

General Certificate of Education  
Ordinary Level

**Syllabus**

SCIENCE (PHYSICS, CHEMISTRY) 5124

SCIENCE (PHYSICS, BIOLOGY) 5125

SCIENCE (CHEMISTRY, BIOLOGY) 5126

For examination in November 2009



# COMBINED SCIENCES

## GCE ORDINARY LEVEL

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#### Exclusions

Syllabus **5124** must not be offered in the same session with any of the following syllabuses:

0620 Chemistry  
0625 Physics  
0652 Physical Science  
0653 Combined Science  
0654 Co-ordinated Sciences (Double Award)  
5054 Physics  
5070 Chemistry  
5125 Science (Physics, Biology)  
5126 Science (Chemistry, Biology)  
5129 Combined Science  
5130 Additional Combined Science

Syllabus **5125** must not be offered in the same session with any of the following syllabuses:

0610 Biology  
0625 Physics  
0653 Combined Science  
0654 Co-ordinated Sciences (Double Award)  
5054 Physics  
5090 Biology  
5096 Human and Social Biology  
5124 Science (Physics, Chemistry)  
5126 Science (Chemistry, Biology)  
5129 Combined Science  
5130 Additional Combined Science

Syllabus **5126** must not be offered in the same session with any of the following syllabuses:

0610 Biology  
0620 Chemistry  
0653 Combined Science  
0654 Co-ordinated Sciences (Double Award)  
5070 Chemistry  
5090 Biology  
5096 Human and Social Biology  
5124 Science (Physics, Chemistry)  
5125 Science (Physics, Biology)  
5129 Combined Science  
5130 Additional Combined Science

## Notes

### Information for Teachers

This booklet relates to examinations taken in the year printed on the cover. It is the normal practice of CIE to print and distribute a new version of this booklet each year. Centres should receive copies well in advance of them being required for teaching purposes.

Teachers who are about to teach syllabuses in this booklet for the first time, should obtain and study the relevant past examination papers and Subject Reports.

Any queries relating to this booklet should be addressed to the Product Manager.

### Nomenclature

The proposals in 'Signs, Symbols and Systematics (The Association for Science Education Companion to 5-16 Science, 1995)' and the recommendations on terms, units and symbols in 'Biological Nomenclature (1997)' published by the Institute of Biology, in conjunction with the ASE, will generally be adopted. Reference should be made to the joint statement on chemical nomenclature issued by the GCE boards. In particular, the traditional names sulfate, sulfite, nitrate, nitrite, sulfurous and nitrous acids will be used in question papers.

It is intended that, in order to avoid difficulties arising out of the use of l as the symbol for litre, use of  $\text{dm}^3$  in place of l or litre will be made.

In chemistry, *full structural formulae (displayed formulae)* in answers should show in detail both the relative placing of atoms and the number of bonds between atoms. Hence  $-\text{CONH}_2$  and  $-\text{CO}_2\text{H}$  are not satisfactory as full structural formulae, although either of the usual symbols for the benzene ring is acceptable.

### Units and 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.

### Syllabus Revision

Attention is drawn to alterations in the syllabus by black vertical lines on either side of the text.

**5124 SCIENCE (PHYSICS, CHEMISTRY)**  
**5125 SCIENCE (PHYSICS, BIOLOGY)**  
**5126 SCIENCE (CHEMISTRY, BIOLOGY)**  
**GCE ORDINARY LEVEL/SCHOOL CERTIFICATE**  
*(5124, 5125 and 5126 are available in November only)*

## **AIMS**

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These are not listed in order of priority. The aims are to:

1. provide, through well designed studies of experimental and practical science, a worthwhile educational experience for all students, whether or not they go on to study science beyond this level and, in particular, to enable them to acquire sufficient understanding and knowledge to
  - 1.1 become confident citizens in a technological world, able to take or develop an informed interest in matters of scientific import;
  - 1.2 recognise the usefulness, and limitations, of scientific method and to appreciate its applicability in other disciplines and in everyday life;
  - 1.3 be suitably prepared for studies beyond O/SC level in pure sciences, in applied sciences or in science-dependent vocational courses.
2. develop abilities and skills that
  - 2.1 are relevant to the study and practice of science;
  - 2.2 are useful in everyday life;
  - 2.3 encourage efficient and safe practice;
  - 2.4 encourage effective communication.
3. develop attitudes relevant to science such as
  - 3.1 accuracy and precision;
  - 3.2 objectivity;
  - 3.3 integrity;
  - 3.4 enquiry;
  - 3.5 initiative;
  - 3.6 inventiveness.
4. stimulate interest in and care for the environment.
5. promote an awareness that
  - 5.1 the study and practice of science are co-operative and cumulative activities, and are subject to social, economic, technological, ethical and cultural influences and limitations;
  - 5.2 the applications of science may be both beneficial and detrimental to the individual, the community and the environment.

## **ASSESSMENT OBJECTIVES**

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### **A Knowledge with Understanding**

Students should be able to demonstrate knowledge and understanding in relation to:

1. scientific phenomena, facts, laws, definitions, concepts, theories;
2. scientific vocabulary, terminology, conventions (including symbols, quantities and units contained in 'Signs, Symbols and Systematics', Association for Science Education, 1995);
3. scientific instruments and apparatus, including techniques of operation and aspects of safety;
4. scientific quantities and their determination;
5. scientific and technological applications with their social, economic and environmental implications.

The subject content defines the factual material that candidates need to recall and explain. Questions testing these objectives will often begin with one of the following words: *define, state, describe, explain or outline.* (See the glossary of terms.)

**B Handling Information and Solving Problems**

Students should be able - in words or by using other written, symbolic, graphical and numerical forms of presentation - to:

1. locate, select, organise and present information from a variety of sources;
2. translate information from one form to another;
3. manipulate numerical and other data;
4. use information to identify patterns, report trends and draw inferences;
5. present reasoned explanations for phenomena, patterns and relationships;
6. make predictions and hypotheses;
7. solve problems.

These assessment objectives cannot be precisely specified in the subject content because questions testing such skills may be based on information which is unfamiliar to the candidate. In answering such questions, candidates are required to use principles and concepts that are within the syllabus and apply them in a logical, deductive manner to a novel situation. Questions testing these objectives will often begin with one of the following words: *predict, suggest, calculate* or *determine*. (See the glossary of terms.)

**Weighting of Assessment Objectives**

*A Knowledge with Understanding*, approximately 65% of the marks with approximately 30% allocated to recall.

*B Handling Information and Solving Problems*, approximately 35% of the marks.

**SCHEME OF ASSESSMENT**

Candidates are required to enter for Paper 1 and two of Papers 2, 3 and 4.

Paper	Type of Paper	Duration	Marks	Weighting
1	Multiple Choice	1 h	40	24%
2	Structured and Free Response (Physics)	1 h 15 min	65	38%
3	Structured and Free Response (Chemistry)	1 h 15 min	65	38%
4	Structured and Free Response (Biology)	1 h 15 min	65	38%

**Paper 1** (1 h, 40 marks), consisting of 40 multiple choice questions of the direct choice type providing approximately equal coverage of the *two* appropriate sections of the syllabus. This paper will be set at the same time for all *three* subjects, 5124, 5125 and 5126.

**Paper 2** (1 h 15 min, 65 marks), consisting of *two* sections.

*Section A* will carry 45 marks and will contain a number of compulsory structured questions of variable mark value.

*Section B* will carry 20 marks and will contain *three* free response questions, each of 10 marks. Candidates are required to answer any *two* questions.

The questions will be based on the Physics section of the syllabus.

**Papers 3 and 4** (1 h 15 min, 65 marks), consisting of *two* sections.

These Papers will each have the same structure as Paper 2 but will be based on the Chemistry and Biology sections of the syllabus respectively.

*Science (Physics, Chemistry), Syllabus 5124*

Paper 1 will be based on the Physics and Chemistry sections of the syllabus.

Paper 2 will be based on the Physics section of the syllabus.

Paper 3 will be based on the Chemistry section of the syllabus.

*Science (Physics, Biology), Syllabus 5125*

Paper 1 will be based on the Physics and Biology sections of the syllabus.

Paper 2 will be based on the Physics section of the syllabus.

Paper 4 will be based on the Biology section of the syllabus.

*Science (Chemistry, Biology), Syllabus 5126*

Paper 1 will be based on the Chemistry and Biology sections of the syllabus.

Paper 3 will be based on the Chemistry section of the syllabus.

Paper 4 will be based on the Biology section of the syllabus.

## SUBJECT CONTENT

### PHYSICS SECTION

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Students are expected to have adequate mathematical skills to cope with the curriculum. Throughout the course, attention should be paid to showing the relevance of concepts to the students' everyday life and to the natural and man-made world.

#### 1. Physical Quantities and Units

##### **Content**

- 1.1 Measurement of length, time and volume

##### **Learning Outcomes:**

Candidates should be able to:

- (a) use and describe how to use rules, micrometers, vernier scales and calipers to determine lengths
- (b) use and describe how to use clocks and other devices for measuring an interval of time, including the period of a pendulum
- (c) use and describe how to use a measuring cylinder to measure a volume

#### 2. Kinematics

##### **Content**

- 2.1 Speed, velocity and acceleration  
 2.2 Graphical analysis of motion  
 2.3 Free fall

##### **Learning Outcomes:**

Candidates should be able to:

- (a) state what is meant by *speed*, *velocity* and *acceleration*
- (b) recognise motion for which the acceleration is constant and calculate the acceleration
- (c) recognise motion for which the acceleration is not constant
- (d) plot and interpret a speed-time graph
- (e) recognise from the shape of a speed-time graph when a body is
  - (i) at rest
  - (ii) moving with constant speed
  - (iii) moving with constant acceleration
  - (iv) moving with an acceleration that is not constant
- (f) calculate the area under a speed-time graph to determine the distance travelled for motion with constant speed or constant acceleration
- (g) show understanding that the acceleration of free fall for a body near to the Earth is constant
- (h) describe qualitatively the motion of bodies falling in a uniform gravitational field with and without air resistance (including reference to terminal velocity)

#### 3. Dynamics

##### **Content**

- 3.1 Motion  
 3.2 Friction

##### **Learning Outcomes:**

Candidates should be able to:

- (a) describe the ways in which a force may change the motion of a body
- (b) use the relation between force, mass and acceleration
- (c) demonstrate an understanding of the effects of friction on the motion of a body



**4. Mass, Weight and Density****Content**

- 4.1 Mass and weight
- 4.2 Density

**Learning Outcomes:**

Candidates should be able to:

- (a) demonstrate an understanding that mass is a measure of the amount of substance in a body
- (b) demonstrate an understanding of inertia as the property of a mass which resists change from its state of rest or motion
- (c) describe, and use the concept of, weight as the effect of a gravitational field on a mass
- (d) demonstrate understanding that two weights, and therefore masses, can be compared using a balance
- (e) use appropriate balances to measure mass and weight
- (f) describe experiments to determine the density of a liquid, of a regularly shaped solid and of an irregularly shaped solid (by the method of displacement) and make the necessary calculations

**5. Turning Effect of Forces****Content**

- 5.1 Moments
- 5.2 Centre of mass
- 5.3 Stability

**Learning Outcomes:**

Candidates should be able to:

- (a) describe the moment of a force in terms of its turning effect and give everyday examples
- (b) perform and describe an experiment to verify the principle of moments
- (c) make calculations involving the principle of moments
- (d) perform and describe an experiment to determine the position of the centre of mass of a plane lamina
- (e) describe qualitatively the effect of the position of the centre of mass on the stability of simple objects

**6. Deformation****Content**

- 6.1 Elastic deformation

**Learning Outcomes:**

Candidates should be able to:

- (a) state that a force may produce a change in size and shape of a body
- (b) plot, draw and interpret extension-load graphs for elastic solids and describe the associated experimental procedure
- (c) recognise the significance of the term *limit of proportionality* for an extension-load graph of an elastic solid
- (d) use proportionality of an elastic solid in simple calculations involving extension or force required

**7. Energy, Work and Power****Content**

- 7.1 Energy conversion and conservation
- 7.2 Major sources of energy
- 7.3 Work
- 7.4 Power

**Learning Outcomes:**

Candidates should be able to:

- (a) give examples of energy in different forms, its conversion and conservation, and apply the principle of energy conservation to simple examples
- (b) use the terms *kinetic energy* and *potential energy* in context
- (c) calculate kinetic energy and gravitational potential energy

- (d) describe, and express a qualitative understanding of, processes by which energy is converted from one form to another, including reference to
  - (i) chemical/fuel energy (a re-grouping of atoms)
  - (ii) hydroelectric generation (emphasising the mechanical energies involved)
  - (iii) solar energy (nuclei of atoms in the Sun)
  - (iv) nuclear energy
  - (v) geothermal energy
  - (vi) wind energy
- (e) show a qualitative understanding of *efficiency*
- (f) relate work done to the magnitude of a force and the distance moved and make calculations involving  $F \times d$
- (g) relate power to energy transferred and time taken, using appropriate examples and using the equation  $P=E/t$  in simple systems

## 8. Transfer of Thermal Energy

### **Content**

- 8.1 Conduction
- 8.2 Convection
- 8.3 Radiation

### **Learning Outcomes:**

Candidates should be able to:

- (a) describe experiments to distinguish between good and bad conductors of heat
- (b) give a simple molecular account of heat transfer in solids
- (c) relate convection in fluids to density changes and describe experiments to illustrate convection
- (d) describe experiments to distinguish between good and bad emitters and good and bad absorbers of infra-red radiation
- (e) identify and explain some of the everyday applications and consequences of conduction, convection and radiation

## 9. Temperature

### **Content**

- 9.1 Principles of thermometry
- 9.2 Liquid-in-glass thermometers

### **Learning Outcomes:**

Candidates should be able to:

- (a) appreciate how a physical property which varies with temperature may be used for the measurement of temperature and state examples of such properties
- (b) recognise the need for, and identify, fixed points
- (c) show understanding of *sensitivity* and *range*
- (d) apply a given property to the measurement of temperature
- (e) describe the structure and action of liquid-in-glass thermometers (laboratory and clinical) and of a thermocouple thermometer, showing an appreciation of its use for measuring high temperatures and those which vary rapidly

## 10. Thermal Properties of Matter

### **Content**

- 10.1 Thermal expansion of solids, liquids and gases
- 10.2 Melting, boiling and evaporation

### **Learning Outcomes:**

Candidates should be able to:

- (a) describe qualitatively the thermal expansion of solids, liquids and gases
- (b) show an appreciation of the relative order of magnitude of the expansion of solids, liquids and gases
- (c) identify and explain some of the everyday applications and consequences of thermal expansion
- (d) describe melting/solidification and boiling/condensation in terms of energy transfer without a change in temperature
- (e) state the meaning of *melting point* and of *boiling point*
- (f) distinguish between *boiling* and *evaporation*

**11. General Wave Properties****Content**

- 11.1 Describing wave motion
- 11.2 Wave terms
- 11.3 Longitudinal and transverse waves

**Learning Outcomes:**

Candidates should be able to:

- (a) describe what is meant by *wave motion* as illustrated by vibration in ropes, springs and by experiments using a ripple tank
- (b) give the meaning of *speed*, *frequency*, *wavelength* and *amplitude* and use the equation  $c = f \times \lambda$
- (c) distinguish between *longitudinal* and *transverse* waves and give suitable examples

**12. Light****Content**

- 12.1 Reflection of light
- 12.2 Refraction of light
- 12.3 Thin converging lens

**Learning Outcomes:**

Candidates should be able to:

- (a) perform and describe experiments to illustrate the laws of reflection
- (b) describe an experiment to find the position of an optical image formed by a plane mirror
- (c) use the law  $i = r$  in reflection
- (d) perform simple constructions, measurements and calculations for reflection
- (e) describe and perform experiments to demonstrate refraction of light through glass blocks
- (f) use the terminology for the angles  $i$  and  $r$  in refraction and describe the passage of light through parallel-sided transparent material
- (g) use the equation  $\sin i / \sin r = n$  (refractive index)
- (h) give the meaning of *refractive index*
- (i) describe the action of a thin converging lens on a beam of light
- (j) use and understand the term *focal length*
- (k) draw ray diagrams to illustrate the formation of real and virtual images of an object by a lens
- (l) use and describe the use of a single lens as a magnifying glass

**13. Electromagnetic Spectrum****Content**

- 13.1 Properties of electromagnetic waves

**Learning Outcomes:**

Candidates should be able to:

- (a) state that all electromagnetic waves are transverse waves that travel with the same high speed *in vacuo* and state the magnitude of this speed
- (b) describe the main components of the electromagnetic spectrum

**14. Sound****Content**

- 14.1 Sound waves
- 14.2 Speed of sound

**Learning Outcomes:**

Candidates should be able to:

- (a) describe the production of sound by vibrating sources
- (b) describe the longitudinal nature of sound waves and describe compression and rarefaction
- (c) state the approximate range of audible frequencies
- (d) show understanding that a medium is required in order to transmit sound waves
- (e) describe an experiment to determine the speed of sound in air and make the necessary calculation
- (f) state the order of magnitude of the speed of sound in air, liquids and solids

**15. Static Electricity****Content**

15.1 Principles of electrostatics

**Learning Outcomes:**

Candidates should be able to:

- (a) show understanding that there are positive and negative charges and that charge is measured in coulombs
- (b) show understanding that unlike charges attract and that like charges repel

**16. Current Electricity****Content**

16.1 Electric current

16.2 Electromotive force

16.3 Potential difference

16.4 Resistance

**Learning Outcomes:**

Candidates should be able to:

- (a) show understanding that a current is a rate of flow of charge and is measured in amperes
- (b) use the equation  $I = Q/t$
- (c) use and describe the use of an ammeter
- (d) use the concept that the e.m.f. is measured by the energy dissipated by a source in driving charge round the complete circuit
- (e) show appreciation that the volt is given by J/C
- (f) show understanding that the potential difference across a circuit component is measured in volts
- (g) use and describe the use of a voltmeter
- (h) state that  $\text{resistance} = \text{p.d./current}$  and use the equation  $R = V/I$
- (i) describe an experiment to determine resistance using a voltmeter and an ammeter and make the necessary calculation
- (j) use quantitatively the relationship between resistance and the length and the cross-sectional area of a wire
- (k) sketch and interpret the V/I characteristic graphs for metallic (ohmic) and non-ohmic conductors
- (l) appreciate the limitations of Ohm's Law

**17. d.c. Circuits****Content**

17.1 Current and potential difference in circuits

17.2 Series and parallel circuits

**Learning Outcomes:**

Candidates should be able to:

- (a) draw and interpret circuit diagrams containing sources, switches, resistors (fixed and variable), ammeters, voltmeters, magnetising coils, bells, fuses and relays
- (b) show understanding that the current at every point in a series circuit is the same
- (c) use the fact that the sum of the p.d.s in a series circuit is equal to the p.d. across the whole circuit
- (d) calculate the combined resistance of two or more resistors in series
- (e) use the fact that the current from the source is the sum of the currents in the separate branches of a parallel circuit, the current from the source being larger than the current in each branch
- (f) calculate the effective resistance of two resistors in parallel

**18. Practical Electricity****Content**

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

**Learning Outcomes:**

Candidates should be able to:

- (a) describe the use of electricity in heating, lighting (including lamps in parallel) and motors
- (b) use the equations  $P = VI$  and  $E = VIt$
- (c) calculate the cost of using electrical appliances
- (d) state the hazards of
  - (i) damaged insulation
  - (ii) overheating of cables
  - (iii) damp conditions
- (e) show understanding of the use of fuses and fuse ratings
- (f) explain the need for earthing metal cases and for double insulation
- (g) give the meaning of the terms *live*, *neutral* and *earth*
- (h) wire, and describe how to wire, a mains plug
- (i) give the reasons for switches and fuses in live leads

**19. Magnetism****Content**

- 19.1 Laws of magnetism
- 19.2 Magnetic properties of matter

**Learning Outcomes:**

Candidates should be able to:

- (a) state the properties of magnets
- (b) give an account of *induced magnetism*
- (c) distinguish between *magnetic* and *non-magnetic* materials
- (d) describe methods of magnetisation and of demagnetisation
- (e) describe the use of a plotting compass to plot the field lines of magnetic field (Earth's field excluded)
- (f) distinguish between the magnetic properties of iron and steel
- (g) distinguish between the design and use of permanent magnets and electromagnets

**20. Electromagnetic Induction****Content**

- 20.1 Principles of electromagnetic induction
- 20.2 The a.c. generator
- 20.3 The transformer

**Learning Outcomes:**

Candidates should be able to:

- (a) describe an experiment which shows that a changing magnetic field can induce an e.m.f. in a circuit
- (b) state the factors affecting the magnitude of the induced e.m.f
- (c) show understanding that the direction of the induced e.m.f. opposes the change producing it
- (d) describe a simple form of generator (e.g. rotating coil or rotating magnet) and the use of slip rings
- (e) sketch a graph of voltage output against time for a simple a.c. generator
- (f) describe the structure and principle of operation of a basic iron-cored transformer as used for voltage transformations
- (g) use the equations  $(V_p/V_s) = (N_p/N_s)$  and  $V_p I_p = V_s I_s$  (for 100% efficiency)

**21. The Nuclear Atom****Content**

- 21.1 Atomic model
- 21.2 Composition of a nucleus
- 21.3 Proton number and nucleon number
- 21.4 Nuclide notation

**Learning Outcomes:**

Candidates should be able to:

- (a) describe the structure of an atom in terms of a nucleus and electrons
- (b) describe the composition of the nucleus in terms of protons and neutrons
- (c) use the term *nucleon number*, *A*
- (d) use the term *proton number*, *Z*
- (e) use the term *nuclide* and use the nuclide notation  ${}^A_Z X$

**22. Radioactivity****Content**

- 22.1 Detection of radioactivity
- 22.2 Characteristics of the three types of emission
- 22.3 Nuclear reactions
- 22.4 Half-life
- 22.5 Safety precautions

**Learning Outcomes:**

Candidates should be able to:

- (a) describe the detection of alpha-particles, beta-particles and gamma-rays
- (b) show understanding that radioactive emissions occur randomly over space and time
- (c) state, for radioactive emissions,
  - (i) their nature
  - (ii) their relative ionising effects
  - (iii) their relative penetrating powers
- (d) show understanding of the meaning of *radioactive decay*, using equations (involving symbols) to represent changes in the composition of the nucleus when particles are emitted
- (e) use the term *half-life* in simple calculations which might involve information in tables or in decay curves
- (f) describe how radioactive materials are handled, used, stored and disposed of, in a safe way

# CHEMISTRY SECTION

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It is important that, throughout the course, attention should be drawn to:

- (i) the finite life of the world's resources and hence the need for recycling and conservation;
- (ii) some economic considerations in the chemical industry, such as the availability and cost of raw materials and energy;
- (iii) the importance of chemicals in industry and in everyday life.

## 1. Experimental Chemistry

### Content

- 1.1 Experimental design
- 1.2 Methods of purification and analysis
- 1.3 Identification of ions and gases

### Learning Outcomes:

Candidates should be able to:

- (a) name and use appropriate apparatus for the measurement of time, temperature, mass and volume, including burettes, pipettes and measuring cylinders
- (b) design arrangements of apparatus, given information about the substances involved
- (c) describe and use methods of purification by the use of a suitable solvent, filtration, crystallisation and distillation (including description but **not** use of fractional distillation) (Refer to the fractional distillation of
  - (i) crude oil (petroleum) (topic 20.2(c))
  - (ii) fermented liquor (topic 23.1(a)).
- (d) suggest suitable purification techniques, given information about the substances involved
- (e) describe and use paper chromatography and interpret chromatograms
- (f) identify substances and test their purity by melting point and boiling point determination and by paper chromatography
- (g) identify
  - nitrate (by reduction with aluminium)
  - carbonate (by reaction with acid and then limewater)
  - chloride and iodide (by reaction with acidified silver nitrate or with acidified lead(II) nitrate)
  - sulfate (by reaction with acidified barium nitrate)
- (h) identify
  - aluminium, calcium, copper(II), iron(II), iron(III), zinc and ammonium (by using aqueous sodium hydroxide and aqueous ammonia, as appropriate). (Formulae of complex ions are **not** required)
- (i) identify
  - hydrogen (by lighted splint)
  - oxygen (by glowing splint)
  - carbon dioxide (by limewater)
  - chlorine (using indicator paper)
  - ammonia (using indicator paper)

## 2. Kinetic Particle Theory

### Learning Outcomes:

Candidates should be able to:

- (a) describe the states of matter and explain their inter-conversion in terms of the kinetic particle theory

## 3. Atomic Structure

### Content

- 3.1 Atomic structure
- 3.2 Isotopes

### Learning Outcomes:

Candidates should be able to:

- (a) state the relative charge and approximate relative mass of a proton, a neutron and an electron
- (b) define *proton number* and *nucleon number*
- (c) use and interpret such symbols as  ${}^{12}_6\text{C}$

- (d) use proton number and the simple structure of atoms to explain the Periodic Table, with special reference to the elements of proton number 1 to 20
- (e) define *isotopes*
- (f) describe the build-up of electrons in 'shells' and understand the significance of outer electrons and the noble gas electronic structures. (The ideas of the distribution of electrons in s- and p-orbitals and in d-block elements are **not** required. Note that a copy of the Periodic Table will be available in the examination.)

#### 4. Structure and Properties of Materials

##### **Learning Outcomes:**

Candidates should be able to:

- (a) describe the differences between elements, compounds and mixtures, and between metals and non-metals
- (b) describe alloys, such as brass, as a mixture of a metal with other elements

#### 5. Ionic Bonding

##### **Content**

- 5.1 Ion formation
- 5.2 Ionic bond formation

##### **Learning Outcomes:**

Candidates should be able to:

- (a) describe the formation of ions by electron loss or gain
- (b) describe the formation of ionic bonds between metallic and non-metallic elements (e.g. in NaCl and CaCl<sub>2</sub>)

#### 6. Covalent Bonding

##### **Content**

- 6.1 Covalent bond formation
- 6.2 Physical properties of covalent compounds

##### **Learning Outcomes:**

Candidates should be able to:

- (a) describe the formation of covalent bonds as the sharing of pairs of electrons leading to the noble gas configuration (e.g. H<sub>2</sub>, Cl<sub>2</sub>, HCl, H<sub>2</sub>O, CH<sub>4</sub> and CO<sub>2</sub>)
- (b) deduce the electron arrangement in other covalent molecules
- (c) construct 'dot and cross' diagrams to show the outer electrons in covalent molecules
- (d) describe the differences in volatility, solubility and electrical conductivity between ionic and covalent compounds

#### 7. Formulae, Stoichiometry and the Mole Concept

##### **Content**

- 7.1 Formulae
- 7.2 Equations
- 7.3 Stoichiometric calculations

##### **Learning Outcomes:**

Candidates should be able to:

- (a) state the symbols of the elements and the formulae of the compounds mentioned in the syllabus
- (b) deduce the formula of a simple compound from the relative numbers of atoms present and vice versa
- (c) determine the formula of an ionic compound from the charges on the ions present and vice versa
- (d) construct equations with state symbols, including ionic equations
- (e) deduce, from experimental results, the identity of the reactants and the products and the balanced chemical equation for a chemical reaction
- (f) define *relative atomic mass*,  $A_r$
- (g) define *relative molecular mass*,  $M_r$
- (h) use the mole and the Avogadro constant
- (i) use molar gas volume, taken as 24 dm<sup>3</sup> at room temperature and pressure



- (j) calculate the stoichiometric reacting masses and volumes of gases. (Questions on the gas laws and the conversion of gaseous volumes to different temperatures and pressures will **not** be set.)
- (k) use solution concentrations expressed in  $\text{g/dm}^3$  and  $\text{mol/dm}^3$ . (Calculations based on reacting volumes of solution (e.g. titrimetric data) will **not** be set.)

## 8. Energy from Chemicals

### Content

- 8.1 Exothermic and endothermic reactions  
8.2 Photosynthesis

### Learning Outcomes:

Candidates should be able to:

- (a) describe the meaning of *exothermic* and *endothermic* reactions
- (b) describe bond breaking as an endothermic process and bond forming as an exothermic process
- (c) describe the use of silver salts in photography as an endothermic process involving the reduction of silver ions to silver
- (d) describe photosynthesis as the reaction between carbon dioxide and water in the presence of chlorophyll and using sunlight (energy) to produce glucose

## 9. Chemical Reactions

### Content

- 9.1 Rate of reaction  
9.2 Redox

### Learning Outcomes:

Candidates should be able to:

- (a) describe the effect of concentration, pressure, particle size, catalysts (including enzymes) and temperature on the rates of reactions
- (b) describe how the above factors are used to explain the danger of explosive combustion with fine powders (e.g. in flour mills) and combustible gases (e.g. in mines)
- (c) interpret data obtained from experiments concerned with rate of reaction
- (d) define *oxidation* and *reduction* in terms of oxygen/hydrogen gain/loss
- (e) define *redox* in terms of electron transfer

## 10. The Chemistry and Uses of Acids, Bases and Salts

### Content

- 10.1 Characteristic properties of acids and bases  
10.2 pH  
10.3 Types of oxides  
10.4 Preparation of salts

### Learning Outcomes:

Candidates should be able to:

- (a) describe the meanings of the terms *acid* and *alkali* in terms of the ions they contain or produce in aqueous solution
- (b) describe the characteristic properties of acids as in their reactions with metals, bases, carbonates and their effects on indicator paper
- (c) describe the characteristic properties of bases as in their reactions with acids and with ammonium salts and their effects on indicator paper
- (d) describe neutrality and relative acidity and alkalinity in terms of pH (whole numbers only), measured using Universal Indicator paper
- (e) describe and explain the importance of controlling acidity in soil
- (f) classify oxides as either acidic, basic, or amphoteric related to metallic/non-metallic character
- (g) describe the preparation, separation and purification of salts as examples of some of the techniques specified in topic 1.2(c): methods of preparing salts to illustrate the practical techniques should include the action of acids with insoluble bases, and acids with insoluble carbonates
- (h) suggest a method of preparing a given salt from suitable starting materials, given appropriate information

**11. The Periodic Table****Content**

- 11.1 Periodic trends
- 11.2 Group properties

**Learning Outcomes:**

Candidates should be able to:

- (a) describe the Periodic Table as a method of classifying elements and describe its use in predicting properties of elements
- (b) describe the change from metallic to non-metallic character across a period
- (c) describe the relationship between group number, number of outer electrons and metallic/non-metallic character
- (d) describe lithium, sodium and potassium in Group I (the alkali metals) as a collection of relatively soft metals showing a trend in melting point and in reaction with water and with chlorine
- (e) predict the properties of other elements in Group I, given data, where appropriate
- (f) describe chlorine, bromine and iodine in Group VII (the halogens) as a collection of diatomic non-metals showing a trend in colour, state, and in their displacement reactions with other halide ions
- (g) predict the properties of other elements in Group VII, given data, where appropriate
- (h) identify trends in other groups, given information about the elements concerned
- (i) describe the noble gases as being unreactive
- (j) describe the uses of the noble gases in providing an inert atmosphere (e.g. argon in lamps and helium for filling balloons)

**12. Properties of Metals****Content**

- 12.1 Physical properties
- 12.2 Alloys

**Learning Outcomes:**

Candidates should be able to:

- (a) describe the general physical properties of metals
- (b) explain why metals are often used in the form of alloys
- (c) identify representations of metals and alloys from diagrams of structures

**13. Reactivity Series****Content**

- 13.1 Order of reactivity

**Learning Outcomes:**

Candidates should be able to:

- (a) place in order of reactivity calcium, copper, (hydrogen), iron, magnesium, potassium, sodium and zinc by reference to the reactions, if any, of the metals with water (or steam) and dilute hydrochloric acid
- (b) account for the apparent unreactivity of aluminium in terms of the presence of an oxide layer which adheres to the metal
- (c) deduce an order of reactivity from a given set of experimental results

**14. Extraction and Uses of Metals****Content**

- 14.1 Metal ores
- 14.2 The blast furnace
- 14.3 Iron and steel
- 14.4 Aluminium
- 14.5 Zinc
- 14.6 Copper

**Learning Outcomes:**

Candidates should be able to:

- (a) describe the ease in obtaining metals from their ores by relating the elements to the reactivity series

- (b) describe the essential reactions in the extraction of iron from haematite
- (c) describe the idea of changing the properties of iron by the controlled use of additives to form alloys called steels
- (d) state the uses of mild steel (car bodies and machinery) and stainless steel (chemical plant and cutlery)
- (e) state the uses of aluminium (e.g. in the manufacture of aircraft parts because of its strength and low density and in food containers because of its resistance to corrosion)
- (f) state the uses of zinc for galvanising and for making brass (with copper)
- (g) state the uses of copper related to its properties (e.g. electrical wiring)

## 15. Atmosphere and Environment

### **Content**

- 15.1 Air
- 15.2 Corrosion
- 15.3 Pollution
- 15.4 Water

### **Learning Outcomes:**

Candidates should be able to:

- (a) describe the volume composition of clean air in terms of 79% nitrogen, 20% oxygen, with the remainder being noble gases (with argon as the main constituent) carbon dioxide and variable amounts of water vapour
- (b) name the uses of oxygen in making steel, oxygen tents in hospitals, and with acetylene (a hydrocarbon) in welding
- (c) describe, in simple terms, the ideas of respiration, combustion and rusting
- (d) describe methods of rust prevention by painting and other coatings (including galvanising)
- (e) name common pollutants of air (carbon monoxide, sulfur dioxide, oxides of nitrogen and lead compounds)
- (f) state the source of each of these pollutants
  - (i) carbon monoxide from the incomplete combustion of carbon-containing substances
  - (ii) sulfur dioxide from the combustion of fossil fuels which contain sulfur compounds (leading to acid rain)
  - (iii) oxides of nitrogen and lead compounds from car exhausts
- (g) state the adverse effect of acidic pollutants on buildings and plants, and of carbon monoxide and lead compounds on health
- (h) describe, in outline, the purification of the water supply in terms of filtration and chlorination
- (i) state some of the uses of water in industry and in the home

## 16. Hydrogen

### **Learning Outcomes:**

Candidates should be able to:

- (a) describe the formation of hydrogen as a product of the reaction between
  - (i) reactive metals and water
  - (ii) metals and acids
- (b) name the uses of hydrogen in the manufacture of ammonia and margarine, and as a fuel in rockets

## 17. Nitrogen

### **Content**

- 17.1 Ammonia and the Haber process
- 17.2 Fertiliser manufacture

### **Learning Outcomes:**

Candidates should be able to:

- (a) describe the need for nitrogen, phosphorus and potassium compounds in plant life
- (b) name the use of nitrogen in the manufacture of ammonia
- (c) describe the essential conditions for the manufacture of ammonia by the Haber process
- (d) name the uses of ammonia in the manufacture of fertilisers such as ammonium sulfate and nitrate

**18. Carbon and Carbonates****Content**

- 18.1 Allotropes of carbon
- 18.2 Manufacture and uses of lime
- 18.3 Uses of calcium carbonate

**Learning Outcomes:**

Candidates should be able to:

- (a) name the allotropes of carbon as graphite and diamond
- (b) relate their structures to the use of graphite as a lubricant and diamond in cutting
- (c) describe the manufacture of lime (calcium oxide) from calcium carbonate (limestone) in terms of the chemical reaction involved
- (d) state some uses of lime and slaked lime as in treating acidic soil and neutralising acidic industrial waste products
- (e) state the uses of calcium carbonate in the manufacture of iron, glass and cement

**19. Organic Chemistry****Content**

- 19.1 Names of compounds
- 19.2 Structures of compounds
- 19.3 Homologous series

**Learning Outcomes:**

Candidates should be able to:

- (a) name, and draw the structure of, the unbranched alkanes, alkenes (**not** cis-trans), alcohols and acids containing up to four carbon atoms per molecule and the products of the reactions stated in topics 21 to 24.
- (b) state the type of compound present given a chemical name, ending in -ane, -ene, -ol, or -oic acid, or given a molecular structure
- (c) describe the general characteristics of a homologous series

**20. Fuels****Content**

- 20.1 Natural gas and petroleum as energy sources
- 20.2 Fractional distillation
- 20.3 Uses of fractions

**Learning Outcomes:**

Candidates should be able to:

- (a) name natural gas and petroleum as sources of fuels
- (b) name methane as the main constituent of natural gas
- (c) describe petroleum as a mixture of hydrocarbons and its separation into useful fractions by fractional distillation
- (d) name the uses of petroleum fractions: petrol (gasoline), as fuel in cars; paraffin (kerosene), for oil stoves and aircraft fuel; diesel, for fuel in diesel engines; oils, for lubricants and making waxes and polishes; bitumen, for making roads

**21. Alkanes****Content**

- 21.1 Properties of alkanes

**Learning Outcomes:**

Candidates should be able to:

- (a) describe the properties of alkanes (exemplified by methane) as being generally unreactive, except in terms of burning

**22. Alkenes**

**Content**

- 22.1 Cracking
- 22.2 Unsaturated hydrocarbons
- 22.3 Polymerisation

**Learning Outcomes:**

Candidates should be able to:

- (a) describe the manufacture of alkenes and of hydrogen by cracking
- (b) describe the properties of alkenes in terms of burning and addition reactions with hydrogen and steam
- (c) distinguish between saturated and unsaturated hydrocarbons
  - (i) from molecular structures
  - (ii) by using aqueous bromine
- (d) describe the formation of poly(ethene) as an example of addition polymerisation of monomer units
- (e) name some uses of poly(ethene) as a typical plastic (e.g. plastic bags)

**23. Alcohols**

**Content**

- 23.1 Formation of ethanol
- 23.2 Combustion and oxidation
- 23.3 Uses of ethanol

**Learning Outcomes:**

Candidates should be able to:

- (a) describe the formation of ethanol by fermentation and by the catalytic addition of steam to ethene
- (b) describe the properties of ethanol in terms of combustion and of oxidation
- (c) name the uses of ethanol (e.g. as a solvent, as a fuel and as a constituent of wine and beer)

**24. Acids**

**Content**

- 24.1 Ethanoic acid

**Learning Outcomes:**

Candidates should be able to:

- (a) describe the formation of ethanoic acid as the oxidation of ethanol by the action of atmospheric oxygen
- (b) describe the reaction of ethanoic acid with ethanol to give an ester (ethyl ethanoate)

**25. Macromolecules**

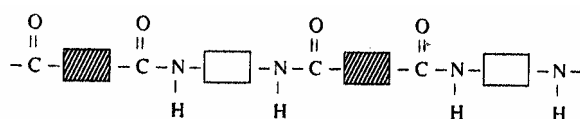
**Content**

- 25.1 Monomers and polymers
- 25.2 Man-made fibres
- 25.3 Pollution
- 25.4 Natural macromolecules

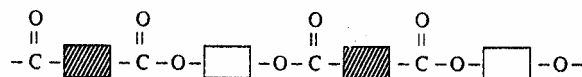
**Learning Outcomes:**

Candidates should be able to:

- (a) describe macromolecules in terms of large molecules built up from small units, different macromolecules having different units and/or different linkages
- (b) deduce the structure of the polymer product from a given alkene and vice versa
- (c) describe the formation of *nylon* (a polyamide) and *Terylene* (a polyester) by condensation polymerisation, the structure of nylon represented as

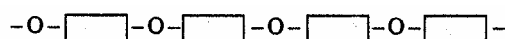


and the structure of *Terylene* as



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

- (d) name some typical uses of man-made fibres such as nylon and *Terylene* (e.g. clothing)
- (e) describe the pollution problems caused by non-biodegradable plastics
- (f) name proteins, fats and carbohydrates as the main constituents of foods
- (g) describe proteins as possessing the same (amide) linkages as nylon but with different units
- (h) describe the hydrolysis of proteins to amino acids (structures and names **not** required)
- (i) describe fats as esters possessing the same linkages as *Terylene* but with different units
- (j) describe soap as a product of the hydrolysis of fats
- (k) describe the carbohydrate starch as a macromolecule represented as



being formed by the condensation polymerisation of smaller carbohydrate units called sugars, represented as



- (l) describe the acid hydrolysis of carbohydrates such as starch to give simple sugars
- (m) describe the fermentation of simple sugars to produce ethanol (and carbon dioxide) and its importance to brewing and wine-making (Candidates will **not** be expected to give the molecular formulae of sugars.)

# BIOLOGY SECTION

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## 1. Cell Structure and Organisation

### Content

- 1.1 Plant and animal cells
- 1.2 Specialised cells

### Learning Outcomes:

Candidates should be able to:

- (a) examine under the microscope an animal cell (e.g. from fresh liver) and a plant cell (e.g. from Elodea, a moss, or any suitable locally available material), using an appropriate temporary staining technique
- (b) draw diagrams to represent these observations (cell membrane, nucleus and cytoplasm for animal cells; cell wall, cell membrane, nucleus, cytoplasm, sap vacuole and chloroplasts for plant cells)
- (c) compare the visible differences in structure of the animal and plant cells examined
- (d) state the function of the cell membrane in controlling the passage of substances into and out of the cell
- (e) state, in simple terms, the relationship between cell structure and cell function for
  - (i) root hair cells – absorption
  - (ii) xylem vessels – conduction and support
  - (iii) red blood cells – transport of oxygen
- (f) identify these cells from fresh or preserved materials under the microscope, from diagrams and from photomicrographs

## 2. Diffusion and Osmosis

### Content

- 2.1 Diffusion
- 2.2 Osmosis

### Learning Outcomes:

Candidates should be able to:

- (a) define *diffusion* as the movement of molecules from a region of their higher concentration to a region of their lower concentration, down a concentration gradient
- (b) define *osmosis* as the passage of water molecules from a region of their higher concentration to a region of their lower concentration, through a partially permeable membrane
- (c) describe the importance of water potential gradient in the uptake of water by plants and the effects of osmosis on plant and animal tissues

## 3. Enzymes

### Content

- 3.1 Enzyme action
- 3.2 Effects of temperature and of pH

### Learning Outcomes:

Candidates should be able to:

- (a) define *enzymes* as proteins which function as biological catalysts
- (b) investigate and describe the effect of temperature and of pH on enzyme activity
- (c) state the effect of enzymes on the germination of seeds

## 4. Plant Nutrition

### Content

- 4.1 Photosynthesis
- 4.2 Leaf structure
- 4.3 Mineral nutrition

### Learning Outcomes:

Candidates should be able to:

- (a)