

General Certificate of Education  
Ordinary Level

**Syllabus**

ADDITIONAL COMBINED SCIENCE 5130

For examination in November 2009

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# ADDITIONAL COMBINED SCIENCE 5130

## GCE ORDINARY LEVEL

### CONTENTS

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	<i>Page</i>
<b>NOTES</b>	i
<b>ADDITIONAL COMBINED SCIENCE GCE O Level/SC 5130 (November only)</b>	1
<b>Aims</b>	1
<b>Assessment Objectives</b>	2
<b>Scheme of Assessment</b>	3
<b>Physics Section</b>	4
<b>Chemistry Section</b>	12
<b>Biology Section</b>	21
<b>DATA SHEET</b>	27
<b>RESOURCE LIST</b>	28
<b>MATHEMATICAL REQUIREMENTS</b>	30
<b>SYMBOLS, UNITS AND DEFINITIONS OF PHYSICAL QUANTITIES</b>	31
<b>GLOSSARY OF TERMS USED IN SCIENCE PAPERS</b>	32

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### Exclusions

This syllabus must not be offered in the same session with any of the following syllabuses:

0610 Biology  
0625 Physics  
0652 Physical Science  
0653 Combined Science  
0654 Co-ordinated Sciences (Double)  
5054 Physics  
5070 Chemistry  
5090 Biology  
5096 Human and Social Biology  
5124 Science (Physics, Chemistry)  
5125 Science (Physics, Biology)  
5126 Science (Chemistry, Biology)

# NOTES

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## 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.

**5130 ADDITIONAL COMBINED SCIENCE  
GCE ORDINARY LEVEL/SCHOOL CERTIFICATE**

It is expected that this subject will be taken in conjunction with Combined Science (5129).  
(This syllabus is 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 sciences 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

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Paper	Type of Paper	Duration	Marks	Weighting
1	Multiple Choice	1 h	40	29%
2	Theory	2 h 15 min	100	71%

**Candidates are required to enter for Papers 1 and 2.**

**Paper 1** (1 h, 40 marks), consisting of 40 multiple choice questions of the direct choice type providing approximately equal coverage of the Physics, Chemistry and Biology sections of the syllabus.

**Paper 2** (2 h 15 min, 100 marks), consisting of two sections.

Section A will carry 70 marks and will contain a number of compulsory structured questions of variable mark value.

Section B will carry 30 marks and will contain a question on each of the Physics, Chemistry and Biology sections of the syllabus. Each question will have a degree of choice, *either* the first part *or* the second part to be answered. Each part will carry 10 marks.

## 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) understand nuclear fusion and fission as energy releasing processes
- (g) use the mass-energy equivalence equation  $E = mc^2$
- (h) relate work done to the magnitude of a force and the distance moved and make calculations involving  $F \times d$
- (i) 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) show understanding of the term *wavefront*
- (c) give the meaning of *speed, frequency, wavelength* and *amplitude* and use the equation  $c = f \times \lambda$
- (d) distinguish between *longitudinal* and *transverse* waves and give suitable examples
- (e) describe the use of a ripple tank to show
  - (i) reflection at a plane surface
  - (ii) refraction due to a change of speed

## 12. Light

### Content

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

### 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
- (m) give a qualitative account of the dispersion of light as illustrated by the action on light of a glass prism

## 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
- (g) relate the loudness and pitch of sound waves to amplitude and frequency
- (h) describe how the reflection of sound may produce an echo

## 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  $resistance = P.D./current$  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 uses 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
- 20.4 The d.c. motor
- 20.5 Action of a loudspeaker

### 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
 
$$V_p I_p = V_s I_s \text{ (for 100\% efficiency)}$$
- (h) describe the use of the transformer in high-voltage transmission of electricity
- (i) discuss the energy loss in cables
- (j) give the advantages of high voltage transmission

- (k) show understanding that 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
- (l) relate this turning effect to the action of an electric motor
- (m) describe and show understanding of the action of a split-ring commutator in a two-pole, single-coil motor and the effect of a soft-iron cylinder between the poles of the magnet
- (n) describe the action of a loudspeaker (Details of the cone will **not** be required.)

## 21. Introductory Electronics

### **Content**

- 21.1 Thermionic emission
- 21.2 Simple treatment of cathode-ray oscilloscope
- 21.3 Action and use of circuit components

### **Learning Outcomes:**

Candidates should be able to:

- (a) show understanding that electrons are emitted by a hot-metal filament and describe their deflection in electric fields and magnetic fields
- (b) distinguish between the direction of an electron current and a conventional current
- (c) describe in outline the basic structure, and action, of a cathode-ray oscilloscope (Detailed circuits are **not** required.)
- (d) use and describe the use of a cathode-ray oscilloscope to display wave forms and to measure p.d.s and short intervals of time (Detailed circuits are **not** required.)
- (e) show understanding of the behaviour of resistors

## 22. The Nuclear Atom

### **Content**

- 22.1 Atomic model
- 22.2 Composition of a nucleus
- 22.3 Proton number and nucleon number
- 22.4 Nuclide notation
- 22.5 Isotopes

### **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 *proton number, Z*
- (d) use the term *nucleon number, A*
- (e) use the term *nuclide* and use the nuclide notation  ${}^A_Z X$
- (f) use the term *isotopes*
- (g) give examples of the appropriate use of isotopes

## 23. Radioactivity

### **Content**

- 23.1 Detection of radioactivity
- 23.2 Characteristics of the three types of emission
- 23.3 Nuclear reactions
- 23.4 Half-life
- 23.5 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) describe their deflection in electric fields and magnetic fields
- (e) 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

- (f) distinguish between *fusion* and *fission*
- (g) use the term *half-life* in simple calculations which might involve information in tables or in decay curves
- (h) 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 23.2(c))
  - (ii) fermented liquor (topic 26.1(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*  
state the two types of isotopes as being non-radioactive (stable) and radioactive (unstable, emitting radiation)
- (f) state one medical and one industrial use of named radioactive isotopes
- (g) 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. Macromolecules

##### **Content**

- 7.1 Structure
- 7.2 Properties

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

Candidates should be able to:

- (a) describe the structure of macromolecules such as graphite, diamond, silicon(IV) oxide (silica) and poly(ethene)
- (b) describe the similarity in properties between diamond and silicon, diamond and silicon(IV) oxide (silica), related to their structures

#### 8. Metallic Bonding

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

Candidates should be able to:

- (a) describe metallic bonding as a lattice of positive ions in a 'sea of electrons' and explain the electrical conductivity and malleability of metals

## 9. Formulae, Stoichiometry and the Mole Concept

### Content

- 9.1 Formulae
- 9.2 Equations
- 9.3 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  $24 \text{ dm}^3$  at room temperature and pressure
- (j) calculate 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.)

## 10. Electricity and Chemistry

### Content

- 10.1 Electrolysis
- 10.2 Manufacture of aluminium, chlorine and sodium hydroxide
- 10.3 Electroplating
- 10.4 Uses of conductors and insulators

### Learning Outcomes:

Candidates should be able to:

- (a) describe the electrode products in the electrolysis of
  - (i) molten lead(II) bromide, concentrated hydrochloric acid, concentrated aqueous sodium chloride and dilute sulfuric acid (as essentially the electrolysis of water) between inert electrodes
  - (ii) aqueous copper(II) sulfate between carbon electrodes and between copper electrodes (as used in the refining of copper)
- (b) describe electrolysis in terms of the ions present and the reactions at the electrodes in the examples given
- (c) state the general principle that metals or hydrogen are formed at the negative electrode (cathode) and that non-metals (other than hydrogen) are formed at the positive electrode (anode)
- (d) predict the likely products of the electrolysis of a specified binary compound in the molten state, or in concentrated aqueous solution
- (e) describe, in outline, the manufacture of
  - (i) aluminium from pure aluminium oxide in molten cryolite
  - (ii) chlorine and sodium hydroxide from concentrated aqueous sodium chloride (starting materials and essential conditions should be given together with equations for the electrode reactions but **no** technical details or diagrams)
- (f) describe the electroplating of metals exemplified by copper plating
- (g) state *two* uses of electroplating
- (h) describe the reasons for the use of copper and (steel-cored) aluminium in cables and why plastics and ceramics are used as insulators

## 11. Energy from Chemicals

### Content

- 11.1 Exothermic and endothermic reactions
- 11.2 Heat energy from fuels
- 11.3 Nuclear energy from radioactive isotopes
- 11.4 Electrical energy from simple cells
- 11.5 Energy from 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) state that the burning of fuels (e.g. wood, coal and oil) produces heat energy
- (d) describe hydrogen as a fuel (e.g. in rockets)
- (e) describe radioactive isotopes, such as  $^{235}\text{U}$ , as a source of nuclear energy
- (f) describe the production of electrical energy from simple cells (i.e. two electrodes in an electrolyte) (This should be linked with the reactivity series, topic 16.1.)
- (g) describe the use of batteries as a convenient, portable energy source
- (h) describe the use of silver salts in photography as an endothermic process involving reduction of silver ions to silver
- (i) describe photosynthesis as the reaction between carbon dioxide and water in the presence of chlorophyll and using sunlight (energy) to produce glucose

**12. Chemical Reactions**

**Content**

- 12.1 Rate of reaction
- 12.2 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

**13. The Chemistry and Uses of Acids, Bases and Salts**

**Content**

- 13.1 Characteristic properties of acids and bases
- 13.2 pH
- 13.3 Types of oxides
- 13.4 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

#### 14. The Periodic Table

##### **Content**

- 14.1 Periodic trends
- 14.2 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)

#### 15. Properties of Metals

##### **Content**

- 15.1 Physical properties
- 15.2 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

#### 16. Reactivity Series

##### **Content**

- 16.1 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

#### 17. Extraction and Uses of Metals

##### **Content**

- 17.1 Metal ores
- 17.2 The blast furnace
- 17.3 Iron and steel
- 17.4 Aluminium
- 17.5 Zinc
- 17.6 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) describe, in outline, the extraction of aluminium from pure aluminium oxide (see also topic 10.2(e))
- (f) 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)
- (g) state the uses of zinc for galvanising and for making brass (with copper)
- (h) state the uses of copper related to its properties (e.g. electrical wiring (see also topic 10.3(h)))

## 18. Atmosphere and Environment

### **Content**

- 18.1 Air
- 18.2 Corrosion
- 18.3 Pollution
- 18.4 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

## 19. 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

## 20. Nitrogen

### **Content**

- 20.1 Ammonia and the Haber process
- 20.2 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

## 21. Carbon and Carbonates

### **Content**

- 21.1 Allotropes of carbon
- 21.2 Manufacture and uses of lime
- 21.3 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

## 22. Organic Chemistry

### **Content**

- 22.1 Names of compounds
- 22.2 Structures of compounds
- 22.3 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 24 to 27.
- (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

## 23. Fuels

### **Content**

- 23.1 Natural gas and petroleum as energy sources
- 23.2 Fractional distillation
- 23.3 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

## 24. Alkanes

### **Content**

- 24.1 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

**25. Alkenes**

**Content**

- 25.1 Cracking
- 25.2 Unsaturated hydrocarbons
- 25.3 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, 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)

**26. Alcohols**

**Content**

- 26.1 Formation of ethanol
- 26.2 Combustion and oxidation
- 26.3 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)

**27. Acids**

**Content**

- 27.1 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)

**28. Macromolecules**

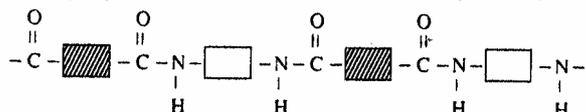
**Content**

- 28.1 Monomers and polymers
- 28.2 Man-made fibres
- 28.3 Pollution
- 28.4 Natural macromolecules

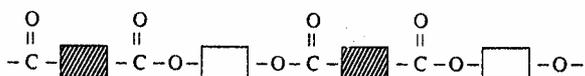
**Learning Outcomes:**

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



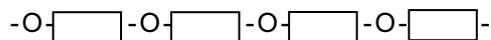
and the structure of *Terylene* as



(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 food
- (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 *Eloдея*, a moss, or any suitable locally available material), using an appropriate temporary staining technique
- (b) draw diagrams to represent the 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) understand that photosynthesis is the fundamental process by which plants manufacture carbohydrates from raw materials
- (b) investigate the necessity for chlorophyll, light and carbon dioxide for photosynthesis using appropriate controls, and derive, as far as possible, the equation (in words or symbols) for photosynthesis

- (c) investigate and state the effect of varying light intensity and temperature on the rate of photosynthesis (e.g. in submerged aquatic plants, such as *Elodea*)
- (d) describe the intake of carbon dioxide and water by plants, the trapping of light energy by chlorophyll, the conversion of light energy into chemical energy, the formation of carbohydrates, their subsequent storage, and the release of oxygen
- (e) explain why most forms of life are completely dependent on photosynthesis
- (f) identify and label the cellular and tissue structure of a dicotyledonous leaf, as seen in cross-section under the microscope and describe the significance of these features in terms of functions (i.e. distribution of chloroplasts – photosynthesis; stomata and mesophyll cells – gaseous exchange; vascular bundles – transport)
- (g) investigate and state the effect of insufficient nitrogen on plant growth and state the importance of nitrogen-containing ions for protein synthesis and their use in nitrogen-containing fertilisers for agriculture

## 5. Animal Nutrition

### **Content**

- 5.1 Diet
- 5.2 Human alimentary canal
- 5.3 Mechanical and physical digestion
- 5.4 Chemical digestion
- 5.5 Absorption and assimilation

### **Learning Outcomes:**

Candidates should be able to:

- (a) define a *balanced diet* as a diet supplying sufficient quantities of protein, carbohydrates, fat, vitamins, minerals, fibre, water and energy to sustain a healthy life
- (b) explain why diet, especially energy intake, should be related to age, sex, and activity of an individual
- (c) state the effects of malnutrition in relation to constipation and obesity
- (d) identify, on diagrams and photographs, and name the main regions of the alimentary canal and the associated organs: mouth, salivary glands, oesophagus, stomach, duodenum, pancreas, gall bladder, liver, ileum, colon, rectum and anus
- (e) describe the main functions of these parts in relation to ingestion, digestion, absorption, assimilation and egestion of food, as appropriate
- (f) describe the function of the teeth in reducing the size of food particles
- (g) state the causes of dental decay and describe the proper care of teeth
- (h) describe chewing and peristalsis
- (i) state the reasons why most foods must be digested
- (j) describe the function of a typical amylase, listing the substrate and end-products as an example of extra-cellular digestion in the alimentary canal
- (k) describe absorption as the passage of soluble products of digestion through the wall of the small intestine and into the blood capillaries (Structure of villi is **not** required.)
- (l) state the function of the hepatic portal vein as the route taken by most of the food absorbed from the small intestine
- (m) state
  - (i) that large molecules are synthesised from smaller basic units:
    - glycogen from simple sugars
    - proteins from amino acids
    - lipids (fats and oils) from glycerol and fatty acids
  - (ii) the role of the liver in the metabolism of glucose and amino acids
  - (iii) the role of fat as a storage substance
- (n) state that the formation of urea and the breakdown of alcohol occur in the liver

## 6. Transport in Flowering Plants

### **Content**

- 6.1 Water and ion uptake
- 6.2 Transpiration and translocation

### **Learning Outcomes:**

Candidates should be able to:

- (a) describe the structure and function of root hairs in relation to their surface area, and to water and ion uptake (topic 1.2(e))
- (b) define *transpiration* as the loss of water vapour from stomata
- (c) describe
  - (i) how water vapour loss is related to cell surfaces, air spaces and stomata
  - (ii) the effects of variation of temperature, humidity and light intensity on transpiration rate
- (d) investigate, using a suitable stain, the pathway of water in a cut stem
- (e) describe how wilting occurs
- (f) state the functions of xylem (support and conduction of water and mineral salts, topic 1.2(e)) and phloem (movement of sugars throughout the plant) (Details of root and stem structure are **not** required.)

## 7. Transport in Humans

### **Content**

- 7.1 Circulatory system

### **Learning Outcomes:**

Candidates should be able to:

- (a) describe the circulatory system as a system of tubes with a pump and valves to ensure one-way flow of blood
- (b) describe the dual circulation in terms of a low pressure circulation to the lungs and a high pressure circulation to the body tissues and relate these differences to the different functions of the two circuits
- (c) describe the structure and function of the heart in terms of muscular contraction and the working of valves
- (d) compare the structure and function of arteries, veins and capillaries
- (e) investigate and state the effect of physical activity on pulse rate
- (f) describe coronary heart disease in terms of blockage of coronary arteries and list the possible causes
- (g) identify red and white blood cells as seen under the microscope on prepared slides, and in diagrams and photomicrographs
- (h) list the components of blood as red blood cells, white blood cells, platelets and plasma
- (i) state the functions of blood
  - (i) red blood cells – haemoglobin and oxygen transport
  - (ii) white blood cells – phagocytosis, antibody formation and tissue rejection
  - (iii) platelets – fibrinogen to fibrin causing clotting
  - (iv) plasma – transport of blood cells, ions, soluble food substances, hormones, carbon dioxide, urea, vitamins and plasma proteins

## 8. Respiration

### **Content**

- 8.1 Aerobic respiration
- 8.2 Anaerobic respiration
- 8.3 Human gaseous exchange

### **Learning Outcomes:**

Candidates should be able to:

- (a) define *respiration* as the release of energy from food substances in living cells
- (b) define *aerobic respiration* as the release of a relatively large amount of energy by the breakdown of food substances in the presence of oxygen
- (c) state the equation for aerobic respiration, using words only
- (d) define *anaerobic respiration* as the release of a relatively small amount of energy by the breakdown of food substances in the absence of oxygen
- (e) state the equation for anaerobic respiration, using words only
- (f) describe the production of lactic acid in muscles during exercise
- (g) state the differences between inspired and expired air

- (h) investigate and state the effect of physical activity on rate and depth of breathing
- (i) identify on diagrams and name the larynx, trachea, bronchi, bronchioles, alveoli and associated capillaries
- (j) describe the role of the exchange surface of the alveoli in gaseous exchange (Details of the role of the diaphragm, ribs and intercostal muscles in breathing are **not** required.)

## 9. Excretion

### **Content**

- 9.1 Excretion
- 9.2 Urinary system
- 9.3 Dialysis

### **Learning Outcomes:**

Candidates should be able to:

- (a) define *excretion* as the removal of toxic materials and the waste products of metabolism from organisms
- (b) describe the removal of carbon dioxide from the lungs, and of water and urea through the kidneys (Details of kidney structure and nephron are **not** required.)
- (c) identify on diagrams and name the kidneys, ureters, bladder and urethra, and state the function of each (the function of the kidney should be described simply as removing urea and excess water from the blood)
- (d) describe dialysis in kidney machines as the diffusion of waste products and salts (small molecules) through a membrane, large molecules (e.g. protein) remaining in the blood

## 10. Homeostasis

### **Learning Outcomes:**

Candidates should be able to:

- (a) define *homeostasis* as the maintenance of a constant internal environment
- (b) describe the maintenance of a constant body temperature in Man in terms of the role of temperature receptors in the skin, sweating, shivering, blood vessels near the skin surface and the co-ordinating role of the brain

## 11. Co-ordination and Response

### **Content**

- 11.1 Receptors
- 11.2 Reflex action
- 11.3 Hormones
- 11.4 Diabetes mellitus

### **Learning Outcomes:**

Candidates should be able to:

- (a) state the principal functions of component parts of the eye in producing a focused image of near and distant objects on the retina
- (b) describe the pupil reflex in response to bright and dim light
- (c) outline the functions of sensory neurones in relaying information from receptors (e.g. the eye) to the brain and/or spinal cord, relay neurones in transferring information to other parts of the brain and/or spinal cord and motor neurones in relaying information to muscles and glands
- (d) 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
- (e) state the role of the hormone adrenaline in boosting blood glucose levels and give examples of situations in which this may occur
- (f) describe the signs (increased blood glucose level and glucose in urine) and treatment (administration of insulin) of diabetes mellitus

## 12. The Use and Abuse of Drugs

### **Content**

- 12.1 Antibiotics
- 12.2 Effects of heroin
- 12.3 Effects of alcohol
- 12.4 Effects of smoking

### **Learning Outcomes:**

Candidates should be able to:

- (a) define a *drug* as an externally administered substance which modifies or affects chemical reactions in the body
- (b) describe the medicinal use of antibiotics (e.g. penicillin) for the treatment of bacterial infections
- (c) describe a drug such as heroin as a drug of abuse and its related effects such as a powerful depressant, problems of addiction, severe withdrawal symptoms, associated problems such as crime and infection (e.g. AIDS)
- (d) describe the effects of excessive consumption of alcohol: reduced self-control, depressant, problems of addiction, severe withdrawal symptoms, associated problems such as crime and infection (e.g. AIDS)
- (e) describe the effects of smoking on health: strong association with bronchitis, emphysema, lung cancer and heart disease, and the association between smoking during pregnancy and reduced birth weight of the baby; recognise the fact that smoking is no longer socially accepted by an increasing number of people

## 13. Relationships of Organisms with One Another and with the Environment

### **Content**

- 13.1 Energy flow
- 13.2 Food chains and food webs
- 13.3 Carbon and water cycles
- 13.4 Effects of Man on the ecosystem
- 13.5 Pollution
- 13.6 Conservation

### **Learning Outcomes:**

Candidates should be able to:

- (a) state that the Sun is the principal source of energy input to biological systems
- (b) describe the non-cyclical nature of energy flow
- (c) define *food chain*, *food web*, *producer*, *consumer*, *herbivore*, *carnivore* and *decomposer*
- (d) describe energy losses between trophic levels and the advantages of short food chains
- (e) describe the carbon cycle in terms of photosynthesis, animal nutrition, respiration and combustion
- (f) describe the water cycle
- (g) describe the effects of Man on the ecosystem with emphasis on examples of international importance (tropical rain forests, oceans and rivers)
- (h) describe the consequences of deforestation in terms of effects on: soil stability, climate (water cycle) and local human populations
- (i) describe the problems which contribute to famine (unequal distribution of food, drought and flooding and increasing population)
- (j) describe the undesirable effects of
  - (i) water pollution by sewage and by inorganic waste
  - (ii) air pollution by sulfur dioxide (acid rain)
  - (iii) pollution due to insecticides
- (k) state reasons for the conservation of species with reference to plants as sources of useful products such as drugs, timbers, oils, fibres, chemicals (e.g. pyrethrum), and products such as rubber, and to the need to investigate threatened species before they become extinct
- (l) state reasons for the recycling of materials such as water (sewage) and paper (from trees)

#### 14. Development of Organisms and Continuity of Life

##### **Content**

- 14.1 Asexual reproduction
- 14.2 Sexual reproduction in plants
- 14.3 Sexual reproduction in humans
- 14.4 Sexually transmitted diseases

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

Candidates should be able to:

- (a) define *asexual reproduction* as the process resulting in the production of genetically identical offspring from one parent
- (b) describe *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 dicotyledonous flower
- (d) state the functions of the sepals, petals, anthers and carpels
- (e) outline the process of pollination and describe the growth of the pollen tube and its entry into the ovule followed by fertilisation (Production of endosperm and details of development are **not** required.)
- (f) investigate and describe the structure of a non-endospermic seed in terms of the embryo (radicle, plumule and cotyledons) and the testa, protected by the pericarp (fruit wall)
- (g) state that seed and fruit dispersal by wind and animals provides a means of colonising new areas
- (h) investigate and state the environmental conditions which affect germination of seeds (suitable temperature, water and oxygen)
- (i) identify on diagrams of the male reproductive system and give the functions of testes, scrotum, sperm ducts, prostate gland, urethra and penis
- (j) identify on diagrams of the female reproductive system and give the functions of: ovaries, oviducts, uterus, cervix and vagina
- (k) compare male and female gametes in terms of size, numbers and mobility
- (l) describe the menstrual cycle with reference to the alternation of menstruation and ovulation, the natural variation in its length, and fertile and infertile phases of the cycle
- (m) state the effect of factors, such as diet and emotional state, which affect the menstrual cycle
- (n) describe *fertilisation* and the 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, where it develops as the fetus
- (o) state the function of the amniotic sac and of the amniotic fluid
- (p) 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.)
- (q) describe the advantages of breast milk compared with bottle feeding
- (r) describe the following methods of birth control: natural, chemical (spermicides), mechanical, hormonal and surgical
- (s) describe the symptoms, signs, effects and treatment of gonorrhoea and syphilis
- (t) discuss the spread of human immuno-deficiency virus (HIV) and methods by which it may be controlled

#### 15. Inheritance

##### **Content**

- 15.1 Variation
- 15.2 Chromosomes and genes

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

Candidates should be able to:

- (a) describe the difference between *continuous* and *discontinuous* variation and give examples of each
- (b) define a *gene* as a unit of inheritance and distinguish clearly between the terms *gene* and *allele*
- (c) state that genes are carried on chromosomes
- (d) describe complete dominance using the terms *dominant*, *recessive*, *phenotype* and *genotype*
- (e) describe mutation as a change in the structure of a gene (sickle cell anaemia) or in the chromosome number (Down's syndrome)
- (f) name radiation and chemicals as factors which may increase the rate of mutation
- (g) describe the determination of sex in Man (XX and XY chromosomes)

## The Periodic Table of the Elements

Group																				
I	II											III	IV	V	VI	VII	0			
												1 H Hydrogen 1								4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10			
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18			
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36			
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54			
133 Cs Caesium 55	137 Ba Barium 56	139 La Lanthanum 57	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	Po Polonium 84	At Astatine 85	Rn Radon 86			
Fr Francium 87	226 Ra Radium 88	227 Ac actinium 89																		

27

\*58-71 Lanthanoid series

†90-103 Actinoid series

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	163 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	Pa Protactinium 91	238 U Uranium 92	Np Neptunium 93	Pu Plutonium 94	Am Americium 95	Cm Curium 96	Bk Berkelium 97	Cf Californium 98	Es Einsteinium 99	Fm Fermium 100	Md Mendelevium 101	No Nobelium 102	Lr Lawrencium 103

Key

a
X
b

a = relative atomic mass

X = atomic symbol

b = proton (atomic) number

The volume of one mole of any gas is 24dm<sup>3</sup> at room temperature and pressure (r.t.p)..

## RESOURCE LIST

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### Resources – Combined Sciences Ordinary Level

Science	(Physics, Chemistry)	5124
	(Physics, Biology)	5125
	(Chemistry, Biology)	5126
Combined Science		5129
Additional Combined Science		5130

### BOOKS

Brian Samuel Beckett; Illustrated Biology; Oxford University Press; 0 19 914044 8;

Beckett & Gallagher; Co-ordinated Science: Biology; Oxford University Press; 0 19 914653 5;

Kevin Byrne; Revise GCSE in a week – Science Double & Single Award; BPP (Letts Educational) Ltd; 1 85758 702 2;

Gallagher, Ingram & Whitehead; Co-ordinated Science: Chemistry; Oxford University Press; 0 19 914652 7;

Pople and Whitehead; Co-ordinated Science: Physics; Oxford University Press; 0 19 914651 9  
Activities Books and Teacher's Guides are also available for this series;

K Foulds; GCSE Science Double Award Physics; John Murray; 07195 7159;

S Gater & V Wood-Robinson; GCE Science Double Award Biology; John Murray; 07195 7157 X;

G Hill; Science for GCSE Double Award 2nd ed (June '01); Hodder & Stoughton; Text 0340800445 Pupils' Handbook 034073079X  
Existing edition has been very highly praised by international teachers teaching IGCSE;

K Hirst; The Complete A-Z Double Award Science Handbook; Hodder & Stoughton; 0340730609;

Jones & Jones, et al; Balanced Science; Cambridge University Press; Book 1 - 0521 59979 2 Book 2 – 0521 59980 6;  
Also available as a three volume set:

Jones & Jones; Cambridge Co-ordinated Science: Biology (2nd ed); Cambridge University Press; 0 521 59981 4;  
Jones, Jones & Acaster; Cambridge Co-ordinated Science: Chemistry; Cambridge University Press; 0 521 59983 0;  
Jones, Jones & Marchington; Cambridge Co-ordinated Science: Physics (2nd ed); Cambridge University Press; 0 521 59982 2;

V Slaughter; Living Things 2nd Ed (Sept '01); Hodder & Stoughton; 03407 72816;

## **TEACHERS' RESOURCES**

### **WEBSITES**

Coordination Group Publications; [www.cgpbooks.co.uk](http://www.cgpbooks.co.uk); (a useful and extensive set of resources available at an economical price);

### **PROFESSIONAL ASSOCIATIONS**

Royal Society of Chemistry; Burlington House, Piccadilly, London W1J 0BA, UK; tel +44 (0) 20 7437 8656; fax +44 (0) 20 7437 8883; website [www.rsc.org](http://www.rsc.org);

Institute of Physics; 76 Portland Place, London W1B 1NT. UK; tel +44 (0)20 7470 4800; fax: +44 (0)20 7470 4848; Email: [physics@iop.org](mailto:physics@iop.org); website [www.iop.org](http://www.iop.org);

Institute of Biology; 20 Queensberry Place, London SW7 2DZ, UK; tel +44(020) 7581-8333; fax: +44(020) 7823-9409; Email: [info@iob.org](mailto:info@iob.org); website [www.iob.org](http://www.iob.org);

# MATHEMATICAL REQUIREMENTS

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Calculators may be used in all parts of the examination.

Candidates should be able to:

1. add, subtract, multiply and divide;
2. understand and use *averages, decimals, fractions, percentages, ratios and reciprocals*;
3. recognise and use standard notation;
4. use direct and inverse proportion;
5. use positive, whole number indices;
6. draw charts and graphs from given data;
7. interpret charts and graphs;
8. select suitable scales and axes for graphs;
9. make approximate evaluations of numerical expressions;
10. recognise and use the relationship between length, surface area and volume, and their units on metric scales;
11. use usual mathematical instruments, (ruler, compasses, protractor, set square);
12. understand the meaning of *angle, curve, circle, radius, diameter, square, parallelogram, rectangle and diagonal*;
13. solve equations of the form  $x = yz$  for any one term when the other two are known;
14. recognise and use points of the compass (N, S, E, W).

## SYMBOLS, UNITS AND DEFINITIONS OF PHYSICAL QUANTITIES

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Students should be able to state the symbols for the following physical quantities and, where indicated, state the units in which they are measured.

<i>Quantity</i>	<i>Symbol</i>	<i>Unit</i>
Length	<i>l, h...</i>	km, m, cm, mm
area	<i>A</i>	m <sup>2</sup> , cm <sup>2</sup>
volume	<i>V</i>	m <sup>3</sup> , cm <sup>3</sup>
weight	<i>W</i>	N
mass	<i>m, M</i>	kg, g, mg
time	<i>t</i>	h, min, s
density	<i>d, ρ</i>	g/cm <sup>3</sup> , kg/m <sup>3</sup>
speed	<i>u, v</i>	km/h, m/s, cm/s
acceleration	<i>a</i>	m/s <sup>2</sup>
acceleration of free fall	<i>g</i>	
force	<i>F, P...</i>	N
moment of a force		Nm
work done	<i>W, E</i>	J
energy	<i>E</i>	J, kW h
power	<i>P</i>	W
pressure	<i>p, P</i>	Pa, N/m <sup>2</sup>
atmospheric pressure		use of millibar
temperature	<i>t</i>	°C
frequency	<i>f</i>	Hz
wavelength	<i>λ</i>	m, cm
focal length	<i>f</i>	
angle of incidence.	<i>i</i>	degree (°)
angles of reflection, refraction	<i>r</i>	degree (°)
critical angle	<i>c</i>	degree (°)
potential difference/voltage	<i>V</i>	V, mV
current	<i>I</i>	A, mA
charge		C, A s
e.m.f.	<i>E</i>	V
resistance	<i>R</i>	Ω

## GLOSSARY OF TERMS USED IN SCIENCE PAPERS

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During the moderation of a question paper, care is taken to try and ensure that the paper and its individual questions are, in relation to the syllabus, fair as regards balance, overall difficulty and suitability. Attention is also paid to wording to make questions as concise and yet as unambiguous as possible. In many instances, Examiners are able to make appropriate allowance for an interpretation that differs, but acceptably so, from the one intended.

It is hoped that the glossary (which is relevant only to Science subjects) will prove helpful to candidates as a guide (i.e. it is neither exhaustive nor definitive). The glossary has been deliberately kept brief not only with respect to the number of terms included but also to their definitions. Candidates should appreciate that the meaning of a term must depend in part on its context.

1. *Define (the term(s)...) is intended literally, only a formal statement or equivalent paraphrase being required.*
2. *What do you understand by/What is meant by (the term(s)...) 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 readily be obtained 'by inspection').*
4. *List requires a number of points, generally each of one word, with no elaboration. Where a given number of points is specified, this should not be exceeded.*
5. *State and explain normally also implies conciseness; explain may imply reasoning or some reference to theory, depending on the context.*
6. *Describe requires the candidate 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. In the latter instance, the answer may often follow a standard pattern (e.g. Apparatus, Method, Measurements, Results and Precautions).*

In other contexts, *describe* and *give an account of* should be interpreted more generally (i.e. the candidate has greater discretion about the nature and the organisation of the material to be included in the answer). *Describe and explain* may be coupled in a similar way to *state and explain* - see paragraph 5.

7. *Discuss* requires the candidate to give a critical account of the points involved in the topic.
8. *Outline* implies brevity (i.e. restricting the answer to giving essentials).
9. *Predict* implies that the candidate is 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.

*Predict* also implies a concise answer with no supporting statement required.

10. *Deduce* is used in a similar way to *predict* except that some supporting statement is required (e.g. reference to a law/principle or the necessary reasoning is to be included in the answer).

11. *Suggest* is used in two main contexts, i.e. either to imply that there is no unique answer (e.g. in chemistry, two or more substances may satisfy the given conditions describing an 'unknown'), or to imply that candidates are expected to apply their general knowledge to a 'novel' situation, one that may be formally 'not in the syllabus'.
12. *Find* is a general term that may variously be interpreted as *calculate*, *measure*, *determine*, etc.
13. *Calculate* is used when a numerical answer is required. In general working should be shown, especially where two or more steps are involved.
14. *Measure* implies that the quantity concerned can be directly obtained from a suitable measuring instrument (e.g. length, using a rule or mass, using a balance).
15. *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 (e.g. Young modulus, relative molecular mass).
16. *Estimate* implies a reasoned order of magnitude statement or calculation of the quantity concerned, making such simplifying assumptions as may be necessary about points of principle and about the values of quantities not otherwise included in the question.
17. *Sketch*, when applied to graph work, implies that the shape and/or position of the curve need only be qualitatively correct *but* 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).

In diagrams, *sketch* implies that a simple freehand drawing is acceptable; nevertheless, care should be taken over proportions and the clear exposition of important details.