International General Certificate of Secondary Education

Syllabus

COMBINED SCIENCE 0653

For examination in June and November 2009

Combined Science

Syllabus code: 0653

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Exclusions

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

0610 Biology
0620 Chemistry
0625 Physics
0652 Physical Science
0654 Co-ordinated Sciences (Double Award)
5054 Physics
5070 Chemistry
5090 Biology
5096 Human and Social Biology
5124 Science (Physics, Chemistry)
5125 Science (Physics, Biology)
5126 Science (Chemistry, Biology)
5129 Combined Science
5130 Additional Combined Science

Notes

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

Conventions (e.g. signs, symbols, terminology and nomenclature)
Syllabuses and question papers will conform with generally accepted international practice. In particular, attention is drawn to the following documents, published in the UK, which will be used as guidelines.

(a) Reports produced by the Association for Science Education (ASE):
SI Units, Signs, Symbols and Abbreviations (1981),
Chemical Nomenclature, Symbols and Terminology for use in school science (1985),
Signs, Symbols and Systematics: The ASE Companion to 5-16 Science (1995).

(b) Reports produced by the Institute of Biology (in association with the ASE):
Biological Nomenclature, Recommendations on Terms, Units and Symbols (1997).

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

INTRODUCTION

International General Certificate of Secondary Education (IGCSE) syllabuses are designed as two-year courses for examination at age 16-plus.

All IGCSE syllabuses follow a general pattern. The main sections are:

Aims

Assessment Objectives

Assessment

Curriculum Content.

The IGCSE subjects have been categorised into groups, subjects within each group having similar aims and assessment objectives.

Combined Science falls into Group III, Science, of the International Certificate of Education (ICE).

BACKGROUND

This syllabus has been developed to

- be appropriate to the wide range of teaching environments in IGCSE Centres,
- encourage the consideration of science within an international context,
- be relevant to the differing backgrounds and experiences of students throughout the world.

SKILLS AND PROCESSES

The syllabus is designed with the processes and skills that are the fabric of science as much in mind as knowledge and understanding of scientific ideas. Examination questions will test understanding of these processes and skills.

EXPERIMENTAL WORK

Experimental work is an essential component of all science. Experimental work within science education

- gives students first hand experience of phenomena,
- enables students to acquire practical skills,
- provides students with the opportunity to plan and carry out investigations into practical problems.

This can be achieved by individual or group experimental work, or by demonstrations which actively involve the students.

TARGET GROUP

The syllabus is aimed at students across a very wide range of attainments, and will allow them to show success over the full range of grades from A* to G.

DURATION OF COURSE

While Centres will obviously make their own decisions about the length of time taken to teach this course, it is assumed that most Centres will attempt to cover it in two years.

Within that time it is assumed that Centres may wish to allocate 3 x 40 minute periods per week to science, and that at least 56 full teaching weeks will be available.

Working on this basis a possible time allowance has been allocated to each topic in the curriculum content.

AIMS

The aims of the syllabus are the same for all students. These are set out below and describe the educational purposes of a course in Combined Science for the IGCSE examination. They 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. In particular, students' studies should enable them to acquire understanding and knowledge of the concepts, principles and applications of biology, chemistry and physics and, where appropriate, other related sciences so that they may
   - 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 appreciate its applicability in other disciplines and in everyday life,
   - 1.3 be suitably prepared to embark upon further studies in science;
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 safe practice,
   - 2.4 encourage effective communication;
3. stimulate
   - 3.1 curiosity, interest and enjoyment in science and its methods of enquiry,
   - 3.2 interest in, and care for, the environment;
4. promote an awareness that
   - 4.1 the study and practice of science are co-operative and cumulative activities subject to social, economic, technological, ethical and cultural influences and limitations,
   - 4.2 the applications of science may be both beneficial and detrimental to the individual, the community and the environment,
   - 4.3 the concepts of science are of a developing and sometimes transient nature,
   - 4.4 science transcends national boundaries and that the language of science is universal;
5. introduce students to the methods used by scientists and to the ways in which scientific discoveries are made.

ASSESSMENT OBJECTIVES

The three assessment objectives in Combined Science are

A Knowledge with Understanding
B Handling Information and Problem Solving
C Experimental Skills and Investigations

A description of each assessment objective follows.

A KNOWLEDGE WITH UNDERSTANDING

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

1. scientific phenomena, facts, laws, definitions, concepts and theories,
2. scientific vocabulary, terminology and conventions (including symbols, quantities and units),
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 curriculum content defines the factual material that candidates may be required to recall and explain. Questions testing this will often begin with one of the following words: *define, state, describe, explain* or *outline*.

B HANDLING INFORMATION AND PROBLEM SOLVING

Students should be able, in words or using other written forms of presentation (i.e. symbolic, graphical and numerical), 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 skills cannot be precisely specified in the curriculum content because questions testing such skills are often 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 skills will often begin with one of the following words: *discuss, predict, suggest, calculate* or *determine*.

C EXPERIMENTAL SKILLS AND INVESTIGATIONS

Students should be able to

1. use techniques, apparatus and materials (including the following of a sequence of instructions where appropriate),
2. make and record observations, measurements and estimates,
3. interpret and evaluate experimental observations and data,
4. plan investigations and/or evaluate methods and suggest possible improvements (including the selection of techniques, apparatus and materials).

SPECIFICATION GRID

The approximate weightings allocated to each of the assessment objectives in the assessment model are summarised in the table below.

Assessment Objective	Weighting
A Knowledge with Understanding	50% (not more than 25% recall)
B Handling Information and Problem Solving	30%
C Experimental Skills and Investigations	20%

ASSESSMENT

All candidates must enter for three Papers. These will be Paper 1, one from either Paper 2 or Paper 3, and one from Papers 4, 5 or 6.

Candidates who have only studied the Core curriculum or who are expected to achieve a grade D or below should normally be entered for Paper 2. Candidates who have studied the Extended curriculum and who are expected to achieve a grade C or above should be entered for Paper 3.

All candidates must take a practical paper, chosen from Paper 4 (School-based Assessment of Practical Skills), or Paper 5 (Practical Test), or Paper 6 (Alternative to Practical).

The data sheet (Periodic Table) will be included in Papers 1, 2 and 3.

Core curriculum Grades C to G available	*Extended curriculum* Grades A* to G available
Paper 1 (45 minutes) **Compulsory** A multiple-choice paper consisting of forty items of the four-choice type. The questions will be based on the Core curriculum, will be of a difficulty appropriate to grades C to G, and will test skills mainly in Assessment Objectives A and B. This paper will be weighted at 30% of the final total available marks.	
Either: **Paper 2** (1 hour 15 minutes) Core theory paper consisting of 80 marks of short-answer and structured questions. The questions will be of a difficulty appropriate to grades C to G and will test skills mainly in Assessment Objectives A and B. The questions will be based on the Core curriculum. This Paper will be weighted at 50% of the final total available marks.	**Or:** **Paper 3** (1 hour 15 minutes) Extended theory paper consisting of 80 marks of short-answer and structured questions. The questions will be of a difficulty appropriate to the higher grades and will test skills mainly in Assessment Objectives A and B. A quarter of the marks available will be based on Core material and the remainder on the Supplement. This Paper will be weighted at 50% of the final total available marks.
Practical Assessment **Compulsory** The purpose of this component is to test appropriate skills in assessment Objective C. Candidates will not be required to use knowledge outside the Core curriculum. Candidates must be entered for one of the following: **Either: Paper 4** Coursework (school-based assessment of practical skills)* **Or: Paper 5** Practical Test (1 hour 30 minutes), with questions covering experimental and observational skills. **Or: Paper 6** Alternative to Practical Paper (1 hour). This is a written paper designed to test familiarity with laboratory based procedures. The practical assessment will be weighted at 20% of the final total available marks.	

*Teachers may not undertake school-based assessment without the written approval of CIE. This will only be given to teachers who satisfy CIE requirements concerning moderation and they will have to undergo special training in assessment before entering candidates. CIE offers schools in-service training in the form of occasional face-to-face courses held in countries where there is a need, and also through the IGCSE Coursework Training Handbook, available from CIE Publications.

CURRICULUM CONTENT

The curriculum content that follows is divided into three sections: Biology, Chemistry and Physics. Students entered for this single subject must study all three sections.

Students can follow either the core curriculum only or they may follow the extended curriculum which includes both the core and the supplement. Students aiming for grades A* to C should follow the extended curriculum.

Note:

1. The curriculum content is designed to provide guidance to teachers as to what will be assessed in the overall evaluation of the student. It is not meant to limit, in any way, the teaching programme of any particular school or college.
2. The content is set out in topic areas within Biology, Chemistry and Physics. The left-hand column provides amplification of the core content, which all students are to study. The centre column outlines the supplementary content and should be studied by students following the extended curriculum.

   The right-hand column gives some suggested approaches which teachers may adopt in teaching each topic.

BIOLOGY TOPIC ONE **CELLS**

Suggested time: 10 x 40 minute lessons.

CORE	SUPPLEMENT	SUGGESTED APPROACHES
All students should:	In addition to what is required in the core, students following the extended curriculum should:	
– know that the characteristics of living organisms are reproduction, respiration, nutrition, excretion, growth, sensitivity and movement		
Cell structure – know that all living organisms are made of cells – be able to draw and label diagrams of animal and plant cells, including cell surface membrane, cytoplasm and nucleus both in animal and plant cells, and cellulose cell wall, chloroplasts containing chlorophyll and starch grains and vacuole containing cell sap in plant cells – be able to describe the functions of the following parts of an animal and plant cell: *cell surface membrane*, which controls what enters and leaves the cell; *nucleus*, which contains DNA which is inherited, and which controls the activities of the cell; *chloroplasts*, in which photosynthesis takes place	– be able to explain the significance of the differences between plant and animal cells, in terms of methods of nutrition – know that, both in plants and animals, cells are often grouped together to form tissues – be able to describe the structure of epidermal tissue from an onion bulb – know that tissues are often grouped together to form organs, and state examples of organs both in animals and plants	If at all possible, students should be given the opportunity to observe living plant cells using a microscope. Filamentous algae, and epidermal cells from leaves or onion bulbs, are particularly suitable. It is less easy to observe animal cells, and teachers may prefer no to attempt this. All students should be able to construct a table showing the similarities and differences between animal and plant cells. Students aiming for higher grades should discuss the reasons for, and implications of, these differences.

CORE	SUPPLEMENT	SUGGESTED APPROACHES
How substances enter and leave cells		
– know that all cells have a cell surface membrane which is partially permeable, and that any substance entering or leaving the cell must pass through this membrane – know that plant cells also have a cellulose cell wall, which is fully permeable – understand how diffusion takes place (see Physics Topic Four) and state examples of substances which diffuse into or out of cells	– be able to describe the process of osmosis, in which water molecules but not solute molecules diffuse through a partially permeable membrane – understand how animal and plant cells respond to immersion in solutions which are of different concentrations to their cytoplasm – be able to perform investigations into osmosis, using an artificial membrane such as Visking tubing, using living plant cells such as potato and interpret results from osmosis experiments using both animal and plant material	An understanding of diffusion depends on an understanding of kinetic theory, which is covered in Physics Topic Four. Students will greatly benefit from performing, or seeing demonstrated, some investigations into diffusion. It is not easy to do this with living materials, but simple experiments can be carried out involving the diffusion of a coloured soluble substance in water, or of ammonia in a glass tube in which red litmus paper has been placed It is very important that students aiming for higher grades understand that osmosis is simply a special case of diffusion, and not an entirely different process.
Enzymes		
– know that many chemical reactions, called metabolic reactions, take place inside and around cells – know that each of these reactions is catalysed (see Chemistry Topic Five) by a particular enzyme – know that all enzymes are proteins, and are made by living cells and that they are denatured (destroyed) by high temperatures – be able to perform investigations into the activity of the enzyme catalase in breaking down hydrogen peroxide to water and oxygen, including the effect that surface area has on the rate of this reaction	– be able to perform an experiment to investigate how temperature affects the rate of an enzyme-catalysed reaction – be able to draw a graph to show how temperature affects the rate of an enzyme-catalysed reaction – be able to explain the reasons for this effect, including the reasons for an increase in rate as temperature rises to the optimum (see Chemistry Topic Five) and the reasons for a decrease in rate as temperature rises above the optimum	Catalase is an excellent enzyme to introduce this topic in a practical way, because it produces a product which is instantly visible, so that the students are immediately aware that something is going on. This is not so with other enzymes, such as amylase. However, questions may be set involving data from experiments with other enzymes, and teachers may also like to carry out experiments with these.

BIOLOGY TOPIC TWO **ENERGY IN LIVING ORGANISMS**

Suggested time: 14 x 40 minute lessons.

CORE	SUPPLEMENT	SUGGESTED APPROACHES
– know that all living organisms need a supply of energy, in order to carry out processes such as movement, making large molecules from small ones, and maintaining body temperature – be able to explain that the energy used by living organisms originates from sunlight, and is passed from one organism to another in the form of food		It is very important that the concept of energy – which is a difficult one for most students – is dealt with consistently in the biology, chemistry and physics sections of the syllabus. It may be best to cover this part of the syllabus *after* energy has been dealt with in Physics Topic Two.
Photosynthesis		
– know that photosynthesis happens in the chloroplasts of green plants when energy from sunlight is captured by chlorophyll, and used to combine water and carbon dioxide, to produce glucose and oxygen – know that energy is transferred from sunlight to chemical energy in the glucose	– know that plants use the glucose they make in photosynthesis as a basis for making other substances, such as cellulose, proteins, and chlorophyll – know that to do this, they also need nitrate for making proteins, and magnesium for making chlorophyll, which they obtain from the soil	There are many experiments, other than those required by the syllabus in the first two columns, which are well worth carrying out. In particular, the production of oxygen by an aquatic plant is easy to show. Students aiming for higher grades could investigate the effect of different light intensities on the rate of oxygen production
– be able to write a word equation for photosynthesis	– be able to write a balanced chemical equation for photosynthesis	
– be able to describe the structure of a leaf, including upper and lower epidermis, palisade mesophyll and spongy mesophyll, vascular bundle containing xylem and phloem, guard cells, air spaces and stomata	– be able to explain how the large surface area, thinness, xylem vessels, air spaces and stomata of a leaf help to supply the raw materials for photosynthesis efficiently	
– know that some of the glucose made in photosynthesis is changed to starch and stored in the leaf – know how to perform starch tests on leaves	– be able to explain why, in order to perform a starch test, a leaf must be boiled and treated with hot alcohol before iodine solution is added – be able to perform experiments to investigate the need for light and chlorophyll in photosynthesis	
Human diet and digestion		
– know that humans need carbohydrates (sugar and starch) and fats for energy; proteins for energy, building new cells, making enzymes and defence against disease – know good dietary sources of carbohydrates, fats and proteins	– be able to describe any one health problem resulting from a poor diet which is important in the student's own country, discuss the reasons for this problem and suggest ways in which it could be reduced	

CORE	SUPPLEMENT	SUGGESTED APPROACHES
– know how to perform the Benedict's test for reducing sugars, the iodine test for starch, and the biuret test for proteins		
– know the functions of vitamin C, vitamin D, iron and calcium in the human body, state good sources of these nutrients and describe the symptoms of diseases resulting from their deficiency in the diet		
– understand that the alimentary canal is a tube passing right through the body, and that nutrients cannot be used by cells until they have passed through the walls of the alimentary canal; this process is called *absorption* and happens in the small intestine	– be able to label the following parts on a diagram of the human digestive system: mouth, oesophagus, stomach, small intestine, colon, rectum, anus, liver	
– understand that, before absorption can occur, large pieces of food must be broken into small ones, and large molecules into small ones, and that this process is called *digestion*	– know that amylase breaks down starch to sugar in the mouth and small intestine; protease breaks down proteins to amino acids in the stomach and small intestine; lipase breaks down fats to fatty acids and glycerol in the small intestine	
– be able to describe the structure of a tooth and describe the roles of teeth in digestion	– know that amino acids, sugar, fatty acids and glycerol are absorbed into the blood through the walls of the small intestine and that water is absorbed in the colon	
– know that large molecules are broken down into small ones by enzymes in the alimentary canal		
Respiration		
– be able to explain that respiration is a metabolic reaction carried out in all living cells (including plant cells) to provide energy for the cell – know that respiration releases energy from substances such as sugar		
– be able to write a word equation to show that glucose combines with oxygen to produce water and carbon dioxide, and a supply of useful energy	– be able to write a balanced chemical equation for aerobic respiration	
– be able to perform experiments to show that air breathed out by a person contains more carbon dioxide than air breathed in	– know that anaerobic respiration is a process in which glucose is broken down without using oxygen, releasing far less energy than in aerobic respiration and that, in humans, anaerobic respiration produces lactic acid, which later has to be removed by combining it with oxygen	Students aiming for higher grades should link their knowledge of anaerobic respiration, and the need for the removal of lactic acid, with their work on the effect of exercise on heart rate in Topic Three.

CORE	SUPPLEMENT	SUGGESTED APPROACHES
– be able to label the following parts on diagrams of the human gaseous exchange system: trachea, bronchi, lungs, alveoli, pleural membranes, ribs		If possible, students should be able to examine a set of lungs from an animal such as a sheep.
– be able to explain how oxygen diffuses through the thin wall of the alveoli into the blood, while carbon dioxide diffuses from the blood into the alveoli and how the large surface area of the alveoli in the lungs speeds up this process		
– be able to describe how goblet cells and cilia in the trachea and bronchi help to keep the lungs clean – be able to explain how smoking can stop cilia working and so lead to bronchitis and emphysema – be able to describe other problems which often result from smoking, including lung and other cancers and heart disease		

BIOLOGY TOPIC THREE **TRANSPORT AND CO-ORDINATION**

Suggested time: 14 x 40 minute lessons.

CORE	SUPPLEMENT	SUGGESTED APPROACHES
Transport in humans		
The heart and double circulatory system		
– be able to label a diagram of a vertical section through a human heart, including left and right atria and ventricles, septum, bicuspid and tricuspid valves, semi-lunar valves, tendons supporting valves, aorta, pulmonary artery, pulmonary veins and vena cava	– understand why the walls of the ventricles are thicker than those of the atria, and why the wall of the left ventricle is thicker than the wall of the right ventricle	Students may enjoy looking at the structure of a heart from an animal such as a sheep. No details of the names of blood vessels, other than those named here, are expected
– know that the heart is a pump, in which rhythmic contractions of the muscle which makes up the walls cause blood to pass from the veins into the atria and ventricles, then into the arteries from the ventricles and understand how the valves ensure one-way flow of blood	– be able to perform an experiment to investigate how rate of heart beat changes during and after exercise and interpret the results in terms of increased aerobic and anaerobic respiration and oxygen debt	Heart beat is most easily measured by taking a pulse, either in the wrist or neck.

CORE	SUPPLEMENT	SUGGESTED APPROACHES
– be able to describe the double circulatory system and know where blood becomes oxygenated and deoxygenated – know that the heart muscle is supplied with oxygenated blood through the coronary arteries and understand how blockage of these arteries can lead to a heart attack	– be able to outline the differences in structure between *arteries, veins* and *capillaries,* and relate these differences to their functions – be able to discuss possible links between heart disease and diet	The importance of heart disease varies greatly in different countries. The relative importance of diet in increasing the risk of heart disease is not clear and other factors should also be discussed, such as smoking, genetic make-up and stress.
Blood		
– know that blood is made up of a liquid called plasma, in which red cells, white cells and platelets float and be able to recognise red cells, white cells and platelets from diagrams or micrographs – know that red blood cells contain a red pigment called haemoglobin and outline the function of haemoglobin in transporting oxygen from lungs to tissues	– be able to explain how the structure of a red blood cell (no nucleus, small size, biconcave shape) adapts it for its function of oxygen transport	
– know that white blood cells help to destroy harmful micro-organisms – know that platelets help in blood clotting	– know that phagocytes ingest and destroy pathogens of any kind and that lymphocytes produce antibodies which destroy specific antigens – be able to explain why immunity often results after an infection or vaccination – be able to explain how transplanted organs may be rejected by the body and know that a close relationship between donor and recipient, and/or the use of immunosupressant drugs, can increase the chances of a successful transplant	The immune response and immunity are best discussed in relationship to a particular disease, such as influenza or TB. Students may be interested to discuss why people do not become immune to colds (the virus which causes it changes constantly) or malaria. Links should be made here with the problem of AIDS.
Transport in plants		
– be able to describe the pathway taken by water as it passes through a plant – as liquid water into root hairs, across the root into xylem vessels and across the leaf; as water vapour through stomata	– understand that transpiration reduces pressure at the top of xylem vessels and so causes water to move up the xylem	Details of the structure of xylem vessels or phloem tubes are **not** required.

CORE	SUPPLEMENT	SUGGESTED APPROACHES
– be able to perform an experiment to investigate the rate of transpiration in a leafy shoot, using a simple potometer	– be able to discuss the effect of temperature, humidity and wind strength on the rate of transpiration – know that substances that the plant makes in its leaves, especially sugar, are transported in phloem tubes – know that phloem tubes are found near the outer surface of a stem and understand that damage to the outer surface of a stem or tree trunk may destroy phloem vessels and kill the plant	A straight glass tube can make a perfectly adequate simple potometer. A small piece of rubber tubing firmly pushed onto the top of the glass tube will allow the cut end of a plant stem to be tightly fixed in place. The whole apparatus must be filled with water, with no air bubbles, and with good contact between the water and the plant stem. Students aiming for higher grades could investigate the effects of varying the external conditions on the rate of transpiration.
	– know that systemic pesticides are transported in phloem and explain the advantages of the use of systemic pesticides over contact pesticide	For students aiming for higher grades, links should be made here to the section on biological control in Topic Five.
Co-ordination and homeostasis		
– be able to describe the structure of the human nervous system; central nervous system made up of brain and spinal cord; nerves to all parts of the body – know that signals pass rapidly along nerves from receptors, through the central nervous system, to effectors, which respond to a stimulus	– be able to describe and understand a *spinal reflex arc,* including receptor, sensory neurone, immediate neurone, motor neurone and effector – be able to discuss the advantages and disadvantages of reflex actions compared to voluntary actions	
– know that drinking alcohol slows down the rate at which signals pass along nerves, which therefore increases reaction time		
– know that messages are also passed around the human body in the form of hormones, which are made in endocrine glands		
– be able to explain that insulin is secreted by the pancreas in response to high concentrations of sugar in the blood and that it causes the liver to remove glucose from the blood, helping to keep blood sugar levels constant	– be able to describe the regulation of blood sugar levels in terms of negative feedback – be able to outline the way in which sweating, vasodilation and vasoconstriction help to regulate body temperature	Students aiming for higher grades could perform investigations into the effects of various factors on the rate of heat loss from tubes of hot water (to represent bodies), such as surface area to volume ratio and covering.
	– Be able to explain the meaning of the term *homeostasis* and explain why it is important to the working of the human body	They should relate their understanding of the importance of homeostasis to their work on enzymes in Topic One.

BIOLOGY TOPIC FOUR **REPRODUCTION AND GENETICS**

Suggested time: 13 x 40 minute lessons.

CORE	SUPPLEMENT	SUGGESTED APPROACHES
Sexual and asexual reproduction		
– understand that, in asexual reproduction, new individuals are produced which are genetically identical to their parent and be able to describe one natural method of asexual reproduction in plants		
– understand the importance of propagation of plants by humans by asexual methods, to produce clones	– be able to discuss the relative advantages and disadvantages to organisms or reproducing asexually or sexually	
– understand that, in sexual reproduction, gametes fuse together in a process called *fertilisation* to produce a zygote which is genetically different from its parents	– be able to discuss the relative advantages and disadvantages to a plant breeder of using asexual or sexual methods of propagation	
Reproduction in humans		
– be able to label diagrams of the female and male reproductive systems, including ovaries, oviducts, uterus, cervix, vagina, testes, sperm tubes, bladder, ureter, urethra and penis		
– be able to describe the structure of a sperm and an egg and discuss how their structure and size helps them to perform their functions		Knowledge of reproductive hormones is **not** required.
– know that eggs are produced in ovaries and outline the events of the menstrual cycle – know that sperm are produced in testes – be able to explain how and where fertilisation may occur and know that the zygote subsequently implants in the lining of the uterus		
– be able to label a diagram of a developing fetus in the uterus, including uterus wall, placenta, umbilical cord containing blood vessels, amnion and amniotic fluid – understand that the developing fetus obtains all of its requirements, including oxygen and dissolved nutrients, through the placenta, by diffusion from its mother's blood		

CORE	SUPPLEMENT	SUGGESTED APPROACHES
– know that harmful substances such as nicotine, carbon monoxide, viruses and drugs, also cross the placenta and may harm the developing fetus and be able to relate this knowledge to the ways in which a pregnant mother should take care of herself and her unborn baby – be able to outline the process of birth	– be able to discuss the advantages of breast feeding compared with bottle feeding	
– know that gonorrhoea, syphilis and AIDS are transmitted by sexual intercourse and understand how their spread can be reduced		
– be able to discuss the importance of family planning and describe the way in which the following methods work: condom, rhythm, intra-uterine device (IUD), cap, pill and sterilisation		
Reproduction in plants		
– be able to label a diagram of an insect-pollinated flower, including petals, sepals, anthers, filaments, stamens, stigma, style, ovary and ovules – know that pollen, made in anthers, contains male gametes and ovules, made in ovaries contain female gametes – be able to describe the way in which a named flower is pollinated by insects – know that the male gamete then travels down a tube from the stigma to reach the female gamete in the ovule	– know the structure of a wind-pollinated flower and discuss the differences between insect-and wind-pollinated flowers	All students should look at the structure of a simple insect-pollinated flower. Students aiming for higher grades may like to use a locally-important crop plant, such as maize, as their example of a wind-pollinated flower. Details of the fertilisation process are **not** required. Students aiming for higher grades should see a range of fruits and consider how they are adapted to ensure seed dispersal.
– know that the ovule then develops into a seed containing an embryo plant and the ovary into a fruit – be able to perform an investigation into the conditions needed for germination of seeds	– be able to explain the importance of seed dispersal and describe examples of the ways fruits are adapted to disperse seeds using animals and wind	
Variation and inheritance		
– know that variation is caused by genes and is also affected by the environment and give examples of both of these types of variation – understand that variation caused by genes can be inherited but that variation caused by the environment cannot	– be able to use the terms *gene, allele, genotype, phenotype, homozygous, heterozygous, dominant* and *recessive* – be able to draw genetic diagrams to predict and explain the results of crosses involving dominant and recessive alleles – understand the use of a test cross to find the genotype of an organism showing the dominant characteristic in its phenotype	Suitable examples of genetic variation in humans include sex and blood groups. Height is a good example of variation which is also influences by environment (food supply).

BIOLOGY TOPIC FIVE **ORGANISMS IN THEIR ENVIRONMENT**

Suggested time: 8 x 40 minute lessons.

CORE	SUPPLEMENT	SUGGESTED APPROACHES
Food chains and nutrient cycles		
– understand the meanings of the terms *habitat, population, community* and *ecosystem* – understand how energy flows through an ecosystem and be able to draw food chains and food webs, with arrows indicating the direction of energy flow, using the terms *producer, consumer* and *decomposer* – be able to describe the carbon cycle, including the roles of photosynthesis, respiration, plants, animals, decomposers, fossil fuels and combustion	– be able to describe how energy is lost between trophic levels in a food chain and explain why food chains rarely have five or more links	Students should relate their work from Topic Two to their understanding of food chains.
Humans and the environment		
– be able to explain how the increased burning of fossil fuels may be causing an increase in the amount of carbon dioxide in the air – know that this may cause global warming and discuss possible effects of global warming on the Earth – be able to explain the meaning of the term *species diversity* and discuss the importance of maintaining species diversity – understand that tropical rain forests have especially high species diversity and therefore that their conservation is particularly important – appreciate the damage which can be caused by soil erosion and that deforestation and overgrazing can increase the rate of soil erosion – be able to discuss ways in which soil erosion can be reduced, including maintaining plant cover and terracing	– know that burning fossil fuels also releases nitrogen oxides and sulfur dioxide and that these can cause acid rain – be able to outline the effects of acid rain on forests, crops, aquatic organisms and limestone buildings and discuss ways in which the problems caused by acid rain can be reduced – be able to discuss the conflicts which may arise between conservation and exploitation of resources, for example in agriculture, logging or mining – be able to discuss the ways in which the use of pesticides can harm living organisms other than pests – be able to describe one example of the use of biological control to control a named pest – be able to discuss the disadvantages and advantages of the use of pesticides and biological control	Students should realise that the greenhouse effect is an entirely natural and desirable phenomenon – without it, the Earth would be too cold to support life. The problem of global warming may result from an *enhanced* greenhouse effect, which may occur if too much carbon dioxide (and methane) build up in the atmosphere. However, the extent to which this is happening, and whether it is being caused by humans, is very uncertain and students should be aware of these uncertainties. Students aiming for higher grades should not only understand the importance of conservation for maintaining species diversity, but also understand that, in practice, it is often difficult to reconcile the needs of people with this aim. This may be best done by consideration of a particular case study.

CHEMISTRY TOPIC ONE **ATOMIC STRUCTURE AND BONDING**

Suggested time: 12 x 40 minute lessons.

CORE	SUPPLEMENT	SUGGESTED APPROACHES
All students should:	In addition to what is required in the core, students following the extended curriculum should:	
Atomic structure		
– know the three fundamental particles, *protons, neutrons* and *electrons,* and their relative charges and masses (the electron mass may be quoted as a fraction of the proton mass)		A brief historical introduction may be useful but is not essential. The concept of zero electron mass may cause some problems especially when a particle picture is presented of electrons in shells.
– understand and be able to define *proton number* and *nucleon number* – know that the former identifies an element and locates its position in the Periodic Table – know that elements can be represented by a symbol which is shown in the Periodic Table – use the notation $^{a}_{b}X$ for an atom		It is useful to introduce the Periodic Table at this stage. It may be viewed simply as an organiser for the special set of substances called elements. If the atom has been defined as the smallest part of an element, the Periodic Table shows students at a glance the number of different types of atom.
– appreciate that electrons move around the nucleus and know how to draw the electrons in shells model – be able to work out the arrangement of electrons for the first twenty elements of the Periodic Table	– understand that shells correspond to electron energy levels	Students should be shown, or could draw, labelled diagrams of the first twenty elements. The patterns in electron configuration within the Periodic Table will be useful for valency and bonding work. (The description of electrons in sub-shells and orbitals is **not** required.)
– know that the noble gas electronic structure is associated with the inert nature of these elements – be able to write down proton number, nucleon number and electron configuration by interpreting information from the Periodic Table (limited to elements 1 to 20 inclusive)	– know that atoms of the same element with different nucleon numbers are called *isotopes* – know the difference between relative atomic mass (A_r) of an element and nucleon number of a particular isotope – appreciate that the former is an average and understand why an accurate value of A_r is not a whole number	One approach might involve the use of cards showing details of the element and its atomic diagram. These can help in showing the type of thinking which Mendeleev pioneered. If possible, students should have their own copy of the Periodic Table. Chlorine provides the most common example and students should be familiar with the two main chlorine isotopes. Students aiming for higher grades should have experience of the calculation of the relative atomic mass of chlorine.

CORE	SUPPLEMENT	SUGGESTED APPROACHES
Elements, mixtures and compounds		
– be able to describe the differences between *elements*, *mixtures* and *compounds* – know that elements are made of atoms having the same proton number and that they cannot be separated into simpler substances – know that compounds are formed when elements join together – appreciate that the properties of compounds are usually very different from the elements from which they have formed – be able to describe *mixtures* as two or more substances which are present together but which retain their individual properties – know that mixing does not involve a significant energy change and that it is often easy to separate mixtures by physical methods – be able to describe suitable methods for the physical separation of mixtures		Students should be able to classify a range of everyday substances as elements, mixtures or compounds. Suitable examples could be air, air gases, pure water, seawater, various metals and alloys. If possible, students should see direct combinations between metals and non-metals and should have experience of the reaction between iron and sulfur to form iron(II) sulfide. A study of the properties of the elements, of a mixture of the elements and of iron (II) sulfide is a convenient illustration of these concepts.
– be able to suggest a method of separation given a mixture of an insoluble solid and liquid (filtration, simple distillation); a solution (evaporation, crystallisation); a liquid mixture (fractional distillation); coloured solutes in a water solution (chromatography) – know that when compounds form, there is usually a significant energy change and that most compounds are difficult to split up	– appreciate that solvents other than water can be used in chromatography, if water -insoluble substances are involved	Students should, as far as possible, experience for themselves, all of the methods described in the core. Paper chromatography is easily done on filter paper using coloured inks or food colourings. The use of ethanol or propanone in the preparation of an extract from green leaves is a useful example of chromatography.
Bonding – appreciate that compounds can be classified into two broad types, *ionic* and *covalent,* according to the particular way that the atoms have bonded		This topic can be introduced by an examination of the appropriate properties of a selected number of compounds and allowing students to see two distinct groups (i.e. the properties of ionic and covalent compounds). It is helpful to stress the particular importance

CORE	**SUPPLEMENT**	**SUGGESTED APPROACHES**
– know that ionic and covalent compounds tend to have certain characteristic physical properties but the most reliable distinction is in their ability to behave as electrolytes (see also Topic Five) – be able to use the word *molecule* to describe the units produced when covalent bonds form		of electrolyte formation as a reliable test and to be clear that properties such as volatility and solubility may give clues only.
– appreciate that *ionic compounds* usually form when a metal joins with a non-metal – know that *ions* are particles which are electrically charged either positively or negatively – know that metals form positive ions and the non-metals form negative ions	– be able to describe how atoms from Groups I, II, VI and VII form ions by losing or gaining electrons to achieve a noble gas configuration – be able to explain the nature of the charge on the resulting ions and to understand that the ionic bond is the result of electrical attraction between ions – be able to draw dot and cross representations of simple binary ionic compounds	If students are unfamiliar with the laws governing electrostatic attraction and repulsion it is of great benefit to take a little time to establish the ideas by demonstration, possibly with suspended charged rods. Electrolysis of copper(II) chloride or molten lead(II) bromide is a useful way of developing the concepts involved in ionic bonding. It also emphasises the energy price to be paid when splitting compounds.
– know that when atoms of non-metallic elements join they form covalent bonds – be able to write and recognise displayed (graphical) representations of the molecules H_2, Cl_2, H_2O, CH_4, NH_3 and HCl	– be able to describe the formation of single covalent bonds by the sharing of electrons *in pairs* to achieve noble gas configurations – be familiar with the molecules of H_2, Cl_2, H_2O, CH_4, NH_3 and HCl and be able to draw dot and cross diagrams to represent them	Displayed (graphical) formulae should be taken to mean the joining of chemical symbols by lines to show the bonds.
– appreciate that multiple bonds can exist between atoms and be able to draw displayed representations of molecules of N_2, CO_2 and ethene	– be able to describe multiple bond formation in terms of electron pair sharing in N_2, CO_2 and ethene – be able to draw dot and cross diagrams for these molecules	

CHEMISTRY TOPIC TWO **PERIODIC TABLE, FORMULAE, EQUATIONS**

Suggested time: 8 x 40 minute lessons.

CORE	SUPPLEMENT	SUGGESTED APPROACHES
Formulae and equations		
– know that a formula shows the number ratio and type of atoms which have joined – be able to write a formula given the number ratio and be able to state the names and numbers of combined atoms given a formula	– know that all compounds are electrically neutral and be able to construct the formula of an ionic compound given the charges on ions (recall of the formulae of radicals such as SO_4^{2-}, CO_3^{2-}, NO_3^- and NH_4^+ is **not** expected)	Students should appreciate that a symbol or formula when written, represents a specific amount of substance. This should be limited to element symbols representing one atom and formulae of simple covalent substances representing one molecule. (See Topic One for a list of example molecules.) The meaning of the phrase *empirical formula* for giant structures will **not** be examined.
– know the purpose of a word equation and what it shows – appreciate that symbolic equations must be balanced and be able to recognise whether a given equation is balanced – be able to complete the balancing of a given simple equation	– be able to construct simple balanced equations from information supplied – know the meaning of relative molecular mass, M_r and calculate it as the sum of the relative atomic masses, A_r (the term relative formula mass or M_r will be used for ionic compounds) – appreciate that a balanced equation enables the calculation of the masses of reactants or products (stoichiometric calculations involving the mole concept will **not** be required)	Examples should be limited to contexts within the other Chemistry Topics. Calculations may be set in Paper 3 involving simple proportion (e.g. given a balanced equation and a stated mass of a reactant and product, students could be asked to calculate a product mass based on a different reactant mass).
Further uses of the Periodic Table		
– know that the Periodic Table is a method of organising the elements and that it can be used to predict their properties – know the meaning of the words *group* and *period* and understand that elements within a group have similar properties – be able to describe the key differences between *metallic* and *non-metallic elements* – know that metallic elements are found towards the left and non-metallic elements towards the right of the table		A brief history of the construction of the Periodic Table is a good introduction. (See also Topic One.) Investigating the properties of elements and matching them to group numbers may be useful. Interpreting data on elements from Period 3 can help to emphasise the change from metal to non-metal across the table.

CORE	SUPPLEMENT	SUGGESTED APPROACHES
– be able to describe Group I (limited to Li, Na and K) to show their similarities in appearance and reaction with water	– appreciate that the reactivity of Group I metals with water increases down the group and that this reflects a general reactivity trend for Groups I and II	It is very helpful if students see a demonstration of the reactions of Group I metals with water.
– be able to describe Group VII (limited to Cl_2 Br_2 and I_2) as diatomic molecules – be able to describe their colours and their trend in physical state	– appreciate that the reactivity of the halogens decreases down the group	The reactivity of halogens could be shown using halogen displacement reactions and also by using data about the nature of fluorine, although recall of this would **not** be required
	– be able to predict the main properties of an element given information about its position in the Periodic Table	Students could be given the name of an element and be asked to suggest its likely physical properties. Alternatively, they could be given the location of an element in the Periodic Table and be asked to make similar predictions. They might be asked to comment on the relative reactivity of an element they have not directly studied (limited to Groups I, II, VII and 0).
– know that the elements between Sc and Zn are called *transition elements* and that they are similar in that they have high densities, have high melting points, tend to form coloured compounds and that they (or their compounds) are often useful as catalysts		An electronic definition of transition elements is **not** required. The ability of certain transition metal compounds to accelerate the decomposition of hydrogen peroxide may be compared with substances having no catalytic effect.
– show an awareness that noble gases are still useful despite their unreactivity – know that the noble gases increase in density down the group and that because helium is much less dense than air it is used in airships and weather balloons		Suitable examples of the use of noble gases could include gas discharge for advertising signs, producing an inert atmosphere inside electric light bulbs and the use of helium as a safe alternative to hydrogen in balloons.

CHEMISTRY TOPIC THREE **METALS AND NON-METALS**

Suggested time: 14 x 40 minute lessons.

CORE	SUPPLEMENT	SUGGESTED APPROACHES
Oxides of metals and non- metals		
– know that the oxides of metals tend to give alkaline solutions in water and that non-metal oxides give acidic solutions	– appreciate that insoluble oxides do not affect the pH of water	A useful context for the importance of non-metal oxides is in fossil fuel combustion and the environmental consequences of CO_2, SO_2 and NO_x. This is covered later in this topic and in Topic 6.
Metals		
– be able to describe the reactions of K, Na, Ca, Mg, Zn and Cu with water or steam and appreciate that the vigour of reaction is an indication of the reactivity of the metal	– be able to place the following elements in order of reactivity: K, Na, Mg, Zn, Fe, H_2 and Cu and know that this list is part of the reactivity series	
– be able to describe the reactions of Mg, Zn and Cu with dilute mineral acids and know that the vigour of the reaction gives an indication of the reactivity of the metals – know that the reaction between alkali metals and acid is dangerously explosive – know the flame test for identifying potassium, sodium, calcium and copper	– be able to describe metal displacement reactions limited to metals from the above list (ionic equations will **not** be required) – be able to interpret the results of metal displacement to place metals into reactivity order	If possible students should investigate these metal reactions themselves, where appropriate. If microscopes are available, the growth of metal crystals during metal displacement can be viewed.
Extraction of metals		
– know that reactive metals occur in ores which contain a compound of the metal – know that a chemical reaction called reduction (see also Topic Five) can be used to extract the metal (e.g. reduction of iron(III) oxide or copper(II) oxide) – know that for very reactive metals, electrolysis is required (see also Topic Five) – know that an *alloy* is a mixture mainly of metals – know that steels are examples of alloys of iron which contain controlled amounts of carbon and other elements – know that steels are stronger and less brittle than iron and are more resistant to rusting	– be able to give an outline description of the extraction of iron by reduction in the blast furnace (recall of the diagram is **not** required) – know the main chemical reactions involved; combustion of carbon to give CO_2 and heat, reduction of CO_2 to CO and know that iron(III) oxide is reduced mainly by CO	The moderate reactivity of iron can be cited as a reason why iron has been used since early times and why rusting is such a problem. Students could be asked to consider why the thermite reaction is not a viable industrial process for iron production. Students could be asked to undertake a short survey of common alloys and to explain their advantages. Students could be asked to explain the uses of steels and aluminium.

CORE	SUPPLEMENT	SUGGESTED APPROACHES
– state the use of mild steel for car bodies and machinery and stainless steel for cutlery and industrial chemical plant		
– know some of the common uses of aluminium linked firmly to its properties; in particular, its use in food containers and kitchen utensils because of its resistance to corrosion, its use in overhead cables because of its low density and good electrical conductivity, its use in making low density alloys used in airframes	– appreciate that aluminium is not extracted by chemical reduction because it is too reactive	
Non-metals		
– know that air is a mixture of elements and compounds and be able to name the main components, including the noble gases, water and carbon dioxide	– be able to describe one practical method for determining the percentage of oxygen in the air	An appropriate method is the repeated passage of a measured volume of air over excess heated copper.
– know the approximate volume % composition of air limited to nitrogen, oxygen, carbon dioxide and 'other gases'		
– be able to name some of the common pollutants (i.e. carbon monoxide, sulfur dioxide and nitrogen oxides)		
– be able to explain that CO and NO_x are found in exhaust gases from vehicles when hydrocarbon fuels are burnt and know that these gases are highly toxic	– understand that CO is the result of incomplete combustion of carbon-containing fuels (see Topic Six)	Students should be aware of the dangers of carbon monoxide poisoning and that these increase when the oxygen supply to combustion is restricted. They should be aware of the danger of operating a car engine in a confined space for any length of time.
– appreciate that sulfur must be removed from fossil fuels to avoid formation of SO_2		
– know that SO_2 can exacerbate breathing problems such as asthma if inhaled, and that it contributes to 'acid rain' which can damage buildings, vegetation and habitats		
Rusting of iron		
– know that both water and oxygen are needed together for iron to rust	– be able to describe rusting as an oxidation reaction and understand why there is an increase in mass during rusting	Students should investigate the conditions needed for rusting via test-tube scale reactions. This is a useful experiment to emphasise the concept of a control and fair testing.
– be able to describe the common methods of preventing rusting including barriers, galvanising, tinning and alloying		

CORE	SUPPLEMENT	SUGGESTED APPROACHES
Water		
– appreciate the need for a supply of clean drinking water	– be able to describe a chemical test for water such as the use of cobalt (II) chloride paper	
– be able to describe, in outline, the purification of the water supply in terms of filtration and chlorination		
– understand that chlorination sterilises the supply and why this is important		

CHEMISTRY TOPIC FOUR **ACIDS, BASES AND SALTS**

Suggested time: 6 x 40 minute lessons.

CORE	SUPPLEMENT	SUGGESTED APPROACHES
– be able to describe an *acid* as a substance containing hydrogen that can be replaced by a metal to form a salt – be able to describe a *base* as a substance that will neutralise an acid to form a salt and water	– know that hydrogen can be released in aqueous solution as $H^+(aq)$ and that pH is related to the concentration of hydrogen ions – know that alkaline solutions contain excess OH^- ions	Students should see for themselves the reaction of acids via test-tube reactions. They should all have the chance to collect and identify hydrogen and carbon dioxide and should attempt to assess the pH of a range of everyday substances.
– know the general form of the pH scale	– understand that neutralisation involves the reaction between H^+ and OH^- ions to form water	
– be able to recognise the chemical formulae HCl, H_2SO_4 and HNO_3 and name these acids		
– be able to describe the reactions of the common mineral acids with metals, bases and carbonates and their effect on litmus and Universal Indicator		It is very helpful if students learn general equations such as *acid + base* $\rightarrow$ *salt + water.* In Paper 3, candidates may be asked to select reagents to prepare a named salt.
– be able to write word equations for simple examples of these reactions	– be able to describe how to prepare a soluble salt from a suitable acid and an insoluble base or carbonate	
– know that *alkalis* are soluble bases and recognise the names and formulae of NaOH, KOH and $NH_3(aq)$	– be able to describe the preparation of a soluble salt by controlled neutralisation followed by evaporation or crystallisation	It is not essential that students are familiar with titrimetric analysis although this is a convenient approach if apparatus is available. The use of measuring cylinders and indicators could be used to illustrate the principles.

CHEMISTRY TOPIC FIVE **CHEMICAL REACTIONS**

Suggested time: 12 x 40 minute lessons.

CORE	SUPPLEMENT	SUGGESTED APPROACHES
Rate of reaction		
– appreciate that different chemical reactions proceed at different speeds – know that the speed of a given reaction can be changed by changing the conditions of the reaction	– understand the effects of temperature, concentration and surface area on rate in terms of increased frequency and/or energy of collisions between particles	All students should have an opportunity to carry out one or more experiments to investigate rate. Measuring the volume of a gas produced in a given time is probably the simplest, using an upturned measuring cylinder or burette. A gas syringe is ideal but not essential. The calcium carbonate + dilute hydrochloric acid reaction is perhaps the most convenient. It should be made clear to students that powdering a given mass of a solid will dramatically increase the available surface area. This can be convincingly demonstrated using uniform wooden cubes and asking students to calculate exposed surface areas for themselves.
– know that increasing the temperature increases the speed – know that increasing the concentration of solutions increases the speed – know that increasing the surface area of solid reagents increases the speed	– be able to interpret supplied data from rate experiments	
– know that a catalyst increases the speed without itself suffering chemical change (a discussion of activation energy is **not** required)	– appreciate the importance of catalysts in industrial processes as agents which increase the speed of reactions and reduce costs (recall of specific industrial processes is **not** required)	Only a simple qualitative particle interpretation of reaction rate is expected.
Oxidation and reduction		
– be able to describe *oxidation* as a reaction in which a substance gains oxygen – be able to describe combustion reactions as oxidation – appreciate that oxidation and reduction reactions always take place together in reactions which are often called *redox*	– know that redox can also be described in terms of electron transfer	There are many suitable examples of redox which can be used to illustrate the ideas. It is useful to cover this section within other contexts in the syllabus. The reduction of iron ore is an obvious example and the combustion of hydrocarbons is another.
Thermal decomposition		
– be able to distinguish between *thermal decomposition* and *combustion*	– know the products of the thermal decomposition of calcium carbonate	Useful examples include making charcoal and the decomposition of sodium hydrogencarbonate.
– know that thermal decomposition involves the breaking down of a complex substance into simpler ones by heat alone	– understand the use of calcium carbonate and calcium hydroxide (lime) in treating acid soils and acidic effluent	

CORE	SUPPLEMENT	SUGGESTED APPROACHES
Electrolysis		
– be able to describe *electrolysis* as the breaking down of a compound by the passage of direct electric current – know, in general terms, the apparatus and materials needed for electrolysis – know the terms *anode* and *cathode* – know that an *electrolyte* is a liquid which allows a current to pass through it – know that either dissolving or melting an ionic substance forms an electrolyte		It is very important that the theory of electrolysis is supported by observations which the students make. If possible, they should see more electrolysis reactions than those specified in the syllabus.
– be able to describe the electrolysis of aqueous copper(II) chloride and of molten lead(II) bromide – know the general result that metals are deposited on the cathode and non-metals are formed at the anode – appreciate that energy is used up in electrolysis and that this is supplied from the electrical power source	– understand the principle that positive ions are attracted to the cathode and negative ions are attracted to the anode – understand that positive ions are discharged by gaining electrons from the cathode and negative ions give up electrons to the anode (ion-electron equations are **not** required)	It is important that students aiming for higher grades are clear that the current is carried by mobile ions in the electrolyte and not by electrons. Students may be asked to recall details of specified reactions but could also be asked to use general principles to suggest what they might expect to see in a case which they may not have studied at first hand. For safety reasons, teachers may prefer to demonstrate processes which release chlorine.
– know that electrolysis is used to extract aluminium and is used in the production of chlorine, sodium hydroxide and reactive metals – know that electrolysis is used as a method of plating and is used in the electrolytic purification of copper (details of industrial processes are **not** required)	– appreciate that electrolysis of aqueous electrolytes may produce hydrogen at the cathode and oxygen at the anode – be able to describe the electrolysis using carbon electrodes of aqueous copper(II) sulfate and of concentrated aqueous sodium chloride – be able to describe the electrolysis of molten aluminium oxide (recall of industrial cells is **not** required)	

CORE	SUPPLEMENT	SUGGESTED APPROACHES
Tests for ions and gases		
– be able to describe tests for the following aqueous cations: ammonium, copper(II), iron(II), iron(III) and zinc using aqueous sodium hydroxide and aqueous ammonia – be able to describe tests for the following aqueous anions: carbonate, chloride, nitrate and sulfate – be able to describe tests for the gases: ammonia, carbon dioxide, oxygen, hydrogen and chlorine		*Notes for Use in Qualitative Analysis* give further details of the tests with which students should be familiar. These notes are reproduced in the question paper for the Practical Test, but **not** for the Alternative to Practical paper. Students should have the opportunity to carry out these tests themselves.

CHEMISTRY TOPIC SIX — FUELS AND POLYMERS

Suggested time: 9 x 40 minute lessons

CORE	SUPPLEMENT	SUGGESTED APPROACHES
Fuels and combustion		
– know what is meant by the term *fossil fuel* – be able to give examples and uses of solid, liquid and gaseous fuels – understand that a *hydrocarbon* is a compound containing hydrogen and carbon only – appreciate that hydrocarbon fuels are derived from crude oil (petroleum)		Students are expected to be familiar with natural gas (mainly methane), petrol/gasoline and coal. They may be asked to justify why a particular fuel is suitable for a given application. They should appreciate that the term *fossil* implies that the fuel has taken millions of years to form and that it is derived from once-living material.
– understand burning in terms of the fire triangle (fuel, oxygen, heat) and that the products of the complete combustion of hydrocarbon fuels are carbon dioxide and water – appreciate that the products of burning fossil fuels may have damaging effects on the environment	– know the balanced equation for the complete combustion of methane – understand that incomplete combustion of carbon-containing fuels produces carbon monoxide and carbon (as black smoke)	
– be able to describe *exothermic reactions* as those which give out heat to the surroundings	– understand that bond breaking absorbs energy and that bond making releases it – understand that in exothermic reactions more energy is released when new bonds form than is absorbed to break bonds in the reactants	This topic may be a useful one to give students practice in interpreting information presented in the form of graphs and tables. The idea that bond-making evolves energy may already have been suggested in work on bonding.

CORE	SUPPLEMENT	SUGGESTED APPROACHES
	– appreciate that different fuels release different amounts of energy	The use of simple spirit burners containing different alcohols would allow students to verify different heat values. Students aiming for higher grades could be asked to design their own experiments to do this.
Oils and polymers		
– appreciate that crude oil (petroleum) is a mixture of hydrocarbons		
– know that the mixture can be refined into simpler, more useful mixtures by fractional distillation (details of the industrial plant are **not** required) – understand, in outline, the principles of *fractional distillation* – know that most plastics are made from molecules derived from oil		Although students are not expected to recall details of chemical plant, the extension paper could contain questions which show a schematic diagram of a primary fractionating tower. The concept of fractional distillation can be demonstrated using alcohol/water mixtures. Students should be aware that the process of fractional distillation exploits the difference in boiling point between components.
– understand that plastics are made from long chain-like molecules – understand that long, chain-like molecules are formed when smaller molecules link together – understand and use the terms *monomer* and *polymer*	– understand, in outline, the process of *cracking* – know that cracking involves breaking larger hydrocarbons into smaller ones, some of which contain double bonds and so may be used in addition polymerisation	Students are not expected to recall details of actual crackers. They should know that cracking occurs under conditions of heat and pressure, sometimes in the presence of a catalyst. The laboratory cracking of an alkane over hot porcelain or aluminium oxide should be carried out, if possible.
– appreciate that chemists are able to modify the properties of plastics and that these materials are often used as substitutes for natural materials which may need conservation or whose properties may be inferior	– know the aqueous bromine test for the presence of carbon to carbon double bonds – be able to describe the process of addition polymerisation of ethene to form poly(ethene)	The polymerisation of ethene can be acted out by pairs of pupils to illustrate the ideas involved. This can then be backed up by the use of molecular models and by drawing displayed formulae. The linking of beads or paper clips to illustrate the general idea of polymerisation may be helpful.

PHYSICS TOPIC ONE **MEASUREMENT AND MOTION**

Suggested time: 15 x 40 minute lessons.

CORE	SUPPLEMENT	SUGGESTED APPROACHES
All students should:	In addition to what is required in the core, students following the extended curriculum should:	
Length and time		
– be able to measure length, volume and time using appropriate apparatus (e.g. ruler, measuring cylinder and clock) – know how to measure the length and period of a pendulum	– have an understanding of experimental error and ways in which it may be reduced	It should be possible to cover this section practically, with only the simplest of apparatus. Measurement of the volume of a regular solid using a ruler, the volume of a liquid using a measuring cylinder and the use of a clock or watch to measure a period of time, should be the minimum achieved. An investigation of the variation of the period of a pendulum with length gives good experience in the use of a ruler and watch, an appreciation of timing errors and their reduction and could possibly be used to develop skills in plotting graphs. An interesting task is for students to try to make their own timing device, using whatever materials are available.
Forces		
– know the effects of forces – be able to describe ways in which a force may change the motion of a body (i.e. its direction and speed) – be able to describe how a force can change the shape of a body – be able to obtain readings for, plot, draw and interpret extension-load graphs	– know and use the relationship between *force, mass* and *acceleration*, $F = m \times a$	Relate this to everyday practical examples of objects accelerating and rotating. The relationship between forces and spring extension provides good opportunities for individual practical work. The relationship between force and extension also provides an opportunity for developing graph plotting skills. Even if enough springs are not available for individual work, useful practical skills can be developed using rubber bands.
– know what is meant by the *moment* of a force, with examples	– have an understanding of the *principle of moments* and perform simple calculations using the principle of moments	Students should be given the opportunity to carry out an experiment using the principle of moments. This could be done using metre rulers, picots and small masses.

CORE	SUPPLEMENT	SUGGESTED APPROACHES
Mass and weight		
– understand the ideas of *mass* and *weight* and the distinction between these terms – know that a spring balance measures weight, whereas a lever-arm balance measures mass		Use an appropriate balance to measure mass and weight.
	– know the meaning of the term *centre of mass* and the significance of it for the stability of an object	Students should look at a range of objects to make the connection between stability, wide base and low centre of mass. A useful way of illustrating the effect of base width and height of centre of mass is to use a Bunsen burner, first standing normally and then balanced upside down. Examples of stable objects which are worth discussing are racing cars, high-sided vehicles and table lamps, but examples should be chosen from the experience of the students, wherever possible.
Density		
– be able to describe experiments to determine the density of a liquid and of a regularly shaped solid and know and use the equation *density = mass/volume*	– be able to use and describe the displacement method to find the density of an irregularly shaped solid	This section continues the work begun in **Length and time**. Students should have the opportunity to measure volumes of liquids and solids. The measurement of the volume of an irregular solid can be carried out using either a eureka can or a measuring cylinder.
Speed, velocity and acceleration		
– show familiarity with *speed* and *acceleration* and understand the meaning of each – know and use the equation *distance = speed x time*	– be able to distinguish between *speed* and *velocity*	Determine experimentally the speed or acceleration of a moving object by timing motion of the object over measured distances. The use of ticker-timers is suggested.
– be able to construct a speed-time graph and recognise from the shape when a body is (a) at rest, (b) moving with constant speed and (c) moving with constant acceleration – know that the Earth is a source of a gravitational field	– be able to use such a graph to determine the distance travelled for motion with constant acceleration – be able to recognise from a graph when a body is moving with acceleration that is **not** constant	When teaching students how to find the distance travelled by using the area under the speed-time graph, it is worth taking trouble to see that they appreciate that they are not multiplying a length by a length, but a speed by a time. It is instructive to use a ticker-timer to measure the approximate value of the acceleration due to gravity by allowing a falling object to drag a length of ticker-tape through the timer and then analysing the tape.

CORE	SUPPLEMENT	SUGGESTED APPROACHES
		The subsequent discussion about why the value obtained is less than the expected value can lead to an appreciation of friction and its effect on motion.
	– be able to describe qualitatively the motion of bodies falling in a uniform gravitational field with and without air resistance, including reference to terminal velocity	The everyday observation that an object falling some distance never achieves a falling speed expected from the gravitational force leads on to air resistance and the way this is utilised in safe parachuting.
		Although knowledge of the formula $s = ut + ½ at^2$ is **not** required, it might be instructive to work out a typical speed with which a raindrop might be expected to hit the ground and the practical effects if it really did have this speed. As with parachuting, the discussion of why the speed is less than expected can lead to an appreciation of air resistance and terminal velocity.
	– appreciate why it is possible for objects to orbit the Earth without falling to its surface	Newton’s treatment of falling bodies, in which he showed that if a body was projected at a fast enough speed horizontally, it would ‘fall’ round the Earth without ever returning to the surface, gives an elementary approach to Earth satellites.

PHYSICS TOPIC TWO **ENERGY**

Suggested time: 8 x 40 minutes lessons.

CORE	SUPPLEMENT	SUGGESTED APROACHES
Energy and work		
– be aware of the importance of energy and of examples of different forms (i.e. kinetic, potential, chemical, heat, light, sound, nuclear and electrical)	– show a qualitative understanding of *efficiency*	This topic can be developed through the concept that energy ‘gets things done’.
– know that *work is force x distance* and use in calculations	– understand the equivalence of ‘work done’ and ‘energy transferred’	

CORE	SUPPLEMENT	SUGGESTED APPROACHES
Sources of energy		
– be able to describe processes by which energy is converted from one form to another, to include chemical/fuel, solar, nuclear, wind, waves, tides and hydroelectric and understand *renewable* and *non-renewable* forms		Discuss some of the ways in which the nation's energy is supplied (related to the students' own country) and other forms of energy which might be used, with discussion of advantages and disadvantages of each.
Power		
	– know and make calculations using *power* = *energy/time* in simple systems	Try to use examples within the experience of the students.

PHYSICS TOPIC THREE **ELECTRICITY**

Suggested time: 12 x 40 minute lessons.

CORE	SUPPLEMENT	SUGGESTED APPROACHES
Electric circuits and current		
– be able to draw and interpret circuit diagrams containing electrical sources, switches, resistors (fixed and variable), ammeters, voltmeters, lamps, magnetising coils, bells, fuses and relays and use the correct symbols for these components		The approach may well depend upon how familiar students are with electricity. All students should have an opportunity to build simple circuits and use an electrical source, switch, ammeter, voltmeter and resistors. It is helpful to include small lamps in the circuit.
– be able to state that current is related to the flow of charge and appreciate the need for a complete circuit	– know that the sum of the p.d.s across the components in a series circuit is equal to the total p.d. across the supply	The development of concepts will be helped by practical experience in the measurement of electrical potential difference in a variety of circuits using voltmeters.
– understand the meaning of the terms *current, e.m.f., potential difference (p.d.)* and *resistance,* together with appropriate units	– know the experimental evidence for Ohm's Law	
– be able to explain how an ammeter and voltmeter are used in circuits and what they measure		Relating electricity to domestic equipment familiar to the students can help build confidence in the concepts involved here and give them a reality outside the laboratory.

CORE	SUPPLEMENT	SUGGESTED APPROACHES
Resistance		
– recall and use *resistance = voltage/current,* being aware of the differences in total resistance if resistors are in series or parallel – know that the total resistance of resistors in series is their sum – be able to calculate the combined resistance of two resistors in series	– be able to perform simple calculations involving resistors in parallel	Electric resistance should be introduced as a property of a conductor, regardless of whether or not the current through it is proportional to the p.d. across it. Stress that resistance does not become zero (or infinite) if there is no current. It is important to ensure that by the time this topic is completed, the students have a sound grasp of the relationship between current, potential difference and resistance (and their units). Without this secure understanding, all the rest of their study of electricity will be hindered.
Safety		
– know some safety features of wiring in the home – be aware of the dangers of electricity and state the hazards of poor insulation, overloading and damp conditions		Safety features should be related to the students' own country (e.g. earthed plugs, earthed circuits, plugs recessed into sockets, regulations (e.g. sockets in bathrooms), fused plugs and correct use of conductors/ insulators). Give everyday examples of how circuits can be overloaded.
Electromagnetic effects		
– be able to describe the *turning effect* of a current-carrying coil in a magnetic field and relate this to the action of a d.c. motor (details of the construction of a d.c. motor need **not** be recalled)	– be able to describe the effect of more turns and increased current	Students will benefit from trying to build their own simple d.c. motor. When constructed, these can also be used as simple generators by rotating them manually. This work should lead to an understanding of the working of dynamos and alternators.
– be able to describe the large scale production of electricity as energy→source→turbine→ generator→transmission – be able to give a simple description of a transformer and know and use $V_p/V_s = N_p/N_s$ – be able to describe the use of transformers in high voltage transmissions and why such transmission is used to avoid energy losses	– understand the working of an a.c. generator and use of slip rings – be able to sketch a graph of voltage output against time – show an understanding of the principles of operation of the transformer and of the advantage of a.c. over d.c.	This section could be introduced be showing students the induction of an e.m.f. in a wire and coil. Experience has shown that many students fail to grasp the reason for high-voltage transmission and also the role played by the transformers. It is worth allowing plenty of time for this section.

PHYSICS TOPIC FOUR **HEAT**

Suggested time: 6 x 40 minute lessons.

CORE	SUPPLEMENT	SUGGESTED APPROACHES
States of matter		
– be able to describe the states of matter and their inter-conversion using a simple molecular model	– be able to explain the states of matter in terms of forces between particles	The Kinetic Theory is perhaps a good starting point, describing a model for matter in terms of particles in motion. A tray and some marbles, or drawing pins on an acetate sheet and overhead projector, could be used for a demonstration.
Thermal expansion and heat transfer		
– be able to describe experiments to show that solids, liquids and gases expand on heating and identify and explain some everyday examples of expansion	– be able to describe the relative order of magnitude of the expansion of solids, liquids and gases – know the relationship between the pressure and volume of a gas at a constant temperature	Some examples of expansion can include railway lines, bridge buildings and liquid-in-glass thermometers.
– be able to describe the transfer of heat by the processes of conduction, convection and radiation and identify and explain some of the everyday applications and consequences of these methods of energy transfer		Experiments can be performed to show the difference between good and poor heat conductors. Examples of good and bad emitters and absorbers of infra-red radiation should be included.
Conservation of heat		
– be able to describe the use of insulation in both hot and cold climates		In this section, examples should **not** just be restricted to those familiar to the students. Simple experiments relating to insulated and non-insulated bodies (e.g. beakers of hot water) are readily devised, and can be used to develop graph plotting skills. (See also Biology Topic Three.)

PHYSICS TOPIC FIVE **WAVES**

Suggested time: 12 x 40 minute lessons.

CORE	SUPPLEMENT	SUGGESTED APPROACHES
Light		
– be able to state the meaning of the terms *speed, frequency, wavelength* and *amplitude*, as applied to a wave		Rope, long springs (often called slinky springs) and a ripple tank are all useful pieces of equipment for introducing wave motion.
– be able to describe the *reflection* of light from a plane mirror and state that *the angle of incidence is equal to the angle of reflection* – be able to describe *refraction,* including angle of refraction, in terms of the passage of light through a parallel sided block	– be able to perform simple constructions, measurements and calculations – be able to describe *total internal reflection* and the principles of fibre optic transmission	All students should be able to carry out a reflection experiment with pins and a mirror. They should also use a glass block and pins to show refraction. However, although experiments using pins **should** be done, some students find this a difficult skill and it would be worth reinforcing their work with demonstrations using a ray box. A visible ray makes the concepts of reflection and refraction much more accessible, particularly to the weaker students.
– be able to use a converging lens to produce a real image and understand and use the term *focal length*	– be able to explain the meaning of a *virtual image* and the use of a converging lens as a magnifying glass	Total internal reflection is readily demonstrated using a semicircular glass block and a ray of light from a ray box. It is most effective if the lower surface of the block is either ground or painted white. Experiments with small filament lamps/illuminated gauzes, lenses and screens can be most instructive, even if only done as a demonstration.
Electromagnetic spectrum		
– be able to describe the features of the Electromagnetic Spectrum – know the six main regions and their sources, detectors, uses and characteristic properties	– know that *wavelength/ frequency* changes across the e-m spectrum – know that e-m waves are transverse waves that can travel in a vacuum at the same high speed – know this value	Some indication of wavelengths/ frequencies should be given, and the properties which the regions possess in common (i.e. electromagnetic waves, passage through a vacuum, same speed in a vacuum, transverse waves) should be stressed, so that students can appreciate that the different regions of the e-m spectrum are all different manifestations of 'the same thing'. It is appreciated that it might be difficult to cover this section by practical work, but this is a part of the syllabus which links with modern technology.

CORE	SUPPLEMENT	SUGGESTED APPROACHES
Sound		
– be able to give a simple description of the production of sound from a vibrating source and describe the transmission of sound through a medium – know the approximate range of audible frequencies and relate loudness and pitch to amplitude and frequency		The relationship between the loudness and pitch of sound and the amplitude and frequency of the sound wave is easily demonstrated if a signal generator, loudspeaker and cathode-ray oscilloscope are available.
Communication		
– appreciate that information can be transferred using radio waves	– be able to give similarities and differences between digital and analogue systems and some of the benefits of digital coding	

PHYSICS TOPIC SIX **RADIOACTIVITY**

Suggested time: 5 x 40 minute lessons.

CORE	SUPPLEMENT	SUGGESTED APPROACHES
Radioactivity		
– appreciate that radiations from radioactive materials are capable of breaking up other atoms and molecules – understand the terms *ionising radiation* and *background radiation* and state the sources of background radiation	– appreciate that ionisation produces charged particles	It is appreciated that an understanding of radioactivity is made difficult by its invisibility but it is important that all students are aware of its importance. Its ability to ionise makes it a hazard, but it underpins most of its applications.
Characteristics of the three kinds of emission		
– know the characteristics of the three types of radiation, alpha, beta and gamma (relative powers of penetration, relative charge, particle or wave and mass) – be aware of the dangers to living things of these types of radiation but also realise the usefulness of radiation	– be able to relate radioactivity to the structure of the nucleus of the atoms of a radioactive substance – appreciate the effect of electric and magnetic fields on alpha-, beta- and gamma-radiation	
Detection of radioactivity		
– be able to describe the detection of alpha-particles, beta-particles and gamma-rays.	– be able to state the meaning of the term *radioactive decay* – understand the concept of *half-life*	Many of the properties of ionising emissions can be readily demonstrated by use of standard apparatus purchased for the purpose. This also makes the topic more accessible to the student. It also removes some of the mystique surrounding

CORE	SUPPLEMENT	SUGGESTED APPROACHES
		radioactivity and makes students realise that radiation is quite safe if dealt with sensibly, taking appropriate precautions. The everyday presence of radioactive isotopes in the ground etc. should be stressed. If appropriate apparatus is not available, the random nature of radioactive decay can be illustrated by means of dice. Several hundred small cubes, each with one side painted a distinctive colour, can be used as an analogy for a radioactive material. When thrown, those which land with the painted side uppermost can be deemed to have 'decayed' and are removed. The remainder are thrown again, etc., and by counting the number removed each time, a good 'decay curve' can be obtained, from which the half-life can be found.
Energy from nuclear sources – be aware of nuclear fission for production of electricity and nuclear fusion, as in the Sun		

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. Students should be able to define those items indicated by an asterisk (*). The list for the extended curriculum includes both the core and the supplement.

CORE			**SUPPLEMENT**		
Quantity	*Symbol*	*Unit*	*Quantity*	*Symbol*	*Unit*
length	*l, h ...*	km, m, cm, mm			
area	*A*	m^2, cm^2			
volume	*V*	m^3, dm^3, cm^3			
weight	*W*	N			N*
mass	*m, M*	kg, g			mg
density	*d, ρ*	kg/m^3, g/cm^3			
time	*t*	h, min, s			ms
speed*	*u, v*	km/h, m/s, cm/s			
acceleration	*a*		acceleration*		m/s^2
acceleration of free fall	*g*				
force	*F, P ...*	N	force*		N*
			moment of a force*		N m
work done	*W, E*	J	work done by a force*		J*
energy	*E*	J			J*, kW h*
power	*P*	W	power*		W*
temperature	*t*	°C			
			frequency* *f*	*f*	Hz
			wavelength*	*λ*	m, cm
focal length	*f*	cm, mm			
angle of incidence	*i*	degree (°)			
angle of reflection	*r*	degree (°)			
potential difference/voltage	*V*	V, mV	potential difference*		V*
current	*I*	A, mA	current*		
e.m.f.	*E*	V	e.m.f.*		
resistance	*R*	Ω			

ASSESSMENT CRITERIA FOR PRACTICALS

Practical assessment - Papers 4, 5 or 6

Scientific subjects are, by their nature, experimental. It is accordingly important that an assessment of a student's knowledge and understanding of Science should contain a component relating to practical work and experimental skills (as identified by assessment objective C). In order to accommodate, within IGCSE, differing circumstances - such as the availability of resources - three different means of assessing assessment objective C objectives are provided, namely School-based assessment (see below), a formal Practical Test and an Alternative to Practical Paper.

PAPER 4, COURSEWORK (School-based assessment of practical skills)

The experimental skills and abilities, C1 to C4, to be assessed are given below.

C1 Using and organising techniques, apparatus and materials

C2 Observing, measuring and recording

C3 Handling experimental observations and data

C4 Planning, carrying out and evaluating investigations

The four skills carry equal weighting.

All assessments must be based upon experimental work carried out by the candidates.

It is expected that the teaching and assessment of experimental skills and abilities will take place throughout the course.

Teachers must ensure that they can make available to CIE evidence of two assessments for each skill for each candidate. For skills C1 to C4 inclusive, information about the tasks set and how the marks were awarded will be required. In addition, for skills C2, C3 and C4, the candidate's written work will also be required.

The assessment scores finally recorded for each skill must represent the candidate's best performances.

For candidates who miss the assessment of a given skill through no fault of their own, for example because of illness, and who cannot be assessed **on another occasion**, CIE's procedure for special consideration should be followed. However, candidates who for no good reason absent themselves from an assessment of a given skill should be given a mark of zero for that assessment.

CRITERIA FOR ASSESSMENT OF EXPERIMENTAL SKILLS AND ABILITIES

Each skill must be assessed on a six-point scale, level 6 being the highest level of achievement.
Each of the skills is defined in terms of three levels of achievement at scores of 2, 4 and 6.

A score of 0 is available if there is no evidence of positive achievement for a skill.

For candidates who do not meet the criteria for a score of 2, a score of 1 is available if there is some evidence of positive achievement.

A score of 3 is available for candidates who go beyond the level defined by 2, but who do not meet fully the criteria for 4.

Similarly, a score of 5 is available for those who go beyond the level defined for 4, but do not meet fully the criteria for 6.

SKILL C1 USING AND ORGANISING TECHNIQUES, APPARATUS AND MATERIALS

1
2 - Follows written, diagrammatic or oral instructions to perform a single practical operation.

Uses familiar apparatus and materials adequately, needing reminders on points of safety.

3
4 - Follows written, diagrammatic or oral instructions to perform an experiment involving a series of step-by-step practical operations.

Uses familiar apparatus, materials and techniques adequately and safely.

5
6 - Follows written, diagrammatic or oral instructions to perform an experiment involving a series of practical operations where there may be a need to modify or adjust one step in the light of the effect of a previous step.

Uses familiar apparatus, materials and techniques safely, correctly and methodically.

SKILL C2 OBSERVING, MEASURING AND RECORDING

1
2 - Makes observations or readings given detailed instructions.

Records results in an appropriate manner given a detailed format.

3
4 - Makes relevant observations or measurements given an outline format or brief guidelines.

Records results in an appropriate manner given an outline format.

5
6 - Makes relevant observations or measurements to a degree of accuracy appropriate to the instruments or techniques used.

Records results in an appropriate manner given no format.

SKILL C3 HANDLING EXPERIMENTAL OBSERVATIONS AND DATA

1
2 - Processes results in an appropriate manner given a detailed format.

Draws an obvious qualitative conclusion from the results of an experiment.

3
4 - Processes results in an appropriate manner given an outline format.

Recognises and comments on anomalous results.

Draws qualitative conclusions which are consistent with obtained results and deduces patterns in data.

5
6 - Processes results in an appropriate manner given no format.

Deals appropriately with anomalous or inconsistent results.

Recognises and comments on possible sources of experimental error.

Expresses conclusions as generalisations or patterns where appropriate.

SKILL C4 PLANNING, CARRYING OUT AND EVALUATING INVESTIGATIONS

1
2 - Suggests a simple experimental strategy to investigate a given practical problem.

Attempts 'trial and error' modification in the light of the experimental work carried out.

3
4 - Specifies a sequence of activities to investigate a given practical problem.

In a situation where there are two variables, recognises the need to keep one of them constant while the other is being changed.

Comments critically on the original plan, and implements appropriate changes in the light of the experimental work carried out.

5
6 - Analyses a practical problem systematically and produces a logical plan for an investigation.

In a given situation, recognises that there are a number of variables and attempts to control them.

Evaluates chosen procedures, suggests/implements modifications where appropriate and shows a systematic approach in dealing with unexpected results.

NOTES FOR GUIDANCE

The following notes are intended to provide teachers with information to help them to make valid and reliable assessments of the skills and abilities of their candidates.

The assessments should be based on the principle of positive achievement: candidates should be given opportunities to demonstrate what they understand and can do.

It is expected that candidates will have had opportunities to acquire a given skill before assessment takes place.

It is not expected that all of the practical work undertaken by a candidate will be assessed.

Assessments can be carried out at any time during the course. However, at whatever stage assessments are done, the standards applied must be those expected at the end of the course as exemplified in the criteria for the skills.

Assessments should normally be made by the person responsible for teaching the candidates.

It is recognised that a given practical task is unlikely to provide opportunities for all aspects of the criteria at a given level for a particular skill to be satisfied, for example, there may not be any anomalous results (Skill C3). However, by using a range of practical work, teachers should ensure that opportunities are provided for all aspects of the criteria to be satisfied during the course.

The educational value of extended experimental investigations is widely recognised. Where such investigations are used for assessment purposes, teachers should make sure that candidates have ample opportunity for displaying the skills and abilities required by the scheme of assessment.

It is not necessary for all candidates in a Centre, or in a teaching group within a Centre, to be assessed on exactly the same practical work, although teachers may well wish to make use of work that is undertaken by all of their candidates.

When an assessment is carried out on group work the teacher must ensure that the individual contribution of each candidate can be assessed.

Skill C1 may not generate a written product from the candidates. It will often be assessed by watching the candidates carrying out practical work.

Skills C2, C3 and C4 will usually generate a written product from the candidates. This product will provide evidence for moderation.

Raw scores for individual practical assessments should be recorded on the Individual Candidate Record Card. The final, internally-moderated, total score should be recorded on the Coursework Assessment Summary Form. Examples of both forms are provided at the end of this syllabus.

Raw scores for individual practical assessments may be given to candidates as part of the normal feedback from the teacher. The final, internally-moderated, total score, which is submitted to CIE should not be given to the candidate.

MODERATION

(a) Internal Moderation

When several teachers in a Centre are involved in internal assessments, arrangements must be made within the Centre for all candidates to be assessed to a common standard.

It is essential that within each Centre the marks for each skill assigned within different teaching groups (e.g. different classes) are moderated internally for the whole Centre entry. The Centre assessments will then be subject to external moderation.

(b) External Moderation

Individual Candidate Record Cards and Coursework Assessment Summary Forms are to be submitted to CIE no later than 30 April (for the June examination) and 31 October (for the November examination). For external moderation, CIE will require evidence which must include, for skills C1 to C4 inclusive, information about the tasks set and how the marks were awarded. In addition, for skills C2, C3 and C4, Centres must send three examples of a high mark, three examples of an intermediate mark, and three examples of a low mark (i.e. 27 pieces of work, which contribute to the final mark, chosen from ten different candidates, must be submitted by the Centre). If there are ten or fewer candidates, all the Coursework which contributes to the final mark must be sent to CIE. A further sample may be required. All records and supporting written work should be retained until after publication of results.

Centres may find it convenient to use loose-leaf A4 file paper for assessed written work. This is because samples will be sent through the post for moderation and postage bills are likely to be large if whole exercise books are sent. Authenticated photocopies of the sample required would be acceptable.

The samples sent to CIE should be arranged separately for skills C2, C3 and C4, the skill suitably identified and in some mark order, e.g. high to low. The individual pieces of work should **not** be stapled together. Each piece of work should be labelled with the skill being assessed, the Centre number and candidate name and number, title of the experiment, a copy of the mark scheme used, and the mark awarded. This information should be attached securely, mindful that adhesive labels tend to peel off some plastic surfaces.

PAPER 5, PRACTICAL TEST

BIOLOGY

Candidates should be able to

(a) follow instructions and handle apparatus and materials safely and correctly;

(b) observe and measure biological material or a biological experiment, using appropriate equipment/characters/units;

(c) record observations and measurements by drawing biological material or by recording experimental data in a variety of ways and using appropriate scales, intervals and axes;

(d) interpret and evaluate observational and experimental data from specimens or from experiments;

(e) comment on an experimental method used and suggest possible improvements.

CHEMISTRY

Candidates may be asked to carry out exercises involving

(a) simple quantitative experiments involving the measurement of volumes;

(b) speeds of reactions;

(c) measurement of temperature based on a thermometer with 1 °C graduations;

(d) problems of an investigatory nature, possibly including suitable organic compounds;

(e) simple paper chromotography;

(f) filtration;

(g) identification of ions and gases as specified in the core curriculum. *(Notes for Use in Qualitative Analysis* will be provided in the question paper.)

PHYSICS

Candidates should be able to

(a) follow written instructions for the assembly and use of provided apparatus (e.g. for using ray-tracing equipment, for wiring up simple electrical circuits);

(b) select, from given items, the measuring device suitable for the task;

(c) carry out the specified manipulation of the apparatus (e.g.

when determining a (derived) quantity such as the extension per unit load for a spring,

when testing/identifying the relationship between two variables, such as between the p.d. across a wire and its length,

when comparing physical quantities such as the thermal capacity of two metals);

(d) take readings from a measuring device, including

reading a scale with appropriate precision/accuracy,

consistent use of significant figures,

interpolating between scale and divisions,

allowing for zero errors, where appropriate,

taking repeated measurements to obtain an average value;

(e) record their observations systematically, with appropriate units;

(f) process their data, as required;

(g) present their data graphically, using suitable axes and scales (appropriately labelled) and plotting the points accurately;

(h) take readings from a graph by interpolation and extrapolation;

(i) determine a gradient, intercept or intersection on a graph;

(j) draw and report a conclusion or result clearly;

(k) indicate how they carried out a required instruction;

(l) describe precautions taken in carrying out a procedure;

(m) give reasons for making a choice of items of apparatus;

(n) comment on a procedure used in an experiment and suggest an improvement.

Note: The examination will **not** require the use of textbooks nor will candidates need to have access to their own records of laboratory work made during their course; candidates will be expected to carry out the experiments from the instructions given in the paper.

PAPER 6, ALTERNATIVE TO PRACTICAL

This paper is designed to test candidates' familiarity with laboratory practical procedures.

Questions may be set requesting candidates to

(a) describe in simple terms how they would carry out practical procedures;

(b) explain and/or comment critically on described procedures or points of practical detail;

(c) follow instructions for drawing diagrams;

(d) draw, complete and/or label diagrams of apparatus;

(e) take readings from their own diagrams, drawn as instructed, and/or from printed diagrams including

reading a scale with appropriate precision/accuracy with consistent use of significant figures and with appropriate units,

interpolating between scale divisions,

taking repeat measurements to obtain an average value;

(f) process data as required, complete tables of data;

(g) present data graphically, using suitable axes and scales (appropriately labelled) and plotting the points accurately;

(h) take readings from a graph by interpolation and extrapolation;

(i) determine a gradient, intercept or intersection on a graph;

(j) draw and report a conclusion or result clearly;

(k) identify and/or select, with reasons, items of apparatus to be used for carrying out practical procedures;

(l) explain, suggest and/or comment critically on precautions taken and/or possible improvements to techniques and procedures;

(m) describe, from memory, tests for gases and ions, and/or draw conclusions from such tests. *(Notes for Use in Qualitative Analysis*, will **not** be provided in the question paper.)

NOTES FOR USE IN QUALITATIVE ANALYSIS

Tests for anions

anion	*test*	*test result*
carbonate (CO_3^{2-})	add dilute acid	effervescence, carbon dioxide produced
chloride (Cl^-) [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	white ppt.
nitrate (NO_3^-) [in solution]	add aqueous sodium hydroxide, then aluminium foil; warm carefully	ammonia produced
sulfate (SO_4^{2-}) [in solution]	acidify with dilute nitric acid, then add aqueous barium nitrate	white ppt.

Tests for aqueous cations

cation	*effect of aqueous sodium hydroxide*	*effect of aqueous ammonia*
ammonium (NH_4^+)	ammonia produced on warming	-
copper(II) (Cu^{2+})	light blue ppt., insoluble in excess	light blue ppt., soluble in excess, giving a dark blue solution
iron(II) (Fe^{2+})	green ppt., insoluble in excess	green ppt., insoluble in excess
iron(III) (Fe^{3+})	red-brown ppt., insoluble in excess	red-brown ppt., insoluble in excess
zinc (Zn^{2+})	white ppt., soluble in excess, giving a colourless solution	white ppt., soluble in excess, giving a colourless solution

Tests for gases

gas	*test and test result*
ammonia (NH_3)	turns damp red litmus paper blue
carbon dioxide (CO_2)	turns lime water milky
chlorine (Cl_2)	bleaches damp litmus paper
hydrogen (H_2)	‘pops’ with a lighted splint
oxygen (O_2)	relights a glowing splint

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 †															

*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 24 dm^3 at room temperature and pressure (r.t.p.).

GRADE DESCRIPTIONS

The scheme of assessment is intended to encourage positive achievement by all candidates. Mastery of the core curriculum is required for further academic study.

A **Grade A** candidate must show mastery of the core curriculum and the extended curriculum.

A **Grade C** candidate must show mastery of the core curriculum plus some ability to answer questions which are pitched at a higher level.

A **Grade F** candidate must show competence in the core curriculum.

A **Grade A** candidate is likely to

- relate facts to principles and theories and vice versa
- state why particular techniques are preferred for a procedure or operation
- select and collate information from a number of sources and present it in a clear logical form
- solve problems in situations which may involve a wide range of variables
- process data from a number of sources to identify any patterns or trends
- generate an hypothesis to explain facts, or find facts to support an hypothesis.

A **Grade C** candidate is likely to

- link facts to situations not specified in the syllabus
- describe the correct procedure(s) for a multi-stage operation
- select a range of information from a given source and present it in a clear logical form
- identify patterns or trends in given information
- solve problems involving more than one step, but with a limited range of variables
- generate an hypothesis to explain a given set of facts or data.

A **Grade F** candidate is likely to

- recall facts contained in the syllabus
- indicate the correct procedure for a single operation
- select and present a single piece of information from a given source
- solve a problem involving one step, or more than one step if structured help is given
- identify a pattern or trend where only a minor manipulation of data is needed
- recognise which of two given hypotheses explains a set of facts or data.

MATHEMATICAL REQUIREMENTS

Calculators may be used in all parts of the assessment.

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).

GLOSSARY OF TERMS USED IN SCIENCE PAPERS

It is hoped that the glossary (which is relevant only to Science subjects) will prove helpful to candidates as a guide (e.g. 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 the descriptions of their meanings. 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. *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 other contexts, *describe* 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, as may *state and explain*.
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. resistance, the formula of an ionic compound).
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).

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

COMBINED SCIENCE
Individual Candidate Record Card
IGCSE 2009

Please read the instructions printed overleaf and the General Coursework Regulations before completing this form.

Centre Number						Centre Name		June/November	2	0	0	9
Candidate Number						Candidate Name		Teaching Group/Set				

Date of Assessment	Experiment Number from Sciences Experiment Form	Assess at least twice: ring highest two marks for each skill (Max 6 each assessment)				Relevant comments (for example, if help was given)
		C1	C2	C3	C4	
Marks to be transferred to Coursework Assessment Summary Form		(max 12)	(max 12)	(max 12)	(max 12)	TOTAL (max 48)

INSTRUCTIONS FOR COMPLETING INDIVIDUAL CANDIDATE RECORD CARDS

1. Complete the information at the head of the form.

2. Mark each item of Coursework for each candidate according to instructions given in the Syllabus and Training Manual.

3. Enter marks and total marks in the appropriate spaces. Complete any other sections of the form required.

4. Ensure that the addition of marks is independently checked.

5. **It is essential that the marks of candidates from different teaching groups within each Centre are moderated internally.** This means that the marks awarded to all candidates within a Centre must be brought to a common standard by the teacher responsible for co-ordinating the internal assessment (i.e. the internal moderator), and a single valid and reliable set of marks should be produced which reflects the relative attainment of all the candidates in the Coursework component at the Centre.

6. Transfer the marks to the Coursework Assessment Summary Form in accordance with the instructions given on that document.

7. Retain all Individual Candidate Record Cards and Coursework, **which will be required for external moderation.** Further detailed instructions about external moderation will be sent in late March of the year of the June examination and early October of the year of the November examination. See also the instructions on the Coursework Assessment Summary Form.

   Note: These Record Cards are to be used by teachers only for students who have undertaken Coursework as part of the IGCSE.

SCIENCES
Coursework Assessment Summary Form
IGCSE 2009

Please read the instructions printed overleaf and the General Coursework Regulations before completing this form.

Centre Number						Centre Name		June/November	2	0	0	9
Syllabus Code	0	6	5	3	Syllabus Title	**COMBINED SCIENCE**	Component Number	0	4	Component Title	**COURSEWORK**	

Candidate Number	Candidate Name	Teaching Group/ Set	C1 (max 12)	C2 (max 12)	C3 (max 12)	C4 (max 12)	Total Mark (max 48)	Internally Moderated Mark (max 48)

Name of teacher completing this form		Signature		Date						
Name of internal moderator		Signature		Date						

A. INSTRUCTIONS FOR COMPLETING COURSEWORK ASSESSMENT SUMMARY FORMS

1. Complete the information at the head of the form.
2. List the candidates in an order which will allow ease of transfer of information to a computer-printed Coursework mark sheet MS1 at a later stage (i.e. in candidate index number order, where this is known; see item B.1 below). Show the teaching group or set for each candidate. The initials of the teacher may be used to indicate group or set.
3. Transfer each candidate's marks from his or her Individual Candidate Record Card to this form as follows:
   (a) Where there are columns for individual skills or assignments, enter the marks initially awarded (i.e. before internal moderation took place).
   (b) In the column headed 'Total Mark', enter the total mark awarded before internal moderation took place.
   (c) In the column headed 'Internally Moderated Mark', enter the total mark awarded *after* internal moderation took place.
4. Both the teacher completing the form and the internal moderator (or moderators) should check the form and complete and sign the bottom portion.

B. PROCEDURES FOR EXTERNAL MODERATION

1. University of Cambridge International Examinations (CIE) sends a computer-printed Coursework mark sheet MS1 to each Centre (in late March for the June examination and in early October for the November examination) showing the names and index numbers of each candidate. Transfer the total internally moderated mark for each candidate from the Coursework Assessment Summary Form to the computer-printed Coursework mark sheet MS1.
2. The top copy of the computer-printed Coursework mark sheet MS1 must be despatched in the specially provided envelope to arrive as soon as possible at CIE but no later than 30 April for the June examination and 31 October for the November examination.
3. Send samples of the candidates' work covering the full ability range, with the corresponding Individual Candidate Record Cards, this summary form and the second copy of MS1, to reach CIE by 30 April for the June examination and 31 October for the November examination.
4. Experiment Forms, Work Sheets and Mark Schemes must be included for each assessed task for each of skills C1 to C4 inclusive.
5. For each of skills C2, C3 and C4, Centres must send three examples of a high mark, three examples of an intermediate mark and three examples of a low mark - i.e. 27 examples in total. The examples must be from at least ten candidates and **must have contributed to the final mark of those candidates.**
6. If there is more than one teaching group, the sample should include examples from each group.
7. If there are 10 or fewer candidates submitting Coursework, send all the Coursework **that contributed to the final mark** for every candidate.
8. Photocopies of the samples may be sent **but** candidates' original work, with marks and comments from the teacher, is preferred.
9. (a) The samples should be arranged separately, by tasks, for each of skills C2, C3 and C4, the skill suitably identified and in some mark order, e.g. high to low.
   (b) The pieces of work for each skill should **not** be stapled together, nor should individual sheets be enclosed in plastic wallets.
   (c) Each piece of work should be clearly labelled with the skill being assessed, Centre name, candidate name and index number and the mark awarded. For each task, supply the information requested in B.4 above.
10. CIE reserves the right to ask for further samples of Coursework.

SCIENCES
Experiment Form
IGCSE 2009

Please read the instructions printed overleaf.

Centre Number						Centre Name	
Syllabus Code						Syllabus Title	
Component Number						Component Title	**Coursework**
November	**2**	**0**	**0**	**9**			

Experiment Number	Experiment	Skill(s) Assessed

INSTRUCTIONS FOR COMPLETING SCIENCES EXPERIMENT FORM

1. Complete the information at the head of the form.

2. Use a separate form for each Syllabus.

3. Give a brief description of each of the experiments your students performed for assessment in the IGCSE Science Syllabus indicated. Use additional sheets as necessary.

4. Copies of the experiment forms and the corresponding worksheets/instructions and marking schemes will be required for each assessed task sampled, for each of Skills C1 to C4 inclusive.