalysed addition of steam to ethene and by fermentation of glucose
- state some uses of ethanol, e.g. as a solvent; as a fuel; as a constituent of alcoholic beverages.

(e) Carboxylic acids

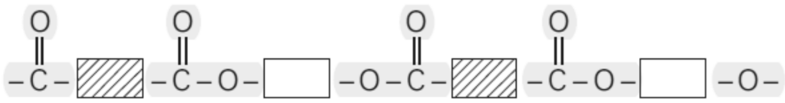
- describe the carboxylic acids as a homologous series containing the $–CO_2H$ group
- draw the structures of carboxylic acids, methanoic acid to butanoic acid, and name the unbranched acids, methanoic acid to butanoic acid
- describe the carboxylic acids as weak acids, reacting with carbonates, bases and some metals
- describe the formation of ethanoic acid by the oxidation of ethanol by atmospheric oxygen or acidified potassium manganate(VII)
- describe the reaction of a carboxylic acid with an alcohol to form an ester, e.g. ethyl ethanoate
- state some commercial uses of esters, e.g. perfumes; flavourings; solvents.

(f) Macromolecules

- describe macromolecules as large molecules built up from small units, different macromolecules having different units and/or different linkages
- 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 polymer product from a given monomer and vice versa
- describe nylon, a polyamide, and Terylene, a polyester, as condensation polymers, the partial structure of nylon being represented as



and the partial structure of Terylene as



(Details of manufacture and mechanisms of these polymerisations are not required.)

- state some typical uses of man-made fibres such as nylon and Terylene, e.g. clothing; curtain materials; fishing line; parachutes; sleeping bags
- describe the pollution problems caused by the disposal of non-biodegradable plastics.

CONTENT STRUCTURE

The following course structure is taken directly from the MOE (SEAB) website for O Level syllabus for Physics (6091).

Section	Topics
I. Measurements	1 Physical Quantities, Units and Measurement
II. Newtonian Mechanics	2 Kinematics 3 Dynamics 4 Mass, Weight and Density 5 Turning Effect of Forces 6 Pressure 7 Energy, Work and Power
III. Thermal Physics	8 Kinetic Model of Matter 9 Transfer of Thermal Energy 10 Temperature 11 Thermal Properties of Matter
IV. Waves	12 General Wave Properties 13 Light 14 Electromagnetic Spectrum 15 Sounds
V. Electricity and Magnetism	16 Static Electricity 17 Current of Electricity 18 D.C. Circuits 19 Practical Electricity 20 Magnetism 21 Electromagnetism 22 Electromagnetic Induction

SUBJECT CONTENT

SECTION I: MEASUREMENT

Overview

In order to gain a better understanding of the physical world, scientists use a process of investigation that follows a general cycle of observation, hypothesis, deduction, test and revision, sometimes referred to as the scientific method. Galileo Galilei, one of the earliest architects of this method, believed that the study of science had a strong logical basis that involved precise definitions of terms and physical quantities, and a mathematical structure to express relationships between these physical quantities.

In this section, we study a set of base physical quantities and units that can be used to derive all other physical quantities. These precisely defined quantities and units, with accompanying order-of-ten prefixes (e.g. milli, centi and kilo), can then be used to describe the interactions between objects in systems that range from celestial objects in space to sub-atomic particles.

1. Physical Quantities, Units and Measurement

Content

- Physical quantities
- SI units
- Prefixes
- Scalars and vectors
- Measurement of length and time

Learning Outcomes

Candidates should be able to:

(a) show understanding that all physical quantities consist of a numerical magnitude and a unit

(b) recall the following base quantities and their units: mass (kg), length (m), time (s), current (A), temperature (K), amount of substance (mol)

(c) use the following prefixes and their symbols to indicate decimal sub-multiples and multiples of the SI units: nano (n), micro (μ), milli (m), centi (c), deci (d), kilo (k), mega (M), giga (G)

(d) show an understanding of the orders of magnitude of the sizes of common objects ranging from a typical atom to the Earth

(e) state what is meant by *scalar* and *vector* quantities and give common examples of each

(f) add two vectors to determine a resultant by a graphical method

(g) describe how to measure a variety of lengths with appropriate accuracy by means of tapes, rules, micrometers and calipers, using a vernier scale as necessary

(h) describe how to measure a short interval of time including the period of a simple pendulum with appropriate accuracy using stopwatches or appropriate instruments

SECTION II: NEWTONIAN MECHANICS

Overview

Mechanics is the branch of physics that deals with the study of motion and its causes. Through a careful process of observation and experimentation, Galileo Galilei used experiments to overturn Aristotle's ideas of the motion of objects, for example the flawed idea that heavy objects fall faster than lighter ones, which dominated physics for about 2000 years.

The greatest contribution to the development of mechanics is by one of the greatest physicists of all time, Isaac Newton. By extending Galileo's methods and understanding of motion and gravitation, Newton developed the three laws of motion and his law of universal gravitation, and successfully applied them to both terrestrial and celestial systems to predict and explain phenomena. He showed that nature is governed by a few special rules or laws that can be expressed in mathematical formulae. Newton's combination of logical experimentation and mathematical analysis shaped the way science has been done ever since.

In this section, we begin by examining kinematics, which is a study of motion without regard for the cause. After which, we study the conditions required for an object to be accelerated and introduce the concept of forces through Newton's Laws. Subsequently, concepts of moments and pressure are introduced as consequences of a force. Finally, this section rounds up by leading the discussion from force to work and energy, and the use of the principle of conservation of energy to explain interactions between bodies.

2. Kinematics

Content

- Speed, velocity and acceleration
- Graphical analysis of motion
- Free-fall
- Effect of air resistance

Learning Outcomes

Candidates should be able to:

(a) state what is meant by speed and velocity

(b) calculate average speed using *distance travelled / time taken*

(c) state what is meant by uniform acceleration and calculate the value of an acceleration using *change in velocity / time taken*

(d) interpret given examples of non-uniform acceleration

(e) plot and interpret a displacement-time graph and a velocity-time graph

(f) deduce from the shape of a displacement-time graph when a body is:
  (i) at rest
  (ii) moving with uniform velocity
  (iii) moving with non-uniform velocity

(g) deduce from the shape of a velocity-time graph when a body is:
  (i) at rest
  (ii) moving with uniform velocity
  (iii) moving with uniform acceleration
  (iv) moving with non-uniform acceleration

(h) calculate the area under a velocity-time graph to determine the displacement travelled for motion with uniform velocity or uniform acceleration

(i) state that the acceleration of free fall for a body near to the Earth is constant and is approximately 10 m/s2

(j) describe the motion of bodies with constant weight falling with or without air resistance, including reference to terminal velocity

3. Dynamics

Content

- Balanced and unbalanced forces
- Free-body diagram
- Friction

Learning Outcomes

Candidates should be able to:

(a) apply Newton's Laws to:
  - (i) describe the effect of balanced and unbalanced forces on a body
  - (ii) describe the ways in which a force may change the motion of a body
  - (iii) identify action-reaction pairs acting on two interacting bodies (stating of Newton's Laws is not required)

(b) identify forces acting on an object and draw free-body diagram(s) representing the forces acting on the object (for cases involving forces acting in at most 2 dimensions)

(c) solve problems for a static point mass under the action of 3 forces for 2-dimensional cases (a graphical method would suffice)

(d) recall and apply the relationship *resultant force = mass ´ acceleration* to new situations or to solve related problems

(e) explain the effects of friction on the motion of a body

4. Mass, Weight and Density

Content

- Mass and weight
- Gravitational field and field strength
- Density

Learning Outcomes

Candidates should be able to:

(a) state that mass is a measure of the amount of substance in a body

(b) state that mass of a body resists a change in the state of rest or motion of the body (inertia)

(c) state that a gravitational field is a region in which a mass experiences a force due to gravitational attraction

(d) define gravitational field strength, g, as *gravitational force per unit mass*

(e) recall and apply the relationship *weight = mass ´ gravitational field strength* to new situations or to solve related problems

(f) distinguish between mass and weight

(g) recall and apply the relationship *density = mass / volume* to new situations or to solve related problems

5. Turning Effect of Forces

Content
- Moments
- Centre of gravity
- Stability

Learning Outcomes

Candidates should be able to:

(a) describe the moment of a force in terms of its turning effect and relate this to everyday examples

(b) recall and apply the relationship *moment of a force (or torque) = force ´ perpendicular distance from the pivot* to new situations or to solve related problems

(c) state the principle of moments for a body in equilibrium

(d) apply the principle of moments to new situations or to solve related problems

(e) show understanding that the weight of a body may be taken as acting at a single point known as its centre of gravity

(f) describe qualitatively the effect of the position of the centre of gravity on the stability of objects

6. Pressure

Content
- Pressure
- Pressure differences
- Pressure measurement

Learning Outcomes

Candidates should be able to:

(a) define the term pressure in terms of force and area

(b) recall and apply the relationship *pressure = force / area* to new situations or to solve related problems

(c) describe and explain the transmission of pressure in hydraulic systems with particular reference to the hydraulic press

(d) recall and apply the relationship *pressure due to a liquid column = height of column ´ density of the liquid ´ gravitational field strength* to new situations or to solve related problems

(e) describe how the height of a liquid column may be used to measure the atmospheric pressure

(f) describe the use of a manometer in the measurement of pressure difference

7. Energy, Work and Power

Content

- Energy conversion and conservation
- Work
- Power

Learning Outcomes

Candidates should be able to:

(a) show understanding that kinetic energy, potential energy (chemical, gravitational, elastic), light energy, thermal energy, electrical energy and nuclear energy are examples of different forms of energy

(b) state the principle of the conservation of energy and apply the principle to new situations or to solve related problems

(c) calculate the efficiency of an energy conversion using the formula *efficiency = energy converted to useful output / total energy input*

(d) state that kinetic energy $E_k = \frac{1}{2} mv^2$ and gravitational potential energy $E_p = mgh$ (for potential energy changes near the Earth's surface)

(e) apply the relationships for kinetic energy and potential energy to new situations or to solve related problems

(f) recall and apply the relationship *work done = force ´ distance moved in the direction of the force* to new situations or to solve related problems

(g) recall and apply the relationship *power = work done / time taken* to new situations or to solve related problems

SECTION III: THERMAL PHYSICS

Overview

Amongst the early scientists, heat was thought of as some kind of invisible, massless fluid called ‘caloric’. Certain objects that released heat upon combustion were thought to be able to ‘store’ the fluid. However, this explanation failed to explain why friction was able to produce heat. In the 1840s, James Prescott Joule used a falling weight to drive an electrical generator that heated a wire immersed in water. This experiment demonstrated that work done by a falling object could be converted to heat.

In the previous section, we studied energy and its conversion. Many energy conversion processes which involve friction will have heat as a product. This section begins with the introduction of the kinetic model of matter. This model is then used to explain and predict the physical properties and changes of matter at the molecular level in relation to heat or thermal energy transfer.

8. Kinetic Model of Matter

Content

- States of matter
- Brownian motion
- Kinetic model

Learning Outcomes

Candidates should be able to:

(a) compare the properties of solids, liquids and gases

(b) describe qualitatively the molecular structure of solids, liquids and gases, relating their properties to the forces and distances between molecules and to the motion of the molecules

(c) infer from a Brownian motion experiment the evidence for the movement of molecules

(d) describe the relationship between the motion of molecules and temperature

(e) explain the pressure of a gas in terms of the motion of its molecules

(f) recall and explain the following relationships using the kinetic model (stating of the corresponding gas laws is not required):
  (i) a change in pressure of a fixed mass of gas at constant volume is caused by a change in temperature of the gas
  (ii) a change in volume occupied by a fixed mass of gas at constant pressure is caused by a change in temperature of the gas
  (iii) a change in pressure of a fixed mass of gas at constant temperature is caused by a change in volume of the gas

(g) use the relationships in (f) in related situations and to solve problems (a qualitative treatment would suffice)

9. Transfer of Thermal Energy

Content
- Conduction
- Convection
- Radiation

Learning Outcomes

Candidates should be able to:

(a) show understanding that thermal energy is transferred from a region of higher temperature to a region of lower temperature

(b) describe, in molecular terms, how energy transfer occurs in solids

(c) describe, in terms of density changes, convection in fluids

(d) explain that energy transfer of a body by radiation does not require a material medium and that the rate of energy transfer is affected by:
(i) colour and texture of the surface
(ii) surface temperature
(iii) surface area

(e) apply the concept of thermal energy transfer to everyday applications

10. Temperature

Content
- Principles of thermometry

Learning Outcomes

Candidates should be able to:

(a) explain how a physical property which varies with temperature, such as volume of liquid column, resistance of metal wire and electromotive force (e.m.f.) produced by junctions formed with wires of two different metals, may be used to define temperature scales

(b) describe the process of calibration of a liquid-in-glass thermometer, including the need for fixed points such as the *ice point* and *steam point*

11. Thermal Properties of Matter

Content

- Internal energy
- Specific heat capacity
- Melting, boiling and evaporation
- Specific latent heat

Learning Outcomes

Candidates should be able to:

(a) describe a rise in temperature of a body in terms of an increase in its internal energy (random thermal energy)

(b) define the terms *heat capacity* and *specific heat capacity*

(c) recall and apply the relationship *thermal energy = mass ´ specific heat capacity ´ change in temperature* to new situations or to solve related problems

(d) describe melting / solidification and boiling / condensation as processes of energy transfer without a change in temperature

(e) explain the difference between boiling and evaporation

(f) define the terms *latent heat* and *specific latent heat*

(g) recall and apply the relationship *thermal energy = mass ´ specific latent heat* to new situations or to solve related problems

(h) explain latent heat in terms of molecular behaviour

(i) sketch and interpret a cooling curve

SECTION IV: WAVES

Overview

Waves are inherent in our everyday lives. Much of our understanding of wave phenomena has been accumulated over the centuries through the study of light (optics) and sound (acoustics). The nature of oscillations in light was only understood when James Clerk Maxwell, in his unification of electricity, magnetism and electromagnetic waves, stated that all electromagnetic fields spread in the form of waves. Using a mathematical model (Maxwell's equations), he calculated the speed of electromagnetic waves and found it to be close to the speed of light, leading him to make a bold but correct inference that light consists of propagating electromagnetic disturbances. This gave the very nature of electromagnetic waves, and hence its name.

In this section, we examine the nature of waves in terms of the coordinated movement of particles. The discussion moves on to wave propagation and its uses by studying the properties of light, electromagnetic waves and sound, as well as their applications in wireless communication, home appliances, medicine and industry.

12. General Wave Properties

Content

- Describing wave motion
- Wave terms
- Longitudinal and transverse waves

Learning Outcomes

Candidates should be able to:

(a) describe what is meant by wave motion as illustrated by vibrations in ropes and springs and by waves in a ripple tank

(b) show understanding that waves transfer energy without transferring matter

(c) define *speed, frequency, wavelength*, *period* and *amplitude*

(d) state what is meant by the term *wavefront*

(e) recall and apply the relationship *velocity = frequency ´ wavelength* to new situations or to solve related problems

(f) compare transverse and longitudinal waves and give suitable examples of each

13. Light

Content

- Reflection of light
- Refraction of light
- Thin lenses

Learning Outcomes

Candidates should be able to:

(a) recall and use the terms for reflection, including *normal*, *angle of incidence* and *angle of reflection*

(b) state that, for reflection, the angle of incidence is equal to the angle of reflection and use this principle in constructions, measurements and calculations

(c) recall and use the terms for refraction, including *normal, angle of incidence* and *angle of refraction*
(d) recall and apply the relationship $\sin i / \sin r$ = constant to new situations or to solve related problems

(e) define *refractive index* of a medium in terms of the ratio of speed of light in vacuum and in the medium

(f) explain the terms *critical angle* and *total internal reflection*

(g) identify the main ideas in total internal reflection and apply them to the use of optical fibres in telecommunication and state the advantages of their use

(h) describe the action of a thin lens (both converging and diverging) on a beam of light

(i) define the term *focal length* for a converging lens

(j) draw ray diagrams to illustrate the formation of real and virtual images of an object by a thin converging lens

14. Electromagnetic Spectrum

Content
- Properties of electromagnetic waves
- Applications of electromagnetic waves
- Effects of electromagnetic waves on cells and tissue

Learning Outcomes

Candidates should be able to:

(a) state that all electromagnetic waves are transverse waves that travel with the same speed in vacuum and state the magnitude of this speed

(b) describe the main components of the electromagnetic spectrum

(c) state examples of the use of the following components:
  (i) radio waves (e.g. radio and television communication)
  (ii) microwaves (e.g. microwave oven and satellite television)
  (iii) infra-red (e.g. infra-red remote controllers and intruder alarms)
  (iv) light (e.g. optical fibres for medical uses and telecommunications)
  (v) ultra-violet (e.g. sunbeds and sterilisation)
  (vi) X-rays (e.g. radiological and engineering applications)
  (vii) gamma rays (e.g. medical treatment)

(d) describe the effects of absorbing electromagnetic waves, e.g. heating, ionisation and damage to living cells and tissue

15. Sound

Content
- Sound waves
- Speed of sound
- Echo
- Ultrasound

Learning Outcomes

Candidates should be able to:

(a) describe the production of sound by vibrating sources

(b) describe the longitudinal nature of sound waves in terms of the processes of compression and rarefaction

(c) explain that a medium is required in order to transmit sound waves and that the speed of sound differs in air, liquids and solids

(d) describe a direct method for the determination of the speed of sound in air and make the necessary calculation

(e) relate loudness of a sound wave to its amplitude and pitch to its frequency

(f) describe how the reflection of sound may produce an echo, and how this may be used for measuring distances

(g) define *ultrasound* and describe one use of ultrasound, e.g. quality control and pre-natal scanning

SECTION V: ELECTRICITY AND MAGNETISM

Overview

For a long time, electricity and magnetism were seen as independent phenomena. Hans Christian Oersted, in 1802, discovered that a current carrying conductor deflected a compass needle. This discovery was overlooked by the scientific community until 18 years later. It may be a chance discovery, but it takes an observant scientist to notice. The exact relationship between an electric current and the magnetic field it produced was deduced mainly through the work of Andre Marie Ampere. However, the major discoveries in electromagnetism were made by two of the greatest names in physics, Michael Faraday and James Clerk Maxwell.

The section begins with a discussion of electric charges that are static, i.e. not moving. Next, we study the phenomena associated with moving charges and the concepts of current, voltage and resistance. We also study how these concepts are applied to simple circuits and household electricity. Thereafter, we study the interaction of magnetic fields to pave the way for the study of the interrelationship between electricity and magnetism. The phenomenon in which a current interacts with a magnetic field is studied in electromagnetism, while the phenomenon in which a current or electromotive force is induced in a moving conductor within a magnetic field is studied in electromagnetic induction.

16. Static Electricity

Content

- Laws of electrostatics
- Principles of electrostatics
- Electric field
- Applications of electrostatics

Learning Outcomes

Candidates should be able to:

(a) state that there are positive and negative charges and that charge is measured in coulombs

(b) state that unlike charges attract and like charges repel

(c) describe an electric field as a region in which an electric charge experiences a force

(d) draw the electric field of an isolated point charge and recall that the direction of the field lines gives the direction of the force acting on a positive test charge

(e) draw the electric field pattern between two isolated point charges

(f) show understanding that electrostatic charging by rubbing involves a transfer of electrons

(g) describe experiments to show electrostatic charging by induction

(h) describe examples where electrostatic charging may be a potential hazard

(i) describe the use of electrostatic charging in a photocopier, and apply the use of electrostatic charging to new situations

17. Current of Electricity

Content

- Conventional current and electron flow
- Electromotive force
- Potential difference
- Resistance

Learning Outcomes

Candidates should be able to:

(a) state that current is a rate of flow of charge and that it is measured in amperes

(b) distinguish between conventional current and electron flow

(c) recall and apply the relationship *charge* = *current* ´ *time* to new situations or to solve related problems

(d) define electromotive force (e.m.f.) as the work done by a source in driving unit charge around a complete circuit

(e) calculate the total e.m.f. where several sources are arranged in series

(f) state that the e.m.f. of a source and the potential difference (p.d.) across a circuit component are measured in volts

(g) define the p.d. across a component in a circuit as the work done to drive unit charge through the component

(h) state the definition that *resistance = p.d. / current*

(i) apply the relationship $R = V / I$ to new situations or to solve related problems

(j) describe an experiment to determine the resistance of a metallic conductor using a voltmeter and an ammeter, and make the necessary calculations

(k) recall and apply the formulae for the effective resistance of a number of resistors in series and in parallel to new situations or to solve related problems

(l) recall and apply the relationship of the proportionality between resistance and the length and cross-sectional area of a wire to new situations or to solve related problems

(m) state Ohm's Law

(n) describe the effect of temperature increase on the resistance of a metallic conductor

(o) sketch and interpret the I / V characteristic graphs for a metallic conductor at constant temperature, for a filament lamp and for a semiconductor diode

18. D.C. Circuits

Content

- Current and potential difference in circuits
- Series and parallel circuits
- Potential divider circuit
- Thermistor and light-dependent resistor

Learning Outcomes

Candidates should be able to:

(a) draw circuit diagrams with power sources (cell, battery, d.c. supply or a.c. supply), switches, lamps, resistors (fixed and variable), variable potential divider (potentiometer), fuses, ammeters and voltmeters, bells, light-dependent resistors, thermistors and light-emitting diodes

(b) state that the current at every point in a series circuit is the same and apply the principle to new situations or to solve related problems

(c) state that the sum of the potential differences in a series circuit is equal to the potential difference across the whole circuit and apply the principle to new situations or to solve related problems

(d) state that the current from the source is the sum of the currents in the separate branches of a parallel circuit and apply the principle to new situations or to solve related problems

(e) state that the potential difference across the separate branches of a parallel circuit is the same and apply the principle to new situations or to solve related problems

(f) recall and apply the relevant relationships, including $R = V / I$ and those for current, potential differences and resistors in series and in parallel circuits, in calculations involving a whole circuit

(g) describe the action of a variable potential divider (potentiometer)

(h) describe the action of thermistors and light-dependent resistors and explain their use as input transducers in potential dividers

(i) solve simple circuit problems involving thermistors and light-dependent resistors

19. Practical Electricity

Content

- Electric power and energy
- Dangers of electricity
- Safe use of electricity in the home

Learning Outcomes

Candidates should be able to:

(a) describe the use of the heating effect of electricity in appliances such as electric kettles, ovens and heaters

(b) recall and apply the relationships $P = VI$ and $E = VIt$ to new situations or to solve related problems

(c) calculate the cost of using electrical appliances where the energy unit is the kW h

(d) compare the use of non-renewable and renewable energy sources such as fossil fuels, nuclear energy, solar energy, wind energy and hydroelectric generation to generate electricity in terms of energy conversion efficiency, cost per kW h produced and environmental impact

(e) state the hazards of using electricity in the following situations:
  (i) damaged insulation
  (ii) overheating of cables
  (iii) damp conditions

(f) explain the use of fuses and circuit breakers in electrical circuits and of fuse ratings

(g) explain the need for earthing metal cases and for double insulation

(h) state the meaning of the terms *live, neutral* and *earth*

(i) describe the wiring in a mains plug

(j) explain why switches, fuses, and circuit breakers are wired into the live conductor

20. Magnetism

Content
- Laws of magnetism
- Magnetic properties of matter
- Magnetic field

Learning Outcomes

Candidates should be able to:

(a) state the properties of magnets

(b) describe induced magnetism

(c) describe electrical methods of magnetisation and demagnetisation

(d) draw the magnetic field pattern around a bar magnet and between the poles of two bar magnets

(e) describe the plotting of magnetic field lines with a compass

(f) distinguish between the properties and uses of temporary magnets (e.g. iron) and permanent magnets (e.g. steel)

21. Electromagnetism

Content
- Magnetic effect of a current
- Applications of the magnetic effect of a current
- Force on a current-carrying conductor
- The d.c. motor

Learning Outcomes

Candidates should be able to:

(a) draw the pattern of the magnetic field due to currents in straight wires and in solenoids and state the effect on the magnetic field of changing the magnitude and / or direction of the current

(b) describe the application of the magnetic effect of a current in a circuit breaker

(c) describe experiments to show the force on a current-carrying conductor, and on a beam of charged particles, in a magnetic field, including the effect of reversing
(i) the current
(ii) the direction of the field

(d) deduce the relative directions of force, field and current when any two of these quantities are at right angles to each other using Fleming's left-hand rule

(e) describe the field patterns between currents in parallel conductors and relate these to the forces which exist between the conductors (excluding the Earth's field)

(f) explain how a current-carrying coil in a magnetic field experiences a turning effect and that the effect is increased by increasing
(i) the number of turns on the coil
(ii) the current

(g) discuss how this turning effect is used in the action of an electric motor

(h) describe the action of a split-ring commutator in a two-pole, single-coil motor and the effect of winding the coil on to a soft-iron cylinder

22. Electromagnetic Induction

Content

- Principles of electromagnetic induction
- The a.c. generator
- Use of cathode-ray oscilloscope
- The transformer

Learning Outcomes

Candidates should be able to:

(a) deduce from Faraday's experiments on electromagnetic induction or other appropriate experiments:
(i) that a changing magnetic field can induce an e.m.f. in a circuit
(ii) that the direction of the induced e.m.f. opposes the change producing it
(iii) the factors affecting the magnitude of the induced e.m.f.

(b) describe a simple form of a.c. generator (rotating coil or rotating magnet) and the use of slip rings (where needed)

(c) sketch a graph of voltage output against time for a simple a.c. generator

(d) describe the use of a cathode-ray oscilloscope (c.r.o.) to display waveforms and to measure potential differences and short intervals of time (detailed circuits, structure and operation of the c.r.o. are not required)

(e) interpret c.r.o. displays of waveforms, potential differences and time intervals to solve related problems

(f) describe the structure and principle of operation of a simple iron-cored transformer as used for voltage transformations

(g) recall and apply the equations $V_P / V_S = N_P / N_S$ and $V_P I_P = V_S I_S$ to new situations or to solve related problems (for an ideal transformer)

(h) describe the energy loss in cables and deduce the advantages of high-voltage transmission

SUMMARY OF KEY QUANTITIES, SYMBOLS AND UNITS

Candidates should be able to state the symbols for the following physical quantities and, where indicated, state the units in which they are measured. Candidates should be able to define those items indicated by an asterisk (*).

Quantity	*Symbol*	*Unit*
length	*l, h* …	km, m, cm, mm
area	*A*	m^2, cm^2
volume	*V*	m^3, cm^3
weight*	*W*	N*
mass	*m, M*	kg, g, mg
time	*t*	h, min, s, ms
period*	*T*	s
density*	ρ	g/cm^3, kg/m^3
speed*	*u, v*	km/h, m/s, cm/s
acceleration*	*a*	m/s^2
acceleration of free fall	*g*	m/s^2, N/kg
force*	*F, f*	N
moment of force*		N m
work done*	*W, E*	J*
energy	*E*	J, kW h*
power*	*P*	W*
pressure*	*p, P*	Pa*, N/m^2, mm Hg
temperature	θ, *T*	°C, K
heat capacity	*C*	J/°C, J/K
specific heat capacity*	*c*	J/(g °C), J/(g K)
latent heat	*L*	J
specific latent heat*	l	J/kg, J/g
frequency*	*f*	Hz
wavelength*	λ	m, cm
focal length	*f*	m, cm
angle of incidence	*i*	degree (°)
angles of reflection, refraction	*r*	degree (°)
critical angle	*c*	degree (°)
potential difference* / voltage	*V*	V*, mV
current*	*I*	A, mA
charge	*q, Q*	C, A s
e.m.f.*	*E*	V
resistance	*R*	Ω

GLOSSARY OF TERMS

It is hoped that the glossary will prove helpful to candidates as a guide, although it is not exhaustive. The glossary has been deliberately kept brief not only with respect to the number of terms included but also to the descriptions of their meanings. Candidates should appreciate that the meaning of a term must depend in part on its context. They should also note that the number of marks allocated for any part of a question is a guide to the depth of treatment required for the answer.

1. *Define (the term(s) ...)* is intended literally. Only a formal statement or equivalent paraphrase, such as the defining equation with symbols identified, is required.

2. *Explain / What is meant by ...* normally implies that a definition should be given, together with some relevant comment on the significance or context of the term(s) concerned, especially where two or more terms are included in the question. The amount of supplementary comment intended should be interpreted in the light of the indicated mark value.

3. *State* implies a concise answer with little or no supporting argument, e.g. a numerical answer that can be obtained 'by inspection'.

4. *List* requires a number of points with no elaboration. Where a given number of points is specified, this should not be exceeded.

5. *Describe* requires candidates to state in words (using diagrams where appropriate) the main points of the topic. It is often used with reference either to particular phenomena or to particular experiments. In the former instance, the term usually implies that the answer should include reference to (visual) observations associated with the phenomena. The amount of description intended should be interpreted in the light of the indicated mark value.

6. *Discuss* requires candidates to give a critical account of the points involved in the topic.

7. *Predict or deduce* implies that candidates are not expected to produce the required answer by recall but by making a logical connection between other pieces of information. Such information may be wholly given in the question or may depend on answers extracted in an earlier part of the question.

8. *Suggest* is used in two main contexts. It may either imply that there is no unique answer or that candidates are expected to apply their general knowledge to a 'novel' situation, one that formally may not be 'in the syllabus'.

9. *Calculate* is used when a numerical answer is required. In general, working should be shown.

10. *Measure* implies that the quantity concerned can be directly obtained from a suitable measuring instrument, e.g. length, using a rule, or angle, using a protractor.

11. *Determine* often implies that the quantity concerned cannot be measured directly but is obtained by calculation, substituting measured or known values of other quantities into a standard formula.

12. *Show* is used when an algebraic deduction has to be made to prove a given equation. It is important that the terms being used by candidates are stated explicitly.

13. *Estimate* implies a reasoned order of magnitude statement or calculation of the quantity concerned. Candidates should make such simplifying assumptions as may be necessary about points of principle and about the values of quantities not otherwise included in the question.

14. *Sketch,* when applied to graph work, implies that the shape and / or position of the curve need only be qualitatively correct. However, candidates should be aware that, depending on the context, some quantitative aspects may be looked for, e.g. passing through the origin, having an intercept, asymptote or discontinuity at a particular value. On a sketch graph it is essential that candidates clearly indicate what is being plotted on each axis.

    Sketch, when applied to diagrams, implies that a simple, freehand drawing is acceptable: nevertheless, care should be taken over proportions and the clear exposition of important details.

SPECIAL NOTE

Nomenclature

The proposals in ‘Signs, Symbols and Systematics (The Association for Science Education Companion to 16–19 Science, 2000)’ will generally be adopted.

Units, significant figures

Candidates should be aware that misuse of units and / or significant figures, i.e. failure to quote units where necessary, the inclusion of units in quantities defined as ratios or quoting answers to an inappropriate number of significant figures, is liable to be penalised.

Calculators

An approved calculator may be used.

Geometrical Instruments

Candidates should have geometrical instruments with them.