

General Certificate of Education
Ordinary Level

Syllabus

COMBINED SCIENCE 5129

For examination in June and November 2010

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COMBINED SCIENCE 5129

GCE ORDINARY LEVEL

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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

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 16-19 Science, 2000)' 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 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.

5129 COMBINED SCIENCE

GCE ORDINARY LEVEL/SCHOOL CERTIFICATE

AIMS

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

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, 2000*);
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 Papers 1 and 2.

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

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 a number of compulsory structured questions on the Physics, Chemistry and Biology sections of the syllabus.

SUBJECT CONTENT

PHYSICS SECTION

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

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
- (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

3. Dynamics

Content

- 3.1 Motion

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

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) describe, and use the concept of, weight as the effect of a gravitational field on a mass
- (c) demonstrate understanding that two weights, and therefore masses, can be compared using a balance
- (d) use appropriate balances to measure mass and weight
- (e) 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

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

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

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) 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
- (d) relate work done to the magnitude of a force and the distance moved and make calculations involving $F \times d$
- (e) 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) relate convection in fluids to density changes and describe experiments to illustrate convection
- (c) describe experiments to distinguish between good and bad emitters and good and bad absorbers of infra-red radiation
- (d) 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) describe the structure and action of liquid-in-glass thermometers (laboratory and clinical)

10. Thermal Properties of Matter**Content**

- 10.1 Thermal expansion of solids, liquids and gases

Learning Outcomes:

Candidates should be able to:

- (a) describe qualitatively the thermal expansion of solids, liquids and gases
- (b) identify and explain some of the everyday applications and consequences of thermal expansion

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

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. Static Electricity

Content

14.1 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

15. Current Electricity

Content

15.1 Electric current

15.2 Electromotive force

15.3 Potential difference

15.4 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 $R = V/I$

16. d.c. Circuits

Content

16.1 Current and potential difference in circuits

16.2 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 and voltmeters
- (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

17. Practical Electricity**Content**

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

Learning Outcomes:

Candidates should be able to:

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

18. Magnetism**Content**

- 18.1 Laws of magnetism
- 18.2 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) distinguish between the magnetic properties of iron and steel
- (e) distinguish between the design and use of permanent magnets and electromagnets

19. Electromagnetic Induction**Content**

- 19.1 Principles of electromagnetic induction
- 19.2 The a.c. generator
- 19.3 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

20. The Nuclear Atom**Content**

- 20.1 Atomic model
- 20.2 Composition of a nucleus
- 20.3 Proton number and nucleon number
- 20.4 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 ${}^A_Z X$

21. Radioactivity**Content**

- 21.1 Detection of radioactivity
- 21.2 Characteristics of the three types of emission
- 21.3 Nuclear reactions
- 21.4 Half-life
- 21.5 Safety precautions

Learning Outcomes:

Candidates should be able to:

- (a) describe the detection of alpha-particles, beta-particles and gamma-rays
- (b) state, for radioactive emissions,
 - (i) their nature
 - (ii) their relative ionising effects
 - (iii) their relative penetrating powers
- (c) 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
- (d) use the term *half-life* in simple calculations which might involve information in tables or in decay curves
- (e) describe how radioactive materials are handled, used, stored and disposed of, in a safe way

CHEMISTRY SECTION

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

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 crude oil (petroleum) (topic 17.2(c)).)
- (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

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 CaCl₂)

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. H₂, Cl₂, HCl, H₂O, CH₄ and CO₂)
- (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 and Equations**Content**

- 7.1 Formulae
- 7.2 Equations

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 (Calculations will **not** be required.)
- (f) define *relative atomic mass*, A_r
- (g) define *relative molecular mass*, M_r
- (h) perform calculations concerning reacting masses using simple proportions (Calculations will **not** involve the mole concept.)

8. The Chemistry and Uses of Acids, Bases and Salts**Content**

- 8.1 Characteristic properties of acids and bases
- 8.2 pH
- 8.3 Types of oxides
- 8.4 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

9. The Periodic Table**Content**

- 9.1 Periodic trends
- 9.2 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)

10. Properties of Metals**Content**

- 10.1 Physical properties
- 10.2 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

11. Reactivity Series**Content**

11.1 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

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

- 12.1 Metal ores
- 12.2 The blast furnace
- 12.3 Iron and steel
- 12.4 Aluminium
- 12.5 Zinc
- 12.6 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)

13. Atmosphere and Environment**Content**

- 13.1 Air
- 13.2 Corrosion
- 13.3 Pollution
- 13.4 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) identify processes involving the addition of oxygen as oxidation and the removal of oxygen as reduction
- (f) define *oxidation* and *reduction* in terms of oxygen/hydrogen gain/loss
- (g) describe the identification of oxygen using a glowing splint
- (h) describe the identification of carbon dioxide using limewater (Equations are **not** required.)
- (i) name common pollutants of air (carbon monoxide, sulfur dioxide, oxides of nitrogen and lead compounds)

- (j) 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
- (k) state the adverse effect of acidic pollutants on buildings and plants, and of carbon monoxide and lead compounds on health
- (l) describe, in outline, the purification of the water supply in terms of filtration and chlorination
- (m) state some of the uses of water in industry and in the home

14. 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
- (c) describe the identification of hydrogen using a lighted splint (water being formed)

15. Nitrogen

Content

- 15.1 Ammonia and the Haber process
- 15.2 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

16. Organic Chemistry

Content

- 16.1 Names of compounds
- 16.2 Structures of compounds
- 16.3 Homologous series

Learning Outcomes:

Candidates should be able to:

- (a) name, and draw the structure of, methane, ethane, ethene, ethanol and poly(ethene)
- (b) state the type of compound present given a chemical name, ending in -ane, -ene, or -ol, or given a molecular structure
- (c) describe the general characteristics of a homologous series

17. Fuels

Content

- 17.1 Natural gas and petroleum as energy sources
- 17.2 Fractional distillation
- 17.3 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

18. Alkanes**Content**

18.1 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

19. Alkenes**Content**

19.1 Cracking

19.2 Unsaturated hydrocarbons

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 additional polymerisation of monomer units
- (e) name some uses of poly(ethene) as a typical plastic (e.g. plastic bags)

20. Alcohols**Content**

20.1 Formation of ethanol

20.2 Combustion and oxidation

20.3 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)

BIOLOGY SECTION

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)
- (b) identify and describe the structures seen, (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) red blood cells – transport of oxygen
- (f) identify these cells 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 osmosis in the uptake of water by plants and the effects of osmosis on animal tissue

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) 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) define *photosynthesis* and state the equation for photosynthesis (in words or symbols)
- (c) 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
- (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) describe the function of a typical amylase, listing the substrate and end products as an example of extra-cellular digestion in the alimentary canal
- (j) 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.)
- (k) state
 - (i) the role of the liver in the metabolism of glucose and amino acids
 - (ii) the role of fat as a storage substance
- (l) 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

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 how wilting occurs

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 structure and function of the heart in terms of muscular contraction and the working of valves
- (c) compare the structure and function of arteries, veins and capillaries
- (d) describe coronary heart disease in terms of blockage of coronary arteries and list the possible causes
- (e) identify red and white blood cells as seen under the microscope on prepared slides, and in diagrams and photomicrographs
- (f) list the components of blood as red blood cells, white blood cells, platelets and plasma
- (g) 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) 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**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.)

10. Co-ordination and Response**Content**

- 10.1 Receptors
- 10.2 Reflex action
- 10.3 Hormones

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) 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

11. The Use and Abuse of Drugs**Content**

- 11.1 Effects of heroin
- 11.2 Effects of alcohol

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 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/HIV)
- (c) 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/HIV)

12. Relationships of Organisms with One Another and with the Environment**Content**

- 12.1 Energy flow
- 12.2 Food chains and food webs
- 12.3 Carbon cycle
- 12.4 Effects of Man on the ecosystem
- 12.5 Pollution

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 effects of Man on the ecosystem with emphasis on examples of international importance (tropical rain forests, oceans and rivers)
- (g) describe the problems which contribute to famine (unequal distribution of food, drought and flooding and increasing population)
- (h) describe the undesirable effects of air pollution on gaseous exchange surfaces

13. Development of Organisms and Continuity of Life

- 13.1 Asexual reproduction
- 13.2 Sexual reproduction in plants
- 13.3 Sexual reproduction in humans
- 13.4 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 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) 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)
- (f) state that seed and fruit dispersal by wind and animals provides a means of colonising new areas
- (g) investigate and state the environmental conditions which affect germination of seeds (suitable temperature, water and oxygen)
- (h) identify on diagrams of the male reproductive system and give the functions of: testes, scrotum, sperm ducts, prostate gland, urethra and penis
- (i) identify on diagrams of the female reproductive system and give the functions of: ovaries, oviducts, uterus, cervix and vagina
- (j) 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
- (k) state the effect of factors, such as diet and emotional state, which affect the menstrual cycle
- (l) 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
- (m) describe the advantages of breast milk compared with bottle-feeding
- (n) describe the following methods of birth control: natural, chemical (spermicides), mechanical, hormonal and surgical
- (o) describe the symptoms, signs, effects and treatment of gonorrhoea and syphilis
- (p) discuss the spread of human immuno-deficiency virus (HIV) and methods by which it may be controlled

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																

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*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 24dm³ at room temperature and pressure (r.t.p).

RESOURCE LIST

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; (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;

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; website 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; website www.iob.org;

MATHEMATICAL REQUIREMENTS

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

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

GLOSSARY OF TERMS USED IN SCIENCE PAPERS

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.