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ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Secondary Education

Applied Science (Double Award) 2007/8

TEACHERS' GUIDE

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AQA Logistics Centre, Unit 2, Wheel Forge Way, Ashburton Park, Trafford Park, Manchester, M17 1EH.
Telephone: 0870 410 1036 Fax: 0161 953 1177
or
can be downloaded from the AQA Website: http://www.aqa.org.uk

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Registered address AQA, Devas Street, Manchester, M15 6EX. *Dr Michael Cresswell Director General.*

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Background Information

1 Introduction

1.1 Purpose

This Teachers' Guide has been produced to help teachers in their preparation for the delivery of AQA GCSE Applied Science (Double Award) and should be read in conjunction with the specification. The specification is available in hard copy, and may be downloaded from the AQA website http://www.aqa.org.uk Specimen assessments for Unit 2, portfolio guidance and standardisation materials are also available.

1.2 Curriculum

The course has been developed as an alternative to the other GCSE Science courses available at key stage 4 and provides a different approach in teaching, learning and assessment style. The context of this course is in terms of 'what scientists do' and the skills that they use. As such, the course emphasises the applied and vocational nature of science and provides opportunities for the study of science in real situations.

As with all other double award science courses, this specification is designed to be delivered in approximately 20% of curriculum time. The content is presented as a clear, coherent and detailed specification targeted at the candidate. The specification clearly indicates to candidates what they have to know, learn, find out and be able to do.

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Specification at a Glance
Applied Science (Double Award)

The award has four assessment units. All units are compulsory.

There are two tiers of assessment for Unit 2: Foundation (G–C) and Higher (D–A*). The centre-assessed units are not tiered.

GCSE Applied Science (Double Award)	
Unit 1 *Science in the Workplace*	
Centre-Assessed	10% of total marks 25 marks
A portfolio of evidence covering two reports	
Unit 2 *Science for the Needs of Society*	
Written Paper	35% of total marks
1½ hours	90 marks
Unit 3 *Developing Scientific Skills*	
Centre-Assessed	27½% of total marks 50 marks
A portfolio of evidence including records of three practical exercises covering six areas	
Unit 4 *Using Scientific Skills for the Benefit of Society*	
Centre-Assessed	27½% of total marks 50 marks
A portfolio of evidence including records of four activities	

GCSE Applied Science (Double Award)
4861

3 The Applied Science GCSE

3.1 Introduction

This specification has been developed to meet the requirements of the new Key Stage 4 National Science Curriculum. The specification is based on the previous GCSE Applied Science (Double Award) specification and contains many of the same features.

The context throughout the specification is on the work of scientists and the vocational/applied nature of the course, and assessment has been enhanced to reflect this.

The focus of the specification is on the vocationality and application of science, which should be emphasised throughout the course.

3.2 Key Skills

All GCSE specifications must identify, as appropriate, opportunities for generating evidence on which candidates may be assessed in the 'main' Key Skills of *Communication*, *Application of Number* and *Information and Communication Technology* at the appropriate level(s). Also, where appropriate, they must identify opportunities for developing and generating evidence for addressing the 'wider' Key Skills of *Working with Others*, *Improving own Learning and Performance* and *Problem Solving*.

Section 14 of the specification shows Key Skills opportunities within each unit.

3.3 Use of ICT

In addition to the Key Skill of ICT, the National Curriculum requires that students should be given opportunities to apply and develop their ICT skills through the use of ICT to support their learning. Where appropriate, candidates should make effective use of ICT within their study of Applied Science.

Candidates should be given opportunities in their Applied Science course to support their work by being encouraged to:

- find things out from a variety of sources, selecting and synthesising the information to meet their needs and developing an ability to question its accuracy, bias and plausibility
- develop their ideas using ICT skills to amend and refine their work and enhance its quality and accuracy
- exchange and share information, both directly and through electronic media
- review, modify and evaluate their work, reflecting critically on its quality, as it progresses.

		Examples of opportunities in GCSE Applied Science (Double Award) for the use of ICT follow. Candidates could: • use multimedia sources to see things that cannot readily be observed at first hand • use dataloggers in investigations • use the internet to find information about vocational applications of science, current developments, products and processes • use spreadsheets for modelling or data analysis • use software simulations • use databases to explore patterns • use CD-ROM software to explore models. **It should be noted that pages of notes printed from the internet or CD-ROMs will not be accepted as portfolio evidence, and will be ignored in the moderation process.**
3.4	Citizenship	Since 2002, students in England have been required to study citizenship as a National Curriculum subject. Section 15 of the specification signposts opportunities for developing citizenship knowledge, skills and understanding.
3.5	Spiritual, Moral, Ethical, Social, Cultural, Environmental, Health and Safety and European Issues	All specifications must identify ways in which the study of the subject can contribute to an awareness and understanding of these issues. Please refer to Section 15 of the specification for the relevant details.
3.6	Differences from and Overlap with the Original Double Award Applied Science Specification (3861)	Although the assessment of the course has been altered, the content of units 1, 3 and 4 of the new specification (4861) matches the content of units 1 and 3 of the original specification (3861): it is in Unit 2 where changes to content have been made. The table on pages 8–17 indicates the areas of Unit 2 that are common to both specifications and which parts are new. It is suggested that Unit 2 forms the core of the course and that the other units are integrated into it (see Scheme of Work, pages 76–102).

Learning objectives	Common with original specification	New
THE HEALTHY BODY		
You need to be able to:		
• describe living organisms as being made up of chemical compounds, and the cell as the common feature of all organisms	✓	
• describe the main features of animal cells (nucleus, cytoplasm, cell membrane)	✓	
• explain how substances enter and leave cells by diffusion and osmosis	✓	
• describe how the process of respiration releases energy (glucose + oxygen → carbon dioxide + water)	✓	
• describe the differences in the structures of some cells that enable them to carry out their functions (red blood cells, white blood cells, nerve cells)		✓
• describe the structure of the human circulatory system, including the function of the heart (a pump) and the composition and function of the blood (red blood cells, white blood cells, platelets, plasma)	✓	
• describe the structure of the thorax (trachea, lungs, intercostal muscles, ribs, diaphragm, diaphragm muscles)	✓	
• explain how ventilation of the lungs occurs and understand the pressure changes involved	✓	
• explain how the body maintains a constant temperature (by sweating and changing the diameter of capillaries)	✓	
• describe how chemical substances called hormones control many processes within the body. Hormones are secreted by glands and are transported to their target organs in the bloodstream		✓
• explain how the hormone insulin controls blood glucose levels (production by the pancreas, conversion of glucose to glycogen by the liver)	✓	
• describe how cells called receptors detect stimuli (changes in the environment)		✓
• give examples of receptor cells that detect stimuli (light, sound, smell, taste, touch)		✓
• describe how information from receptors passes along cells (neurones) to the brain		✓
• describe how an impulse is sent along a neurone to the effector (muscle or gland) which brings about the response (contraction or release of a chemical)		✓
• explain that differences in the characteristics of individuals may be due to genetic causes or environmental causes or a combination of both		✓

Learning objectives	Common with original specification	New
You need to know:		
• that the nucleus of a cell contains chromosomes		✓
• that chromosomes carry genes that control the characteristics of the body		✓
• that genes have different forms called alleles, which produce different characteristics	✓	
• the mechanism of monohybrid inheritance where there are dominant and recessive alleles	✓	
ILLNESSES, DISEASES AND THEIR DIAGNOSIS AND TREATMENT		
You need to be able to:		
• name some examples of diseases caused by microorganisms (measles, mumps, rubella, tuberculosis)	✓	
• describe how platelets help to form a barrier to infection through a cut		✓
• describe how white blood cells help to defend against pathogens		✓
• give examples of a range of methods of protecting against infection by harmful microorganisms – personal hygiene (washing hands, protective clothing) – sterilisation (gamma rays, high temperature) – disinfectants (chemicals used on surfaces) – antiseptics (chemicals used on skin)	✓	
• explain how vaccination protects humans from infection by specific microorganisms (MMR, TB, polio)	✓	
You need to know:		
• that bacteria and viruses make us feel ill when they reproduce rapidly in the body (cell damage and production of toxins)		✓
• that diseases are likely to occur if large numbers of pathogens enter the body as a result of unhygienic conditions or contact with infected people	✓	
• the characteristic properties of X-rays (penetration) that enable them to be used to diagnose medical disorders		✓
• the characteristics and properties of the three main types of nuclear radiation emitted by radioactive sources (alpha particles, beta particles and gamma rays)		✓
• the uses of high-energy radiation and the dangers associated with its use		✓

Learning objectives	Common with original specification	New
THE BODY AT RISK		
You need to know:		✓
• that certain foods are considered healthy (fresh fruit and vegetables) and an excess of others are considered unhealthy (saturated fat, salt, sugar)		✓
• that disease may be treated with medicines that contain useful drugs (eg penicillin is an antibiotic, aspirin is anti-inflammatory)	✓	
• that some medicines, including painkillers, help to relieve the symptoms of disease, but do not kill the pathogens (eg aspirin, paracetamol)		✓
• that some bacteria, but not viruses, may be killed by antibiotics	✓	
• that some bacteria develop resistance to, or may not be easily treated by, antibiotics (eg MRSA)		✓
• examples of recreational drugs that may harm the body (alcohol, nicotine, antidepressants, amphetamines, barbiturates, heroin, cocaine)		✓
• that some people may become dependent on or addicted to recreational drugs because they change some of the chemical processes in the body, and they suffer withdrawal symptoms without them (eg nicotine in tobacco)		✓
• that tobacco smoke contains substances that cause diseases of the respiratory and circulatory systems		✓
• that tobacco smoke also contains carbon monoxide, which reduces the oxygen-carrying capacity of the blood		✓
• that alcohol affects the nervous system by slowing down reactions (loss of self-control and long-term damage to the liver and brain)		✓

Learning objectives	Common with original specification	New
AGRICULTURE AND FARMING		
You need to be able to:		
• describe the differences in the structures of some plant cells that enable them to carry out their function (leaf cell, root hair cell)	✓	
• describe the similarities and differences between animal and plant cells (chloroplasts, cell wall, large vacuole)	✓	
• understand how plants make food by photosynthesis and how the rate of photosynthesis may be changed in horticulture in commercial glass houses (carbon dioxide + water → glucose + oxygen)	✓	
• understand why plants need, among other things, the minerals (nitrate, phosphate, potassium and magnesium) which they obtain from soil for healthy growth	✓	
• describe how intensive farming increases crop yields by using artificial fertilisers, pesticides, herbicides and fungicides, and increases meat production by using controlled environments	✓	
• describe how organic farming uses the alternative methods of natural fertilisers, natural pesticides and mechanical methods of eliminating weeds in crop production and keeps animals under more natural conditions	✓	
• identify useful products that can be made from living things and name the organism used to produce a particular product		
• describe the use of bacteria, yeast and other fungi in food and medicine production (bread, beer, wine, cheese, yoghurt) and antibiotics (eg penicillin)	✓	
• explain that selective breeding involves selecting the parents with desired traits, crossing them, selecting from their offspring, and then repeating the process over several generations	✓	
• explain that genetic engineering involves the transfer of 'foreign' genes into the cells of animals or plants at an early stage in their development so that they develop with desired characteristics	✓	
You need to know:		
• that nitrates are required for proteins, which are needed for cell growth, and that magnesium is required for chlorophyll	✓	

Learning objectives	Common with original specification	New
MANAGING THE ENVIRONMENT		
You need to be able to:		
• classify materials as elements, compounds or mixtures	✓	
• give examples of substances used straight from the ground (gold, sulphur, limestone and marble)	✓	
• describe how some substances are separated before use (salt from rock salt, fractional distillation of crude oil)	✓	
• give examples of reducing agents for the extraction of metals (carbon and carbon monoxide)	✓	
• describe how a metal may be made from its oxide by reduction (iron from iron oxide and lead from lead oxide)	✓	
• know that fossil fuels (natural gas, oil, coal) are useful energy resources	✓	
• appreciate the problems of burning fossil fuels (global warming and its effect on climate, limited deposits)	✓	
• know that nuclear fuels and renewable energy resources (wind, solar, hydroelectric, wave, tidal) may be used as alternatives to fossil fuels	✓	
• appreciate the problems of using nuclear fuels (problems of radioactive emissions, disposal of waste) and of using renewable sources (unreliability and possible effects on the environment)	✓	
• know how electricity is generated from the burning of fossil fuels	✓	
• know that changes in the Earth's atmosphere were originally produced from gases escaping from the Earth's interior and that gases were changed by the emergence of green plants		✓
CHEMICAL BUILDING BLOCKS		
You need to be able to:		
• describe the structure of the atom in terms of numbers of protons, neutrons and electrons	✓	
• explain the difference between atoms, molecules and ions	✓	
• write symbol equations for the chemical reactions in this unit (eg extraction of metals from ores, combustion of hydrocarbons, chemicals from limestone)	✓	
• explain that compounds with small molecules (covalent bonding) have low boiling points (water, methane, carbon dioxide)		✓
• explain that compounds with ionic bonding (eg sodium chloride) or giant molecules (eg silica) have high melting points and boiling points	✓	

Learning objectives	Common with original specification	New
You need to know:		
• that atoms of a particular element have the same number of protons (atomic number)	✓	
• the chemical symbols for the elements listed in the Appendix	✓	
• the chemical formulae for the simple molecules listed in the Appendix	✓	
• the characteristic properties of metals and non-metals (electrical conductivity, density, melting point, appearance)	✓	
MATERIALS USED FOR CONSTRUCTION		
You need to be able to:		
• give some uses of limestone in the building industry		✓
• describe the conversion of limestone into quicklime and quicklime into slaked lime		✓
• outline the manufacturing processes for the production of quicklime, cement and glass		✓
• describe the composition and use of mortar and concrete		✓
• give examples of metals (copper, lead, aluminium) and metal alloys (steel, brass, solder) used in construction	✓	
• describe some uses of metals in the building industry		✓
• classify materials as metals, polymers, ceramics and composites		✓
• describe the uses of these materials in the building industry and their advantages and disadvantages over naturally occurring materials		✓
• explain the properties of composites in terms of the properties of their components and be able to relate their properties to their uses	✓	
You need to know:		
• the chemical formulae of limestone, calcium oxide and calcium hydroxide		✓
• the meanings of the terms endothermic reaction and exothermic reaction		✓
• the characteristic properties of metals (eg electrical conductivity, malleability and hardness) and be able to relate them to their uses	✓	
• the characteristic properties of polymers (eg flexibility, behaviour on heating, poor conductors of heat and electricity) and be able to relate their properties to their uses	✓	
• the characteristic properties of ceramics (eg brittle, high melting point) and be able to relate their properties to their uses	✓	

Learning objectives	Common with original specification	New
SCIENCE IN THE HOME		
You need to be able to:		
• explain why an appropriate source of energy is selected for a particular task (natural gas, oil, mains electricity, batteries)		✓
• recall and use the formula power (watt) = voltage (volt) × current (ampere) to calculate the power of an electrical circuit	✓	
• calculate the current through an appliance from its power and the potential difference of the supply, and from this determine the size of the fuse needed for the appliance	✓	
• describe the use of fuses and circuit breakers to protect the users of faulty electrical appliances		✓
• carry out simple calculations using the formula: $\text{power} = \frac{\text{energy}}{\text{time}}$ to calculate power in watts (W) and to calculate the energy usage in kilowatt-hour (kWh) for electrical appliances	✓	
• calculate the costs of using different electrical appliances using the formula: total cost = number of kilowatt-hours × cost per kilowatt-hour	✓	
• describe how heat is transferred by conduction, convection and radiation	✓	
• explain how to minimise heat loss in the home	✓	
• calculate the percentage efficiency of a device using the formula: $\%\ \text{efficiency} = \frac{\text{useful energy transferred by the device}}{\text{total energy supplied to the device}} \times 100$	✓	
• describe the composition of a solution, suspension, gel, emulsion, foam and aerosol	✓	
• give an example of each type of mixture and explain why its composition makes it useful	✓	

Learning objectives	Common with original specification	New
• name examples of solvents other than water, eg organic solvents used in paints, and ethanol used in cosmetics and toiletries	✓	
• explain the changes that occur when some mixtures are left undisturbed or are left open to the atmosphere (settling of suspension, escape of gas from solution, evaporation of solvent, separation of emulsion)	✓	
You need to know:		
• the advantages to the user, and to society, of making and using devices with high efficiency, by considering the benefits of low energy lamps compared with filament lamps	✓	
• the meaning of the term *efficiency* when applied to simple energy transfers in electrical appliances	✓	

Learning objectives	Common with original specification	New
FORCES, MOVEMENT AND TRANSPORTATION		
You need to be able to:		
• recall and use the formula speed (m/s) = distance travelled (m) / time to calculate the speed, distance travelled, or journey time, for a vehicle moving with a steady speed in a straight line		✓
• recall and use the formula acceleration (m/s^2) = change in velocity (m/s) / time taken for change (s) for vehicles moving in a straight line with a steady acceleration		✓
• describe how the stopping distance of a vehicle depends on: – the distance the vehicle travels during the driver's reaction time – the distance the vehicle travels under braking force		✓
• explain how the overall stopping distance is affected by: – the speed of the vehicle – the type of road surface – the driver's reaction time – the weather conditions (eg wet / icy roads, poor visibility) – the condition of the vehicle's brakes and tyres – how heavily loaded the vehicle is		✓
• appreciate that tiredness, drugs and alcohol may affect a driver's reaction time		✓
• describe how transport safety can be improved by providing information and carrying out tests on vehicles and drivers		✓

Learning objectives	Common with original specification	New
FUELS FOR TRANSPORT		
You need to be able to:		
• describe how, in processes of energy transfer, energy is conserved but tends to spread out and become less useful	✓	
• write symbol equations for the combustion of hydrocarbon fuels and explain the patterns in the equations		✓
• explain how incomplete combustion results in lower energy output and the formation of toxic combustion products (carbon monoxide and soot)	✓	
You need to know:		
• that petrol and diesel are fuels obtained from crude oil	✓	
• that the compounds in crude oil consist of molecules made up of hydrogen and carbon atoms only (hydrocarbons)	✓	
• the meaning of the term efficiency when applied to energy transfers in mechanical systems	✓	
• the advantages of developing the use of alternative fuels (eg hydrogen, gasohol) to replace fossil fuels used for transport	✓	
COMMUNICATION DEVICES		
You need to be able to:		
• describe the uses of different types of waves in communication devices: – radio waves – TV and radio – microwaves – mobile phones – infrared – remote control for TV and DVD players – visible light – fibreoptic cables		✓
• describe the change in frequency when a wave source is moved away from an observer		✓
• describe the evidence for the expanding universe provided by observations using telescopes		✓
You need to know:		
• that electromagnetic radiation travels as waves and moves energy from one place to another		✓
• that the number of waves per second produced by a source is called the frequency and it is measured in hertz (Hz)		✓
• that the higher the frequency of the wave, the higher the energy of the wave		✓
• the different types of waves that make up the electromagnetic spectrum (gamma rays, X-rays, ultraviolet, visible light, infrared, microwaves, radio waves)		✓

Examining 'How Science Works'	Some of the ideas contained in 'How Science Works' will be examined in Unit 2 by providing candidates appropriate data or text to interpret or comment on. The parts of the specification where this is likely to take place are listed below.
The Healthy Body	**You should be able to use data, theories and explanations to:** • evaluate the use of current research in the treatment of genetic disorders.
Illnesses, Diseases and their Diagnosis and Treatment	**You should be able to use data, theories and explanations to:** • evaluate the advantages and disadvantages of being vaccinated against a particular disease • explain how the occurrence of some diseases has changed as a result of increased use of vaccinations.
The Body at Risk	**You should be able to use data, theories and explanations to:** • compare the impact of legal (alcohol and tobacco) and illegal drugs on the body • explain the link between smoking and respiratory and circulatory diseases. **You should be able to assess the implications of science when:** • considering the issues of testing new drugs.
Agriculture and Farming	**You should be able to assess the applications and implications of science when:** • comparing the advantages and disadvantages of both types of farming. **You should be able to use data, theories and explanations to:** • evaluate the effect on the environment of the continued use of artificial fertilisers, pesticides, herbicides and fungicides, and the effect of other factors associated with intensive farming (eg field size, monoculture) **You should be able to assess the applications and implications of science when:** • making informed judgements about the economic, social and ethical issues concerning cloning and genetic engineering and suggest possible long-term evolutionary problems, eg seedless fruits.

Managing the Environment	**You should be able to assess the applications and implications of science when:** • considering and evaluating the social, economic and environmental impacts of exploiting metal ores • evaluating the effects of human activity on the Earth based on environmental measurements • evaluating changes to the composition of water and air as a consequence of industrial and geological activity • evaluating the environmental effects over time of pollution and waste disposal • evaluating the environmental impact over time of energy production and comparing the advantages and disadvantages of using alternative energy sources. **You should be able to use data to:** • explain the position of the Earth in the solar system.
Chemical Building Blocks	**You should be able to use data to:** • write the chemical formulae of some simple ionic compounds. **You should be able to use data and theories to:** • explain the differences in the physical properties of compounds in terms of the types of forces of attraction between the particles in the structure.
Materials used for Construction	**You should be able to use data, theories and explanations to:** • evaluate the environmental, social and economic effects of producing building materials from limestone • select materials for making a particular product given a specification for the product • evaluate the developments in modern building materials, and their advantages and disadvantages compared with traditional materials. **You should be able use data to:** • find the physical properties of materials.
Science in the Home	**You should be able to use data, theories and explanations to:** • evaluate the effectiveness and cost-effectiveness of methods used to reduce domestic energy consumption.

Forces, Movement and Transportation	**You should be able to use data, theories and explanations to:** • evaluate the impact of environmental factors, improvements in technology and changes in rules and regulations on transport safety.
Fuels for Transport	**You should be able to use data, theories and explanations to:** • evaluate the social, economic and environmental impacts of the uses of fuels for transport • compare the energy content of different fuels • evaluate developments in the production and use of better fuels.
Communication Devices	**You should be able to use data, theories and explanations to:** • explain how the uses of different types of waves depend on their properties. **You should be able to assess the applications and implications of science when:** • evaluating the social and environmental impact of the use of communication devices • evaluating the possible hazards associated with the use of different types of electromagnetic radiation.

Scheme of Assessment

GCSE Applied Science (Double Award) is assessed by means of a combination of external assessment and centre assessment (portfolio evidence). Each unit is assessed by one method only.

4 External Assessment

4.1 Introduction

The following unit is assessed externally by a written examination:

- Unit 2: Science for the Needs of Society

  Foundation Tier 1½ hours **or**

  Higher Tier 1½ hours.

First examination is available in June 2007.

Each written paper consists of a number of compulsory questions based on the unit content, and will allow candidates to apply the knowledge, understanding and skills they have gained from teacher-designed activities and assignments. Many of the questions will be written with a vocational context, expecting candidates to apply their science to that context. The context will be based on, and will reflect as far as possible, the work of various occupational groups that use science and the application of science as an important part of their work. Such occupational groups may include:

- transport, including the design, construction and maintenance of cars, roads and bridges
- the building industry
- the generation and distribution of electricity
- the health and safety executive
- the medical professions
- public health inspection
- town and country planning
- agriculture and horticulture
- the food industry
- the cosmetics industry
- the manufacturers of electrical appliances.

All papers are presented as question and answer booklets, are set and marked by AQA and are available in January and June each year.

4.2 Guide to Command Words in GCSE Applied Science

The command words and phrases used in examination papers are there to inform candidates of the style of answer required. Ignorance of the meanings of one or more of these command words or phrases could lose a candidate marks. The list below provides the meanings to many of the most frequently used command words and phrases.

Many questions are best asked as direct questions prefaced by the words 'What?', 'Why?' or 'Where?' So commonplace are these words and so varied the context in which they might be used that no attempt has been made to define them.

AQA's guiding principle in producing its examination papers is to set questions that are clear and unambiguous. While instructions will normally be taken from the list that follows, AQA reserves the right to substitute alternative expressions if it is felt that they make the meaning of the question clearer.

Calculate / Work out	The candidate must produce a numerical answer.
Compare	The candidate needs to describe the similarities and/or differences in sets of data.
Complete	The candidate needs to enter the answer in the spaces provided in a diagram, table, sentence, etc.
Describe	The candidate must state in words, or as diagrams, the important points of the topic.
Draw a bar chart	• Where the axes are labelled and scaled, the candidate needs to plot as bars a series of values. • Where the axes are labelled and not scaled, the candidate needs to add scales and to plot as bars a series of values.
Draw a graph	• Where the axes are labelled and scaled, the candidate needs to plot as points a series of values, and then draw a straight or curved line appropriate to the relationship between the points. • Where the axes are labelled and not scaled, the candidate needs to add scales, to plot as points a series of values, and then draw a straight or curved line appropriate to the relationship between the points.
Explain	The candidate should apply reasoning to the recall of theory. (This command word will **not** be used if the required answer is no more than a list of reasons.)
Give a reason (how/why)	The candidate should give a reason that is an application of scientific knowledge based on the recall of content stated in the specification.
Give/Name/State/Write down	A concise answer is required without supporting evidence.

List	Candidates should give a series of concise answers, each answer being written one after the other.
Predict	The candidate must give a concise answer, without supporting evidence, and should produce their answer by making logical links between various pieces of information.
Sketch a graph	The candidate needs to draw a graph indicating a trend or pattern without the need to first plot a series of points.
Suggest	There is no unique answer: candidates are expected to base their answers on scientific knowledge and/or principles.
Use the information	Candidates should base their answers on information provided within the context of the question.
Use your understanding/ ideas of …..to …..	Candidates should frame their answers around a scientific concept.
What is meant by	The candidate should give a definition, together with some relevant comment on the significance or context of the question.

4.3 Further Requirements

The Unit 2 specification also contains sections entitled '*You should be able to use data, theories and explanations to*:'. These sections of the specification will be assessed by supplying data or 'science media stories'/short case studies, which candidates will need to interpret. They will be expected to use the information to evaluate, give reasoned scientific explanation or to argue a rational case.

4.4 Written Papers

Two tiers of entry are available for the written paper for Unit 2:

- Foundation Tier, targeted at grades C–G
- Higher Tier, targeted at grades A*–D.

Care should be taken to ensure that candidates are entered for the appropriate paper.

The final grades for the double award obtained by the candidate are determined by the total UMS score achieved in the four units. Although the maximum UMS for the Foundation Tier is 195, it is possible for candidates entered for the Foundation Tier paper to achieve overall grades above C if they perform well in the centre-assessed units. See pages 78–80 of the specification for further information on UMS scores.

Both the Foundation and the Higher Tier papers are 1½ hours, with a maximum of 90 marks. Approximately 30–35% of the questions are common. The remaining 65–70% of the marks on the Foundation Tier paper are targeted at the less able candidates (E, F and G).

On the Higher Tier paper approximately 50% of questions are targeted at the more able candidates (A*, A and B).

The common elements of these papers may appear as:

- complete common questions
- part common questions
- common questions that have been extended on the Higher Tier paper to test candidates' deeper understanding and application of topics.

There is no specific Higher Tier content in the specification. Questions set at the 'higher demand' will be more demanding, thus allowing candidates to reach the higher grades.

As the tier of entry for the written examination does not restrict the overall grade awarded for the completed course, it is important to target correctly the entry of individual candidates for these papers. Centres should think carefully before entering borderline grade C/D candidates for the Higher Tier paper.

5 Portfolio

5.1 Introduction

The following are centre-assessed units:

- Unit 1: Science in the Workplace
- Unit 3: Developing Scientific Skills
- Unit 4: Using Scientific Skills for the Benefit of Society.

First moderation of portfolio units will be in June 2007. Subsequently, moderation of portfolio units will be available twice each year, in January and June.

5.2 Support for Coursework

Portfolio Advisers

Each centre is allocated a Portfolio Adviser. Portfolio Advisers will answer telephone or email queries and may look at an example of marked work to give guidance on the standard if a centre is in difficulties.

The advice that a Portfolio Adviser gives will be restricted to:

- issues related to the carrying out of assignments
- standards of marking
- administrative issues
- discussion of feedback from moderators.

Portfolio Advisers cannot prime mark any work.

Portfolio Advisers are all moderators. They will not moderate work from centres that they advise.

Standardisation meetings

Annual meetings will usually be held in the autumn term, at venues around the country. At these meetings teachers will have the opportunity to discuss the portfolio requirements, will be given examples of possible approaches and will receive instruction on the application of the portfolio criteria.

New centres **that have registered** with AQA will be invited automatically to these meetings. Attendance in the first year of the examination is compulsory.

5.3 Annotation of Scripts

Paragraph 5.16 of the GCSE, GCE, VCE, GVNQ and AEA Code of Practice 2006/7 states: '*The awarding body must require internal assessors to show clearly how credit has been assigned in relation to the criteria defined in the specification … The awarding body must provide guidance on how this is to be done.*'

This annotation will enable the moderator to see as precisely as possible where the teacher considers that the candidate has met the criteria in the specification.

It is suggested that teachers refer to the mark descriptors for each unit, using the codes as given in the assessment grid for each unit – for example, 1A.1, 3B.2, etc.

Annotation should show clearly:

- what guidance a candidate has been given
- any ephemeral evidence provided by the candidate to the teacher in order to justify the awarding of a particular mark; eg in Unit 3, selecting and preparing laboratory equipment (3A.3)
- those areas of the work that provide the evidence for the award of a particular mark
- any witness statement that is included in the student portfolio; eg in Unit 3 whether guidance was given in carrying out risk assessment (3A.1).

Any information or guidance provided to candidates (eg data provided for analysis) **must** accompany work that is submitted for moderation. Where secondary evidence is used, candidates must quote the appropriate references.

Work could be annotated by one of the following methods:

- key pieces of evidence flagged throughout the work by annotation, either in the margin or in the text
- summative comments on the work, referencing precise sections in the work.

Optional progress record forms are provided on pages 116–118 to help in tracking candidates' progress.

5.4 Authentication of Candidates' Work

Paragraph 5.13 of the GCSE, GCE, VCE, GNVQ and AEA Code of Practice 2006/7 states: '*The awarding body must require centres to obtain from each candidate a signed declaration that authenticates the coursework they produce as their own. A mark of zero or absent must be recorded if a candidate cannot provide confirmation of the authenticity of the coursework produced.*'

AQA will not accept coursework marks if the work is not authenticated. Centres are asked to bear this in mind when submitting marks, and where work is not authenticated, zero or absent should be recorded on the Centre Mark Sheets. Centres should ensure that all Candidate Record Forms are signed before candidates go on study leave and should check that all work submitted to the moderator has signed forms attached.

5.5 Moderation Procedures

Paragraph 5.20 of the GCSE, GCE, VCE, GVNQ and AEA Code of Practice 2006/7 states: *'To ensure that standards are aligned within and across centres, the awarding body must moderate the marks submitted by each centre against the specified assessment criteria.'*

Moderation is carried out by an AQA moderator, who will undertake detailed scrutiny of all the work of a sample of candidates from each centre. On the basis of this inspection, it will be decided whether to:

- accept the centre's assessments
- adjust the assessments to bring them into line with national standards
- ask for a further sample
- ask for the work of all candidates or request the centre to reassess or internally standardise their marks.

Normally, a centre's judgement about the order of merit will be accepted. However, if major discrepancies are discovered, AQA reserves the right to alter the order of merit and to inform the centre accordingly.

5.6 Explanation of Terminology

Portfolio of evidence

A portfolio of evidence is a collection of evidence to show that the candidate has completed the set tasks to the appropriate standard for the award of the mark given. The form of the evidence can be:

- written work from the candidate
- photographic, audio or video recording of candidate activity
- statements from the teacher/assessor, detailing observations of the candidate performing tasks or relating conversations with the candidate.

Vocational context

This refers to evidence that should have a particular relevance to the use of science in a manner that candidates can appreciate in society, eg the production of useful materials and products such as drugs, plastics, foodstuffs, dyes, burglar alarms, etc.

Scientific workplace

This refers to any workplace that uses scientific knowledge, techniques, skills principles and ideas. These may be major users of science, such as the chemical industry, but are likely to include smaller users of science such as photographers, chefs and gardeners.

Simple calculations	Simple calculations are calculations that involve the basic rules of addition, multiplication, subtraction and division. Candidates would normally be expected to use these rules in equations, eg to determine the percentage yield of product produced in a chemical reaction (Unit 4, 2B.3). At a higher level, candidates would be expected to manipulate data and rearrange equations and formulae.

5.7 Developing Assignments and Tasks in Applied Science

An assignment or task should:

- be clear in its demands and related to a vocational context, demonstrating the use of science or scientific skills
- match the learning being developed
- provide opportunities for producing the evidence required to meet the criteria as appropriate and reflect the demands of the specification
- provide opportunities for higher grades to be achieved as appropriate.

Assignments could be:

- integrated across strands and stages in, eg, Unit 3 and Unit 4
- targeted at a particular stage in Unit 1 (designed to contain a series of activities targeted at particular ability levels)
- integrated across the stages within each strand, eg in health and safety in Unit 1
- targeted across units by developing skills and understanding, eg the biological topics in Unit 3 and Unit 4.

The assignment should:

- be clearly titled
- give clear detailed information/instructions, for candidates, with a clear expected outcome, as the criteria give no credit for the method. Where a task sheet for each assignment is used, a copy should be included in the candidate's portfolio
- allow candidates to follow standard procedure throughout all their experimental work (the standard procedure may be given as part of the task sheet)
- contain advice on what work is expected to meet the criteria and therefore encourage candidates to recognise the strengths of their own work
- where appropriate, contain the background material that candidates will need to complete the work (graphs, reports, tables, etc)
- specify how candidates have to work

- involve various styles of learning (questioning, discussion, research, etc)
- provide opportunities for staff review and feedback to candidates. Candidates may redraft assignments following guidelines given at the review stage
- contain strict deadlines.

The internally assessed work should be seen as an integral part of the course and treated as normal work. It should not be seen as an extra 'bolt on' in addition to the normal scheme of work (see Scheme of Work, pages 76–102). Ideally, candidates should be encouraged to build their portfolios regularly, with work completed as part of the programme.

Contents of the portfolio

As well as the candidate's work, the portfolio should contain:

- a copy of the assignment outline or task. This is particularly important as it helps to put the assignment or task into context for moderation and internal standardisation purposes
- teacher annotation using the codes from the assessment grid. An example in Unit 3 would be 1A.1 ('carry out a risk assessment, given clear guidelines')
- observation evidence by those assessing the work, eg records that a candidate has selected appropriate laboratory equipment, worked safely, and completed risk assessments with guidance, etc
- any feedback sheets used by staff during assignment review
- the final assessment decision and records to show how the decision was reached
- index and numbered pages.

Types of evidence

Types of evidence that the Applied Science portfolio could contain include:

- reports – as a result of experimental work or other research
- job descriptions – as a result of work in Unit 1
- presentations – evidence from candidates to, for example, the whole class group
- questionnaires – as a result of interviews undertaken, eg in Unit 1
- charts – eg flow chart to illustrate a process
- diagrams, observations, surveys, notes or graphs – as a result of work undertaken in the laboratory or when visiting business or industry to research, for example, health and safety, working with scientific skills or investigating a vocational context to illustrate work done in the laboratory

- leaflets – produced by candidates as an alternative to a written report (eg to illustrate first aid in the laboratory or workplace)
- posters – produced by candidates as an alternative to a written report (eg to illustrate careers in science)
- conclusions – made as a result of experimental work
- evaluations of experimental work
- photographs as evidence of products produced, electronic devices made, etc
- audio recordings – eg of interviews candidates have carried out as part of their research
- assessor evidence – witness sheets providing ephemeral evidence
- feedback records – as a result of assessor review.

Use of templates

Some centres may find it useful to give their candidates templates to use in their portfolios to ensure a consistency of approach. These may be of help in:

- recording risk assessment
- making observations of candidates selecting appropriate equipment
- recording that a candidate undertook tasks following appropriate standard procedures and following correct health and safety guidelines
- providing particular help for lower ability candidates (eg the provision of writing frames, etc)
- providing support in the use of calculations (eg chemistry in Unit 3 and Unit 4).

Generally, templates are not suitable for candidates who are assessed as working at Stage 3 (although they may be accepted in the case of risk assessments). Candidates working at this level would normally be expected to work more independently, without the structure of templates or writing frames.

5.8 Guidelines to Successful Assessment

- Treat assessment as part of the course, built into the scheme of work and completed as a part of the normal programme.
- Build the candidates' portfolios regularly throughout the course.
- Set deadlines for work to be completed and keep to them to ensure consistency and fairness.
- Ensure that assignments or tasks will generate sufficient evidence.
- Do **not** accept material downloaded from the internet or CD-ROMs as evidence.
- Ensure that there are sufficient opportunities within the assignments or tasks to meet the criteria.
- Ensure that candidates understand the assessment grid.
- Assess the work against the criteria set throughout the course, not just on the 'odd occasion'.

5.9 Administrative Procedures to Support Assessment

- Ensure that all the Candidate Record Forms are signed before candidates go on study leave and check that all work submitted for moderation has signed forms attached.
- Annotate work clearly in order to identify where the evidence is, how it has been matched to the criteria in a strand and the level it has attained. Ideally, annotations should be on the work itself using the codes from the assessment grids – eg 2A.1 ('carry out risk assessment, given some guidelines') in Unit 3. However, a separate record card may be used if this is considered more appropriate.
- Train candidates to identify where they think criteria have been met and to undertake some form of self-assessment.
- Include any record cards and assignment sheets in the final portfolio. Remember that a moderator must be able to find the evidence easily.
- Keep paperwork to a minimum and encourage candidates to keep their own record of progress whilst building their portfolio.
- Evaluate existing procedures and good practice in either the centre or the department, as these are often easily modified for the Applied Science programme.
- All pieces of work contributing to the final mark for each candidate need to be made available for moderation and kept at the centre until the October following the final award.

5.10 Awarding Marks: Unit 1

Stage 1 Candidates should undertake research into the safe working practices required in the school or college laboratory. They should include details concerning hazards and risks, first aid and fire prevention in order to obtain maximum marks.

It should be noted that in the statement 'a range of organisations that use science' **a range** refers to **a minimum of three** organisations. (Three marks can be awarded for three named organisations where candidates have stated the products made or services offered together with the types of job undertaken by the employees.)

Stage 2 Candidates should undertake research into the safe working practices required in an alternative workplace, preferably outside the school or college environment to allow a meaningful comparison at Stage 3. Candidates should include details concerning hazards and risks, first aid and fire prevention in order to obtain maximum marks.

In the study of a range of organisations criteria 2A.1–2A.5 refer to the organisations considered at Stage 1. The careers in science criterion may be based on these organisations or may be focused on an alternative scientific vocational area in which the candidate is interested.

Stage 3 At this level candidates make a comparison between the health and safety procedures in a workplace and those in their school or college. The comparison should use the same headings as Stage 1 and Stage 2 (ie hazards and risks, first aid and fire prevention) in order to obtain maximum marks.

Candidates need to write a report about one of the organisations used at Stage 1 and Stage 2. Although a visit to the organisation is not essential, it would help candidates to write their report if a visit had taken place.

Skill Area A: The Use of Science in the Workplace

Stage	Marks	Candidates should be able to:	Increasing demand of activity
1	1–3	1A.1 produce a simple study on a range of organisations that use science 1A.2 state the products made or services provided 1A.3 identify the jobs of those employed.	↓
2	4–8	2A.1 identify organisations as local, national or international 2A.2 describe their location 2A.3 describe the products made or services provided 2A.4 describe the jobs and qualifications of the employees and how they use science 2A.5 describe the types of skills scientists need in addition to their qualifications, and a range of careers that are available in science.	
3	9–11	3A.1 produce an in-depth study of **one** particular organisation 3A.2 explain its location 3A.3 describe the products made or services provided and explain their importance to society 3A.4 give a detailed account of the skills and qualifications needed by scientists who work there 3A.5 describe the effect on the local environment of the organisation.	

- Base this activity on local organisations, if possible, as this will be more relevant for candidates.
- This activity could be a literature survey, although candidates will find visits to, and contacts with, local industry and business more relevant.
- In Stage 1 and Stage 2, the 'range' of organisations should be **at least three**.
- The Stage 3 criteria refer to **one** of the organisations used at Stage 1 and Stage 2.
- Criteria 1A.1 to 2A.5 may be awarded 1 mark each.
- At Stage 3, if both criterion 3A.2 and criterion 3A.3 are met then 9 marks may be awarded. Criteria 3A.4 and 3A.5 attract 1 mark each.

Skill Area B: Working Safely in the Workplace

Stage	Marks	Candidates should be able to:	Increasing demand of activity
1	1–4	1B.1 carry out research into working safely in the school or college laboratory, including: – hazards and risks and their assessment – first aid – fire prevention.	
2	5–8	2B.1 carry out research into the issues of working safely in a workplace that uses science or scientific skills, including: – hazards and risks and their assessment – first aid – fire prevention.	
3	9–11	3B.1 carry out research into the issues of working safely in a scientific workplace and compare these with the school or college laboratory, including: – hazards and risks and their assessment – first aid – fire prevention.	

- Work should reflect the specification in the areas of:
  - hazards and risks
  - first aid
  - fire prevention.
- To complete each stage of this report and obtain maximum marks candidates must address each of the above categories, although greater emphasis could be placed on one of the areas.
- To reach stages 2 and 3 candidates should consider an alternative workplace or workplaces. At Stage 3 they should appreciate the similarities with the school/college situation.
- At Stage 1, 1 mark may be awarded for some basic research, and then 1 mark given each for the three categories.
- A candidate cannot obtain a mark of 5 or above unless he or she has included a report on a scientific workplace other than the school laboratory.
- At Stage 2 candidates may be awarded 5 marks for basic research on the issues. One further mark may be added for each of the three categories, to take the total to 8.
- To achieve marks of 9 or above the report must include a comparison of the similarities and differences between the school/college and a workplace. Comparison in each of the categories will take the marks through 9 to 11.

Hierarchy

In Unit 1 marks should be awarded hierarchically; for example, all Stage 1 marks **must** be achieved before any Stage 2 marks can be awarded, and all Stage 2 marks **must** be achieved before Stage 3 marks can be awarded.

If all criteria are achieved within a stage, then the maximum mark for that stage can be awarded.

However, if a candidate completes the Health and Safety study in the workplace without completing the study in the school or college then the maximum mark that he or she may achieve is 4.

Compensatory marking

In Unit 1, if a candidate has missed up to a maximum of two criteria at Stage 1 or Stage 2 this may be compensated by work completed at the stage above. In such cases the maximum mark that may be awarded is the maximum mark allowable at the lower stage.

Where compensatory marking is used this should be justified to the moderator on the Candidate Record Form and by comments on the candidate's work.

Arrangements for incomplete Unit 1 portfolio work

Candidates who do not submit work for 'The Use of Science in the Workplace' should be awarded zero for that strand. Similarly, candidates who submit no work for 'Working Safely in the Workplace' should be awarded zero for that strand.

The Candidate Record form for the unit **must** be completed for each candidate. An optional record form, which centres may use to track a candidate's progress, is given on page 109.

Annotation

To aid both internal standardisation and final moderation of portfolio work it is recommended that candidates' work is annotated using the codes in the assessment evidence grid.

Authentication of candidates' work

Teachers are reminded that candidates must sign the Candidate Record Forms to authenticate the work as their own independent work, and that each portfolio should have a signed form attached.

If any Candidate Record Forms received by the moderator have not been signed by the candidate, the moderator will write to the centre to request a new form with the candidate's signature. If no signature is forthcoming then that candidate will be awarded a mark of zero / absent.

Skill Area C: Research and Communication of Evidence

Stage	Marks	Candidates should be able to:	Increasing demand of activity
1	1	1C.1 use a limited range of sources and information to present findings in their portfolio	
2	2	2C.1 use a range of sources and information to present findings clearly in their portfolio	
3	3	3C.1 identify and use a wide range of sources and information to present findings clearly and logically throughout their portfolio.	

- A candidate's ability to research and communicate is assessed within Unit 1 using the grid above.
- This is the only unit where research and communication is assessed. Compensatory marking is not appropriate in this instance.

5.11 Awarding Marks: Unit 3

Candidates must complete the practical activities as listed in the assessment grid covering **all three areas of work for this unit** (Investigating Living Organisms, Using Chemical Analysis Techniques, Investigating Properties of Materials).

Stage 1 Candidates at this level will show some limited confidence but will need considerable guidance from a member of staff. Results will meet the basic requirement of the activity. Candidates should be able to make a simple judgement on their findings linked to the overall purpose of the activity undertaken, and should demonstrate an awareness of the vocational significance of the activity.

Stage 2 Candidates should be able to demonstrate some independence in their work but seek clarification where necessary. Candidates should begin to interpret data collected as a result of their experimenting and be able to comment on the validity of the data in the context of the activity. They should be able to undertake calculations and obtain correct values. Candidates should be able to recognise the limitations of their procedures and suggest an improvement that may be adopted to collect more reliable data. They should be able to describe a vocational application of their activity.

Stage 3 The practical activities listed in the assessment evidence grid should give a clear indication that candidates have carefully planned their activities and have anticipated any problems that may occur. Candidates should be able to work independently and appreciate the need to repeat experiments where necessary. They should be able to complete calculations and rearrange standard formulae when required. Candidates should be able to evaluate their work and give clear, reasoned conclusions to their research and experimenting. Candidates should be able to explain the vocational significance and application of their activity. They should be able to identify clearly other vocationally relevant situations where techniques they have used may be applied. Candidates working at this stage should be able to recommend modifications to the activity.

Skill Area A: Planning and Following Instructions

Stage	Marks	Candidates for each investigation should be able to:	Increasing demand of activity
1	1–4	1A.1 carry out a risk assessment, given clear guidelines 1A.2 follow instructions, with guidance, in simple standard procedures, one step at a time.	↓
2	5–8	2A.1 carry out risk assessment, given some guidelines 2A.2 follow instructions in standard procedures, with little guidance for the more complex tasks 2A.3 select and prepare appropriate laboratory equipment and use it correctly and safely.*	
3	9–12	3A.1 independently carry out a risk assessment 3A.2 independently follow instructions in standard procedures 3A.3 select and prepare laboratory equipment of appropriate precision and use it correctly and safely.*	

*These criteria should be observed by the teacher.

Risk assessments

- Risk assessments should be comprehensive and include all relevant risks in the activity.
- A maximum of 2 marks may be awarded for criterion 1A.1 if the risk assessment is comprehensive.
- To achieve Stage 3, a candidate's risk assessments must be comprehensive as well as done independently. (Sources of research such as 'Hazcards' are acceptable.)
- At Stage 2 up to 2 marks may be awarded for criterion 2A.1 if the risk assessment is comprehensive. One mark may be awarded for each of criteria 2A.2 and 2A.3.
- Giving a candidate an example to follow (eg the completion of one horizontal row including a substance to be assessed, the hazard, risk and control measure) may be considered as 'some guidelines' at Stage 2.
- 'Clear guidelines' (Stage 1) could be considered as the above, plus supplying candidates with all the materials/activities to be 'risk assessed'.
- An assessor comment stating the level of guidance given is **essential** in helping the moderator assess the pieces of work.
- If the risk assessment at Stage 3 is complete 2 marks may be awarded for criterion 3A.1; if it is not complete then only 1 mark should be given.

Following instructions and use of equipment

- To ensure that it is clear how a candidate has achieved the mark for 'following instructions' it is essential to have assessor annotation indicating a particular stage (similarly for 'the use of equipment').
- Up to 2 marks may be awarded for criterion 1A.2 if the candidate has followed instructions for carrying out the experiment.
- To achieve Stage 3 for either of these points, the activity undertaken must be complex enough for the candidate to be able to demonstrate their abilities. A very simple task will not give opportunities to do this, so even a good candidate might not achieve Stage 3 for all activities.

Skill Area B: Obtaining Evidence by Experimenting

Stage	Marks	Candidates for each investigation should be able to:	Increasing demand of activity
1	1–4	1B.1 make simple observations and measurements 1B.2 record them in tables and in charts or graphs with guidance.	↓
2	5–8	2B.1 make careful and accurate measurements and observations 2B.2 recognise with some guidance when it is necessary to repeat measurements and observations 2B.3 record results accurately in tables and graphs where appropriate and using lines of best fit where appropriate.	
3	9–12	3B.1 make careful and accurate measurements and observations consistently 3B.2 independently repeat measurements and observations, when necessary 3B.3 independently record and present data in an appropriate form.	

Results

- At Stage 1, up to 2 marks may be awarded for each of criteria 1B.1 and 1B.2.
- At Stage 2 'careful and accurate measurements' should include the appropriate number of decimal places, and 'observations' should include the appropriate descriptive detail.
- Recording results 'accurately' includes using a suitable table and correct units.
- To achieve Stage 3 candidates should be able to apply the above consistently throughout.
- At Stage 2, accurate measurements and observations will attain 5 marks, and candidates must recognise the necessity for repeats to be awarded the mark for criterion 2B.2. In cases where it is not necessary to repeat a measurement/observation, a suitable comment made to explain this will obtain the mark.
- Recording results accurately in tables will allow candidates to achieve 7 marks, and the eighth may be awarded if an accurate graph is produced as a result.
- At Stage 3 marks are awarded for consistency and independent working. Consistently accurate measurements (3B.1) will receive 1 mark. At this stage, candidates should independently recognise the need for repeats to receive the second mark for criterion 3B.2. The twelfth mark may be awarded if the candidate has independently recorded and presented the data appropriately.
- In order to gain marks candidates should produce **at least one** hand-drawn graph to demonstrate that they can select appropriate scales and plot points for themselves. If it is not appropriate to draw a graph of the results, or if a candidate has not completed a graph where it is appropriate, then the **maximum mark** that can be achieved for that activity is 10, because criteria 2B.3 and 3B.3 could not be achieved completely. Centres should ensure that within the different practical activities undertaken there are sufficient opportunities for candidates to draw graphs.

Skill Area C: Analysing and Considering Evidence

Stage	Marks	Candidates for each investigation should be able to:	Increasing demand of activity
1	1–4	1C.1 carry out simple calculations with guidance 1C.2 offer simple explanations for their findings.	↓
2	5–8	2C.1 identify and explain patterns within data 2C.2 carry out simple calculations 2C.3 draw conclusions which are consistent with the evidence.	
3	9–12	3C.1 identify relationships where appropriate 3C.2 manipulate data using a variety of sophisticated techniques 3C.3 draw and present well-structured and accurate conclusions from the data which illustrate an in-depth understanding.	

Patterns and relationships

- Candidates should comment on trends or patterns in results to access Stage 2 and should be able to identify a numerical relationship between variables to achieve Stage 3.

Calculations

- A maximum of 4 marks may be awarded if both 1C.1 and 1C.2 are fully achieved.
- 'Simple calculations' (Stage 2) include such procedures as averages, percentages and substitution into equations.
- Examples of 'sophisticated techniques' (Stage 3) include rearranging equations and calculations of reacting quantities and percentage yields. The candidate's work should include evidence that he or she is capable of rearranging equations.
- Calculations of resistance from voltage and current cannot be classified as 'sophisticated techniques' if there is no evidence that the candidate has rearranged an equation.

Conclusions

- At Stage 2, correctly identifying and explaining patterns within the data (2C.1) receives 1 mark. If simple calculations are carried out consistently and accurately candidates may be awarded up to 2 marks for 2C.2. Candidates must draw conclusions consistent with the evidence (criterion 2C.3) to achieve the eighth mark.
- At Stage 3, identification of relationships (3C.1) is worthy of 1 mark, and manipulation of data (3C.2) may be awarded up to 2 marks, depending on consistency and accuracy. Candidates should be able to explain their conclusions by, perhaps, comparing their findings with literature values to achieve the twelfth mark.

Skill Area D: Evaluating Evidence

Stage	Marks	Candidates for each investigation should be able to:	Increasing demand of activity
1	1–2	1D.1 give a simple evaluation of their practical activity.	↓
2	3–4	2D.1 give an evaluation of their practical activity 2D.2 suggest an improvement to their method that would allow the collection of more reliable data.	
3	5–7	3D.1 review their practical activity by presenting a well-structured, logical evaluation of its strengths and weaknesses 3D.2 describe improvements to their method that would allow the collection of more reliable evidence.	

Evaluation

- Candidates should be taught how to evaluate by asking the following questions:
  - What went well and why?
  - What did not go well?
  - What could I do to get more reliable data when carrying out the investigations?
  - What are the strengths and weaknesses of the technique?
- Basic comments about how well the experiment went and how 'good or not' the results were are not worth more than 2 marks (Stage 1). A comment such as 'my experiment work went well' is not worth any marks. Even at Stage 1 candidates need to make any comment specific to the activity and say what went well.
- Generally, to access marks at Stage 2 and Stage 3, candidates should explain how results could be improved.

Suggestion for improvement

- At Stage 2 the suggestion for improvement should be accompanied by a reason to receive 4 marks. If there is no justification or explanation for the improvement, then the maximum mark that may be awarded is 3. Very little credit should be given for simple suggestions such as 'repeat it' or 'work more carefully' that are given without qualification.
- At Stage 3 candidates should be able to discuss the strengths and weaknesses of the technique or their method of completing the investigation for 5 marks. At this level a description of the improvements that could be made and how these would allow the collection of more reliable data should be expected to obtain 6 marks. The justification for these improvements would attract the seventh mark.

Skill Area E: Vocational Application

Stage	Marks	Candidates for each investigation should be able to:	Increasing demand of activity
1	1–2	1E.1 give a use for this practical activity in a workplace that uses science.	↓
2	3–4	2E.1 describe how the practical activity is used in a workplace that uses science.	
3	5–7	3E.1 explain why the practical activity is useful in a workplace that uses science 3E.2 give examples of the types of organisation that use this type of activity.	

- Candidates should appreciate the vocational significance of the activity.
- At Stage 1 candidates should be able to link the activity with its use in a scientific workplace for 2 marks. Simply naming the workplace is worth only 1 mark; it is the link that brings the second mark.
- At Stage 2 candidates should be able to describe the use of the activity (3 marks) in a specified workplace (4 marks).
- At Stage 3 candidates should be able to explain how the results of their investigation might be used (5 marks) and what the benefits of the results obtained may be to the organisation or to society (6 marks). The seventh mark may be awarded to candidates who are specific about the types of organisation that would use the technique.

Hierarchy

As in Unit 1, marks should be awarded hierarchically (see page 35). If all the criteria for a stage are achieved then the maximum mark for that stage may be awarded.

Compensatory marking

If a candidate has missed up to a maximum of two criteria at Stage 1 or Stage 2 this may be compensated by work completed at the stage above. In such cases the maximum mark that may be awarded is the maximum mark allowable at the lower stage.

Where compensatory marking is used this should be justified to the moderator on the Candidate Record Form and by annotation on the candidate's work.

Total marks for the unit

Each skill area should be awarded independently for each of the three investigations, and the best mark used to calculate the total marks. The total mark for the unit is calculated by adding together the best marks awarded for each of the skill areas A–E.

Arrangements for incomplete Unit 3 portfolio work

If any of the pieces of work required in Unit 3 are missing, marks should be adjusted: for every one of the three areas missing the total of the best marks for criteria A, B, C, D, E should be reduced by one-third.

The Candidate Record Form for the unit **must** be completed for each candidate. An optional record form, which centres may use to track a candidate's progress, is given on page 110.

Annotation

To aid both internal standardisation and final moderation of portfolio work, it is recommended that candidates' work is annotated using the codes in the assessment evidence grid.

Authentication of candidates' work

Teachers are reminded that candidates must sign the Candidate Record Forms to authenticate the work as their own independent work, and that each portfolio should have a signed form attached.

If any Candidate Record Forms received by the moderator have not been signed by the candidate, the moderator will write to the centre to request a new form with the candidate's signature. If no signature is forthcoming then that candidate will be awarded a mark of zero / absent.

5.12 Awarding Marks: Unit 4

Stage 1 Candidates should work with guidance in the laboratory to obtain products and data.

Monitoring Living Organisms

Planning skills will be limited and candidates will need considerable help in devising the plan for their investigation. Candidates should be able to record some results successfully in tables that may have been provided for them. Their conclusions, evaluations and any application of the investigation will be limited to simple statements. The use of living organisms and the incorporation of appropriate controls will need teacher intervention to ensure a useful and ethical outcome.

Making a Useful Product

Candidates should be able to produce a chemical product and measure its actual yield (no other calculations are required at Stage 1). They will need help in producing the word equation, and their description of the use of the product will be limited to a simple statement. Similarly, the way in which the rate of reaction may be increased will be limited to a single sentence or statement.

Assembling an Electronic/Electrical Device

Candidates are likely to need help with the design or selection and assembly of electronic or electrical devices. The testing of the device may be limited to 'does it work or not?' unless some intervention is made to suggest suitable tests that could be carried out.

Using Machines

Work at Stage 1 will be limited to examples of the uses of machines.

Stage 2 Candidates should be able to work in the laboratory to obtain products and data with only little guidance.

Monitoring Living Organisms

The candidate's plan should be clear enough so that it can easily be followed by another person. At this stage candidates should be able to collect relatively reliable data and to successfully carry out simple calculations. Their evidence should lead to more accurate conclusions. The evaluation should contain at least one improvement to technique or procedure, and the application should be more descriptive.

Making a Useful Product

At Stage 2 candidates should be able to complete a simple calculation in order to calculate a percentage yield and begin to appreciate how the product is used. They should also appreciate that there are number of factors that could affect the rate of reaction.

Assembling an Electronic/Electrical Device

Candidates should be able to test the device and give a simple evaluation of its effectiveness as well as explaining the function of the components.

Using Machines

Candidates should be able to relate the description to the machine(s) used in Stage 1. They should be able to show that they appreciate that friction results in a lack of efficiency and wastes energy.

Stage 3 Candidates should be able to work independently, with perhaps some consultation in the laboratory to obtain products and data.

The expected approach would be "I'm thinking of doing … next" not "What do I do next?"

In many cases candidates should be able to begin making evaluations and conclusions that link to theoretical work and suggest modifications to aspects of their laboratory work that would improve outcomes, including possible sources of error. Candidates should be able to select the correct form of calculation when carrying out quantitative procedures.

Monitoring Living Organisms

The context in the explanation should link to the investigation.

Making a Useful Product

Candidates should be able to perform some more sophisticated calculations at Stage 3, and be capable of using chemical equations. They should be able to use some research techniques to explain the industrial importance of the product, and particularly its impact on society.

Assembling an Electronic/Electrical Device

As part of the detailed evaluation of the device candidates should be able to suggest some modifications to improve the usefulness of the device.

Using Machines

The machine described should be linked to the machine's use as examples in the previous stage. However, in some instances an alternative example that may be more appropriate in the laboratory should be selected.

Monitoring Living Organisms

Stage	Marks	Candidates should be able to:	Increasing demand of activity
1	1–6	1A.1 produce a simple safe plan for the investigation with guidance 1A.2 monitor the growth, development and response, as appropriate, of an organism with guidance 1A.3 record data obtained 1A.4 offer simple explanations for their findings 1A.5 give a simple evaluation of their activity 1A.6 suggest an application for their investigation.	↓
2	7–12	2A.1 produce a safe plan, with little guidance, which would enable the investigation to be carried out by another person 2A.2 monitor the growth, development and response, as appropriate, of an organism with little guidance 2A.3 record data obtained, identify and explain patterns within the data, and carry out calculations 2A.4 make and explain conclusions from the evidence 2A.5 give evaluations of their activities and suggest an improvement to their method 2A.6 describe an application of monitoring organisms in the scientific workplace.	
3	13–17	3A.1 independently produce a safe plan described in a series of well ordered steps, which would clearly enable the investigation to be carried out by another person 3A.2 independently monitor the growth, development and response, as appropriate, of an organism 3A.3 record data obtained, analyse the data, explaining what they show, identifying any shortcomings in the evidence 3A.4 suggest improvements to the methods used that would enable more reliable evidence to be collected 3A.5 use scientific knowledge and understanding to explain why it is important to monitor organisms in the scientific workplace.	

- This activity may be marked by awarding each completed criterion (1A.1 to 3A.5) 1 mark.
- The activity undertaken should have a clear focus or industrial/commercial application to enable candidates to make appropriate responses in 1A.6, 2A.6 and 3A.5.
- The activity should be carried out over a period of time to allow appropriate data to be collected. Monitoring plants may be the most suitable option here.
- Candidates should have the opportunity to discuss their investigation before undertaking the practical work so that they can produce a plan. Criterion 3A.4 provides candidates with the opportunity to modify their plan.
- At Stage 2 and Stage 3, candidates should be able to demonstrate an understanding of the science underlying the investigation. Opportunities to demonstrate understanding exist in 2A.4, 3A.3 and 3A.5.

Making a Useful Product

Stage	Marks	Candidates should be able to:	Increasing demand of activity
1	1–5	1B.1 given a procedure, obtain a pure chemical product safely, using a named chemical reaction and present it in a labelled sample tube with guidance 1B.2 write a word equation for the reaction with guidance 1B.3 measure the actual yield of the product 1B.4 give a use for the product 1B.5 state one way that the rate of the reaction could be increased.	↓
2	6–11	2B.1 given a procedure, obtain a pure chemical product safely, using a named chemical reaction and present it in a labelled sample tube with little guidance 2B.2 write a word equation for the reaction 2B.3 calculate the percentage yield of the product given the theoretical yield and using the actual mass of product obtained 2B.4 calculate the costs of making a given amount of the product 2B.5 describe the use of the product 2B.6 describe two factors that affect the rate of the reaction.	
3	12–17	3B.1 independently, given a procedure, obtain a pure chemical product safely, using a named chemical reaction and present it in a labelled sample tube 3B.2 write a balanced chemical equation for the reaction and explain the type of reaction taking place 3B.3 calculate the percentage yield of the product given the theoretical yield and using the actual mass of product obtained to the appropriate number of significant figures, stating the correct units 3B.4 calculate the percentage yield of product obtained from a specified amount of reactant 3B.5 explain the industrial importance of the product and its impact on society 3B.6 use scientific knowledge and understanding to explain the factors that affect the rate of the reaction.	

- This activity may be marked by awarding each completed criterion (1B.1 to 3B.6) 1 mark.
- Candidates must make **one** product.
- To achieve Stage 3 candidates should write a balanced equation, and demonstrate a knowledge of the underlying reaction type.
- At Stage 2 candidates should be able to calculate the percentage yield of the product given the theoretical yield and using the actual mass obtained. The difference between 2B.3 and 3B.3 is the precision with which the calculation is carried out and the correct use of units.
- At Stage 3 candidates should be able to provide some brief kinetic explanation concerning rates of reaction.
- Appropriate assessor annotation will be sufficient to obtain the mark at 1B.1, 2B.1 and 3B.1.
- When calculating costs at Stage 2 (criterion 2B.4) it is not necessary to consider overheads such as heat, light, etc.

Assembling an Electronic/Electrical Device

Stage	Marks	Candidates should be able to:	Increasing demand of activity
1	1–2	1C.1 safely assemble a useful electrical or electronic device with guidance 1C.2 test the electrical or electronic device with guidance	↓
2	3–6	2C.1 safely assemble a useful electrical or electronic device with little guidance 2C.2 test the electrical or electronic device 2C.3 explain the function of the components used in the device 2C.4 evaluate the effectiveness of the device when used.	
3	7–9	3C.1 independently and safely assemble a useful electrical or electronic device 3C.2 independently test the electrical or electronic device and suggest alternative tests that could be carried out 3C.3 give a detailed evaluation of the effectiveness of the device and suggest improvements that could be made to make it more useful.	

- This activity may be marked by awarding each completed criterion (1C.1 to 3C.3) 1 mark.
- Marks awarded at 1C.1, 2C.1 and 3C.1 should be justified by assessor annotation that candidates have assembled the device.
- Candidate evidence must be presented for marks to be awarded at 1C.2, 2C.2 and 3C.2.
- At Stage 2 candidates should be able to explain the function of the components.
- At Stage 2 candidates must be able to evaluate the effectiveness of the device under appropriate conditions. 'My device worked' is not creditworthy.
- At Stage 3 (criterion 3C.3) the evaluation should include improvements that could be made to the device.

Using Machines

Stage	Marks	Candidates should be able to:	Increasing demand of activity
1	1	1D.1 give and describe an example of how mechanical machines may be used in the workplace.	↓
2	2–3	2D.1 describe how mechanical machines used in the workplace act as force multipliers 2D.2 describe why the effects of friction are important in mechanical machines.	
3	4–7	3D.1 measure the applied force and the force produced by a machine 3D.2 calculate: – the amount by which the machine multiplies force – the work done by the machine – the efficiency of the machine.	

- Criteria 1D.1 to 3D.1 may each be awarded 1 mark on completion.
- Criterion 3D.2 may be awarded a maximum of 3 marks if the three calculations are complete.
- At Stage 1 (1D.1) candidates should be able to describe the use of a machine in the workplace and what it does.
- The advantage of machines in the workplace should be described at Stage 2 with reference to the selected machine.
- The machine used in Stage 1and Stage 2 would be the ideal example to use at Stage 3. However, an independently based series of laboratory investigations is acceptable. Care should be taken not neglect stages 1 and 2 if candidates are to progress beyond 1 mark.

Risk assessments in Unit 4	Candidates will be expected to use the skills of risk assessment gained in Unit 3 in each of the investigations in Unit 4. A risk assessment should be included in each of the investigations carried out in this unit.
Hierarchy	As in Unit 1, marks should be awarded hierarchically; for example, all Stage 1 marks **must** be achieved before any Stage 2 marks can be awarded, etc. If all criteria are achieved within a stage, then the maximum mark for that stage can be awarded.
Compensatory marking	If a candidate has missed up a maximum of two criteria at Stage 1 or Stage 2 this may be compensated by work completed at the stage above. In such cases the maximum mark that may be awarded is the maximum mark allowable at the lower stage. Where compensatory marking is used this should be justified to the moderator on the Candidate Record Form and by assessor comments on the candidate's work.
Total marks for the unit	The total mark submitted for Unit 4 is calculated by adding together the marks awarded in each strand A–D. All pieces of work contributing to the final mark for each candidate need to be made available for moderation and kept at the centre until the October following the final award.
Arrangements for incomplete Unit 4 portfolio work	Candidates who do not submit work for any one of the strands A–D in Unit 4 should be awarded zero for that strand. The Candidate Record Form for the unit **must** be completed for each candidate. An optional record form is given on page 111, which centres may use to track progress.
Annotation	To aid both internal standardisation and final moderation of portfolio work, it is recommended that candidates' work is annotated using the codes in the assessment evidence grid.
Authentication of candidates' work	Teachers are reminded that candidates must sign the Candidate Record Forms to authenticate the work as their own independent work, and that each portfolio should have a signed form attached. If any Candidate Record Forms received by the moderator have not been signed by the candidate, the moderator will write to the centre to request a new form with the candidate's signature. If no signature is forthcoming then that candidate will be awarded a mark of zero / absent.

Course Organisation

6 Delivery of the Course

6.1 Guidance on Delivery for Unit 1

This unit is designed to be delivered discretely. Parts of the unit may form a good introduction to the course. Alternatively, sections of the unit may be used as part of a work experience programme that candidates undertake at the end of Year 10 or at the beginning of Year 11.

This guidance should be used in conjunction with the statements of what candidates need to be able to do, what candidates need to find out and with the assessment criteria for Unit 1.

Investigating How Science is Used

Candidates will need guidance in their decision on what constitutes a workplace where science is used. They will also need to be aware of the skills required of different types of scientific worker. This could be achieved by, for example, brainstorming exercises in the first instance. Candidates should also be aware of the types of career that are available in science and where scientific skills are used. Where possible, they should experience first hand a 'workplace that uses science'.

Candidates need to be aware of the scientific work carried out in various organisations, for example:

- pharmaceutical company
- civil engineering company
- quality control laboratory
- product development laboratory – such as food
- hospital laboratory
- environmental monitoring consultancy
- agricultural/horticultural development company.

Scientific skills may also be found in such places as hairdressing salons, breweries, garages and water purification units.

Candidates will need to consider **at least three** organisations and to achieve at Stage 3 should look in more detail at one of these organisations.

Links to the scientific workplace or to a workplace that uses scientific skills could be achieved through:

- links with or visits to local organisations or businesses that use science as part of their work. This may form a focus for the work experience or shadowing programme for some candidates
- vocational activity within school or college
- the use of speakers as an integral part of the delivery programme
- using literature produced by organisations (this may be obtained via the internet)
- the use of professional organisations
- the use of a careers service
- the use of work experience providers (eg Trident)
- local 'Education Business Partnerships'
- the Learning and Skills Council
- local Chamber of Commerce Training and Enterprise.

Some useful resources (in addition to the websites of national and local organisations) may be found at:

- http://www.futurevu.com
- http://www.gcseinappliedscience.com
- http://www.vocationallearning.org.uk

Working Safely in Science

This topic could be used as a general introduction to the course and to working in the laboratory. Candidates should be aware of the importance of working safely, not only in their own laboratory environment but also in a wider vocational context. The 'wider context' could include any scientific workplace and, ideally, should be from one of the organisations studied in 'Investigating how science is used'.

Candidates should know that it is necessary to adopt safety procedures and carry out risk assessments for all practical work. They should also appreciate the importance placed on risk assessment in the scientific workplace. Candidates will need to appreciate the importance of safety regulations by finding out about hazard and risk limitation.

It is important that candidates are able to recognise the similarities and differences in the approach to health and safety within their school or college environment and in a named workplace.

The teaching and learning strategy will need to be structured in order to allow each candidate to learn the underpinning knowledge and concepts in the study of laboratory hazards and safety. This may involve formal teaching as well as allowing individual research activities.

Candidates are not expected to study health and safety regulations in depth, but they should be aware of the provision and purpose of common regulations, such as:

- Management of Health and Safety at Work Regulations
- COSHH Regulations
- Electricity at Work Regulations (portable appliance testing).

Candidates should be aware of the first aid techniques used when treating the conditions listed on page 26 of the specification, but it is not intended that they become proficient 'first aiders' as a result of undertaking the Applied Science programme. Local branches of St John Ambulance and the Red Cross are often willing to assist in the delivery of first aid programmes in schools and may be able to offer some additional certification if this is considered desirable within the teaching programme.

Candidates should be taught the basic requirements of fire safety in order to appreciate the use and action of different types of extinguisher. The local fire service is often willing to assist schools by arranging visits and/or demonstrations.

Ideally, candidates' assignments should be structured under the headings given in the assessment criteria for the unit.

Further information and resources may be found at:

- http://www.cleapss.org.uk
- http://www.sserc.org.uk
- http://www.ase.org.uk
- http://www.sja.org.uk
- http://www.redcross.org.uk
- http://www.firstaid.org.uk

Research and Communication

A maximum of three marks is available for the quality of communication skills and expertise in researching and using the researched material.

It should be remembered that material simply downloaded from the internet will not be credited as evidence. Candidates may refer to such information and, if they include it in their portfolio, should produce it as an appendix.

6.2 Guidance on Delivery for Unit 2

Unit 2 will be assessed by external examination, but its delivery does not need to be separated from the teaching of the scientific principles and skills required for the more practically based Unit 3 and Unit 4 (see Scheme of Work, pages 76–102). The examination will mainly test candidates' knowledge and understanding of science and how science works (AO1) and their ability to apply their knowledge, skills and understanding (AO2). However, the content of Unit 2 is not purely theoretical and the examination will also test candidates' practical, enquiry and data handling skills (AO3).

AO1(a), AO2(a), AO2(b) and AO3(c) will form the basis of each examination, although AO1(b), AO1(c), AO2(c) and AO2(d) will also be tested. AO3(a), AO3(b) and AO3(d) will primarily be assessed in the portfolio units.

The information presented in this section is intended to indicate the depth and breadth of treatment required and should be used in conjunction with the statements of content and the guidance given in the specification. The depth of knowledge required will be roughly the same as for an equivalent GCSE Science topic and knowledge will, where appropriate, be examined in a vocational context (a list of possible vocational applications may be found on page 47 of the specification, and on page 21 of this Guide). Centres are advised, where possible, to deliver the content of this unit in contexts that reflect the knowledge, understanding and skills that scientists need to carry out their work.

Sections of the Unit 2 specification that refer to the use of data, theories and explanations or refer to the applications and implications of science will usually be examined by asking candidates to respond to information provided in the form of tables, charts or text.

Questions in both tiers of the examination will assume that candidates have studied science at key stage 3, but key stage 3 content will not be directly assessed.

Health and Medicine

The healthy body

Composition and features of cells

Candidates should be able to describe the main features of animal cells (cell membrane, nucleus and cytoplasm) and the differences in the structures of different animal cells (red blood cells, white blood cells and nerve cells) that enable them to carry out their functions. In the section on Agriculture and Farming candidates are asked to describe the similarities and differences between animal and plant cells (chloroplasts, cell wall and large vacuole) and to describe the differences in the structures of some plant cells (leaf cell and root hair cell) that enable them to carry out their functions.

Compounds that make up the chemical structure of the cell include protein, carbohydrate (sugar, starch and cellulose) and fat.

Diffusion and osmosis

Diffusion should be described as the net movement of particles in a gas or in solution from a high to a low concentration. The greater the difference in concentration, the faster diffusion occurs. Examples should be drawn from living organisms (eg oxygen and carbon dioxide in leaves, in the lungs and in capillaries).

Osmosis (the movement of water, but not solute, from a weak to a stronger solution through a partially permeable membrane) should be related to living organisms (eg root hair cells).

Respiration

Candidates will be expected to know the word equation for respiration and should be able to recognise the equation written using chemical symbols.

The circulatory and respiratory systems

Candidates should appreciate the role and function of the blood and its components:

- the red blood cells, which are involved in transporting oxygen from the lungs
- the plasma, which carries dissolved foods from the gut and carbon dioxide to the lungs
- the platelets, small fragments of cells that, together with proteins from the plasma, form a clot at the site of a wound
- the white blood cells, which have a nucleus and have a role in the defence of the body, producing antibodies and removing microbes and dead tissue. (This links with the section on Disease and illness on page 61).

Candidates will be expected to recognise the heart as a muscular pump, to be able to name the atria and ventricles and to understand how they and the heart valves function to pump the blood. They should be aware that there is a double circulation system.

Candidates need to know that thick-walled elastic arteries carry blood away from the heart, that thinner-walled veins return it and that narrow thin-walled capillaries allow the diffusion of substances needed by the cells and the removal of waste products. They should understand the role of the coronary blood vessels and the consequent seriousness of a blockage (heart attack).

Candidates should be able to name the parts of the thorax, including the ribs, rib muscles (intercostal muscles), diaphragm, lungs, trachea, bronchi, bronchioles and alveoli. They should be able to explain how ventilation occurs, and understand the pressure changes involved. They should know that gases can easily diffuse in and out of the blood in the alveoli.

Homeostasis

Candidates should know that humans maintain a constant body temperature, which is monitored and controlled by the thermoregulatory centre in the brain. They should appreciate how this centre controls body temperature:

- by increasing or decreasing the amount of sweating, which cools the body by evaporation
- by dilating the skin capillaries, increasing the blood flow to, and consequently the amount of heat lost from, the skin
- by restricting skin capillaries, decreasing the blood flow and the amount of heat lost.

Candidates should be able to describe the general action of hormones, and some examples (eg adrenaline and insulin). They should know that hormones are chemicals, produced by glands and released directly into the blood, which travel round the body and affect particular cells.

They should know that adrenaline is produced by the adrenal gland and that its effect is to increase heart rate and breathing rate.

Candidates should also be able to describe how blood glucose levels are monitored and controlled by cells in the pancreas:

- if the blood glucose concentration is too high (following a meal), the pancreas releases the hormone insulin into the blood. This causes the liver to remove glucose from the blood and store it as insoluble glycogen
- if the blood glucose concentration is too low (during exercise, perhaps) the pancreas releases glucagon, which causes the liver to convert glycogen back to glucose and release it into the blood.

Candidates need to be able to give examples of receptor cells and describe the action of receptor cells, nerve cells and effectors in enabling an organism to respond to changes in its environment.

Genetics and inheritance

Candidates should know that the different forms of a gene are called alleles and that in a monohybrid cross characteristics are controlled by a pair of alleles. They should be able to use diagrams to predict or explain the mechanism of a monohybrid cross where there are dominant and recessive alleles. Examples could be taken from agricultural and horticultural situations. Teachers are reminded of the need for sensitivity if human examples are used.

Candidates will be asked to evaluate the impact of scientific developments in the treatment of genetic disorders on individuals and communities.

Illnesses, diseases, and their diagnosis and treatment

Disease and illness

Candidates should be able to give examples of pathogens, know some ways in which pathogens enter the body and why they make us feel ill. They should be able to describe some of the body's natural defence mechanisms against these microorganisms (eg that white blood cells engulf and digest foreign cells and that platelets help the blood to clot at the site of a wound).

Prevention

Candidates should be able to give examples of a range of methods of protecting against infection, including immunisation.

They should appreciate that immunisation involves the introduction of a mild or dead form of the infecting bacterium or virus, which causes white cells to produce antibodies against it. If the individual is later infected by the same organism, the antibodies are produced quickly enough to destroy the organism and prevent development of the disease. Candidates will be asked to demonstrate understanding of how decisions about the use of vaccination are made (eg the advantages and disadvantages of being vaccinated against a particular disease).

Diagnosis and treatment

Candidates should know about the forms of electromagnetic radiation that are suitable for the diagnosis and treatment of certain conditions and illnesses. (Links with the uses of electromagnetic radiation in the section on Communication devices (page 68).)

They should also be able to describe the properties (penetration, hazards) and the nature (particles or waves) of alpha, beta and gamma radiation emitted from radioactive sources. (Links with the uses and hazards associated with nuclear fuels in the section on Energy resources, page 63.)

The body at risk

This section may be introduced by comparing different lifestyles, and could be linked with statistics on health and disease.

Candidates should appreciate the benefits of a healthy diet compared with an unhealthy diet. They should be able to discuss the use and abuse of legal and illegal drugs and need to know the reasons why tobacco and alcohol are considered dangerous and why their use is discouraged (eg advertising and restriction of sales to young people). Candidates should also be aware that some drugs are very useful, helping to relieve the symptoms of disease and even cure some diseases (eg antibiotics, painkillers, antidepressants and barbiturates (sleeping tablets)). They should also be aware that some of these drugs can be sold illegally for recreational use.

The work of healthcare professionals in the prevention and cure of disease should be the vocational focus of this section.

Countryside and Environmental Management

Agriculture and farming

Candidates should be able to describe the similarities and differences between animal and plant cells (chloroplasts, cell wall and large vacuole) and to describe the differences in the structures of some plant cells (leaf cell and root hair cell) that enable them to carry out their functions).

Candidates will be expected to know the word equation for photosynthesis and should be able to recognise the equation written using chemical symbols. Study of photosynthesis should include the capture of light energy by chlorophyll in the chloroplasts in some plant cells and the use of this energy to combine carbon dioxide and water into glucose, with oxygen as a waste gas. The limiting of photosynthesis by low light or carbon dioxide levels or by low temperatures should be related to the use of greenhouses by the horticultural industry.

Candidates need to learn examples of the minerals needed by plants (nitrate, phosphate, potassium and magnesium) and the consequences of depriving plants of nitrates and magnesium. They should be able to recognise the chemical symbols for the elements present in minerals and to use symbols for ions to write the chemical formulae of ionic compounds used in agriculture.

Candidates should understand how artificial fertilisers, pesticides, herbicides, fungicides and controlled environments are used in intensive farming, and will be asked to evaluate the impact of these practices on the environment. They should be able to compare intensive techniques with the techniques used in organic farming (eg natural pests such as ladybirds and parasitic wasps are specific, long lasting and do not leave residues but need a continuous low level of infestation and take time to establish; organic husbandry techniques may be more expensive, produce a less uniform product and take more space, labour or time but avoid artificial chemicals and residues and stressful living conditions).

Candidates should be able to identify products made from living organisms (eg meat, leather and wool from livestock; wood, cotton and paper from plants; yoghurt and cheese from bacteria; bread, beer and wine from yeast; penicillin from mould). They also need to be able to explain how the process of selective breeding has been used to make improvements to these organisms. They will be expected to understand examples of the use of genetic engineering and to know some of the changes that can be made to an organism's characteristics by genetic engineering. Candidates may be asked to show understanding of how decisions about the use of cloning and genetic engineering are made.

Managing the environment

Candidates will be asked to classify materials as metals, non-metals, ionic compounds, covalent compounds or mixtures. They should know that metals and ionic compounds have high melting points, that most non-metals and most covalent compounds have low melting points (see section on Chemical building blocks, pages 64–65).

Rock salt and crude oil are examples of mixtures that are found in the earth and candidates should be able to describe how they are separated.

- Sodium chloride (NaCl) can be separated from rock salt by dissolving, filtering, evaporating and crystallising.
- Crude oil is a mixture of liquids with different boiling points and can be separated into useful substances by fractional distillation.

The compounds present in crude oil contain the element carbon and are known as organic compounds. Hydrocarbons are the simplest of organic compounds, being made up of carbon and hydrogen only. Examples include methane (CH_4) and butane (C_4H_{10}). (See also the section on Fuel for transport and the section on polymers in Materials used for construction, pages 68 and 65 respectively.)

Candidates need to be able to describe how lead and iron may be made from their oxides by heating with carbon. Carbon and carbon monoxide can act as reducing agents:

- $2PbO + C \rightarrow 2Pb + CO_2$ and
- $PbO + CO \rightarrow Pb + CO_2$

Iron oxide (Fe_2O_3) and coke (carbon) are heated in the blast furnace to produce iron. The coke burns to produce carbon dioxide and this reaction heats up the furnace (exothermic reaction):

- $C + O_2 \rightarrow CO_2$

The carbon dioxide reacts with the coke to produce carbon monoxide:

- $C + CO_2 \rightarrow 2CO$

When heated, the iron oxide reacts with the carbon monoxide to produce iron. Iron oxide is reduced and carbon monoxide is oxidised:

- $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

Candidates should demonstrate understanding of how decisions about exploiting deposits of metal ores are made, and will be asked to consider the social, economic and environmental impacts of these decisions.

Energy resources

Candidates need to know that fossil fuels release energy when they are burned. Energy from fuel is used to raise steam to drive turbines. The turbines drive a generator to produce electricity.

The burning of fossil fuels causes pollution, and other problems such as global warming resulting in climate change and rising ocean levels (CO_2), and acid rain (SO_2) (see also the section on Fuel for transport, page 68).

Candidates need to appreciate that nuclear fuels do not produce gases that cause global warming or acid rain but that the waste materials produced by them are radioactive. Radioactive emissions are harmful to life so the waste from nuclear power stations has to be stored in a safe place until the radiation falls to safe levels.

Candidates should know that electricity can also be generated from renewable energy resources:

- wind – electricity is generated directly from wind turbines
- hydroelectric (HEP) and tidal – water movement from higher level to lower level is used to drive turbines
- wave – the rise and fall of water can be used to drive turbines
- solar – solar cells generate electricity directly using the sun's radiation.

Renewable sources generate only a fraction of our present energy needs and are less reliable than fossil or nuclear fuels because the wind, tides and hours of sunshine are variable. The generators of energy from renewable resources appear unsightly when sited in areas of natural beauty. Wind farms cause noise pollution and tidal barrages destroy the natural habitat of many organisms. Hydroelectricity schemes require the damming of rivers and the flooding of land once used for habitation or farming. Solar cells are expensive.

Candidates should compare the atmosphere of the Earth with the atmosphere on other planets and moons in the solar system, and should be able to relate this information to the mass of the planet and its distance from the sun (see also the section on Communication devices, page 68). They should be aware of how volcanic activity and the evolution of green plants have changed the composition of the atmosphere. They should be able to contrast the timescale of these changes with changes to air and water caused by human activity. Candidates will be asked to show understanding of how scientific knowledge about changes in the Earth and its atmosphere have occurred over time, and how these changes are validated.

Candidates will be asked to evaluate the impact of mineral extraction, energy production and waste disposal on individuals, communities and the environment.

The Home Environment

Chemical building blocks

Candidates should be able to describe the structure of an atom: they should know that atoms contain the same number of protons (positive charge) and electrons (negative charge), that the protons and the neutrons (no charge) are at the centre of the atom in the nucleus and that electrons are positioned around the outside of the atom. They will be asked to calculate the number of protons, neutrons and electrons in an atom of an element given the atomic number and mass number of the element.

Candidates should know that molecules are formed by two or more atoms bonded together and that ions are formed when atoms or molecules lose or gain electrons. They are expected to learn the symbols and formulae for the atoms and molecules listed in the Appendix and should be able to construct the formula for an ionic compound when given the symbols for the positive and negative ions present.

Candidates should be able to recognise ionic compounds (made by combining metals and non-metals) and covalent compounds (made by combining non-metals). They should be able to give examples of ionic and covalent compounds and to explain differences in their properties by referring to the strength of the forces between the particles. They should appreciate the difference between a molecular and a giant structure; however, they do not need to describe chemical bonding in terms of the transfer or sharing of electrons.

Materials used for construction

Candidates need to appreciate the importance of limestone in construction. They should know about its uses as a raw material and about the useful products obtained from it. They will be asked to evaluate the impact of quarrying on individuals, communities and the environment and to show an understanding of how decisions about the extraction of minerals are made.

Candidates need to know the characteristic properties of metals, ceramics and polymers and should be able to relate these to some typical uses in construction.

Metals are strong and hard and usually have high melting points. They make excellent structural materials. Metals are malleable; they can be hammered into shape and rolled into sheets. Metals have good electrical conductivity. Uses include aluminium for lightweight structures, copper for pipes and wires and lead for roofing. The properties of a metal can be modified by mixing it with another element. Examples of alloys used in construction are steel (iron and carbon), brass (copper and zinc) and solder (lead and tin).

Uses of alloys include steel structures, brass for pipe fittings and door handles and solder for electrical connections.

Ceramics are hard brittle solids with very high melting points and are resistant to chemical attack. They are used for construction and decoration (bricks and tiles), pottery products (bathroom basins and toilets) and specialist industrial materials (eg lining for furnaces and insulators on power transmission lines).

Polymers are flexible, poor conductors of heat and electricity, waterproof and resist corrosion. Most polymers have low melting points, which makes them easy to mould into shapes. They are used for electrical and thermal insulation, pipes and guttering, containers for water and other chemicals. Most polymers (examples include polyethene, polypropene, polystyrene and PVC) are manufactured using organic chemicals obtained from crude oil.

Candidates should be able to recognise and describe a composite material (eg MDF, fibreglass, reinforced concrete) and explain why the properties of the composite make it more suitable for a particular use than the separate properties of the materials.

Candidates should be able to give examples of particular materials that are used in building and construction, and to describe where they are used. They should be able to compare the uses of different materials and how their properties make them particularly suitable for these uses. They should appreciate the advantages and disadvantages of using modern materials rather than more traditional materials, such as polymers rather than wood (resistance to corrosion; no need for protection) or concrete rather than natural stone (availability and cost).

Knowledge of the structure and bonding in metals, the effects of alloying on the properties of a metal, the effects of cross-linking, altering chain length and branching chains on the properties of polymers, and the effects of firing clay is not required but candidates could be asked to predict the effect of such changes on the properties of a material when given appropriate information.

Science in the home

Candidates need to know that much of the energy transferred in homes and industry is electrical energy. Electrical energy is readily transferred as heat, light, sound and movement (eg when electrical charge flows through a resistor, electrical energy is transferred as heat).

Candidates must be able to recall that the power of an electrical appliance is measured in watts (W) or kilowatts (1kW = 1000W), and to use the formula:

power (watts) = potential difference (volts) x current (amps)

They should appreciate the use of fuses and circuit breakers as safety devices in industry and the home and should be able to suggest suitable fuses to use in conjunction with particular household appliances. They need to know that a fuse should be rated just higher than the normal operating current so that a surge in current will blow the fuse and cut off the electricity supply.

Candidates will be asked to calculate the amount of energy transferred from the mains in kilowatt-hours (kWh) or Units, using the formula:

energy transferred (kWh) = power (kW) × time (h)

and to perform calculations to compare the costs of using different electrical appliances:

total cost = number of Units × cost per Unit

Candidates need to know how heat is transferred and how heat loss can be minimised:

- The transfer of heat energy through a substance (eg metal) without the substance moving is called conduction. Some substances (eg non-metals) are poor heat conductors (insulators). They can be used to reduce heat energy loss by conduction (eg lagging).
- The transfer of heat energy by gases or liquids moving is called convection. Warm fluids rise above cool fluids because they are less dense. A fan or a pump can be used to make a gas or liquid move around more quickly.
- Hot objects emit heat energy by radiation. Shiny surfaces emit less radiation than dark, dull surfaces.

Candidates should understand that when energy is transferred some is always wasted and only part of the energy is transferred to where it is needed. They should be able to calculate the efficiency of a device by recalling and using the formula:

$$\text{Efficiency} = \frac{\text{useful energy transferred by the device}}{\text{total energy supplied to the device}}$$

Candidates must be able to explain the composition and usefulness of different types of mixtures.

- A solution is a solid, liquid or gas dissolved in a liquid (the solvent). An example is cola. They should be able to give examples of different solvents used in household products.
- A suspension is a liquid mixed with small lumps of solid that are not dissolved in the liquid (eg toothpaste).
- A gel is a liquid trapped inside a solid structure (eg hair gel).
- An emulsion consists of liquids mixed together but not dissolved (eg paint).
- A foam is a gas trapped inside bubbles of a liquid (eg shaving cream).
- An aerosol consists of very small liquid particles mixed with a gas (eg deodorant spray).

Candidates will be asked to suggest ways of investigating the properties of mixtures using experimental methods including settling, stirring, filtration, evaporation, heating to boiling and freezing.

Transport and Communication

Forces, movement and transportation

Candidates should be able to recall and use the formulae for calculating speed and acceleration and to give the correct units and appreciate when these types of calculations might be used:

$$\text{speed (m/s)} = \frac{\text{distance travelled (m)}}{\text{time (s)}}$$

$$\text{acceleration (m/s}^2\text{)} = \frac{\text{change in velocity (m/s)}}{\text{time taken for change (s)}}$$

Candidates should also appreciate that stopping a vehicle may involve many factors, including the speed and mass of the vehicle, the type and condition of road surface and the condition of the vehicle. They should also appreciate the effect of drugs, both legal and illegal, on the driver (see also the section on The body at risk, page 61).

Candidates will be asked to show understanding of how decisions about the use of technology to improve road safety are made.

Fuel for transport

Candidates will need to know that petrol and diesel are obtained from crude oil and should appreciate the problems associated with using these fuels (see also the section on Managing the Environment, page 63). They should be able to describe these fuels as hydrocarbons, recognise the pattern in their chemical formulae based on C_nH_{2n+2}. They should also be able to write balanced chemical equations for the complete combustion of hydrocarbon fuels (producing carbon dioxide and water) and recognise qualitative and quantitative patterns in the amounts of reactants and products. The incomplete combustion of hydrocarbons should also be considered in terms of further pollution products (eg soot and carbon monoxide – the toxic effect of carbon monoxide should also be considered in the section on the Body at risk), although chemical equations for incomplete combustion will **not** be required.

Candidates should be able to relate fuel usage to efficiency of mechanical systems (see also the section on efficiency in Science in the home, page 66) and to discuss energy transfers in mechanical systems.

Candidates should also be able to discuss the advantages of using alternative fuels compared with the fuels traditionally used in transport. Examples include hydrogen (less pollution) and biofuels (renewable). They will be asked to evaluate the impact of the use of fossil fuels on individuals and the environment.

Communication devices

Candidates should know the order of the electromagnetic spectrum, from radio waves (low frequency/long wavelength) to gamma rays (high frequency/short wavelength) and must be able to relate this to the energy of the waves. A mathematical treatment is **not** required.

Candidates should have an idea about the nature of electromagnetic radiation and need to be able to describe uses for electromagnetic waves in communication. They should be able to relate the uses of

each type of radiation to its properties when given information about the properties (eg total internal reflection, diffraction, penetration, danger to health). They should also appreciate the dangers associated with the use of each type of wave, and will be asked to show an understanding of how decisions about the use of communication devices are made.

The use of X-rays and gamma rays is discussed in the section on Illnesses, diseases and their diagnosis and treatment (page 61).

Candidates should know that telescopes can be used to detect electromagnetic radiation from space and that this use provides evidence for changes taking place in the universe. They should be able to appreciate the reason for 'red-shift' in light observed from distant objects and relate this to changes in the frequency of sound emitted from an object travelling away from an observer.

Candidates will be asked to show an understanding of how scientific evidence for the expanding universe is collected, and its relationship with scientific theory.

6.3 Guidance on Delivery for Unit 3

Unit 3 may be delivered discretely, although delivery will be more effective if is integrated into the overall scheme of work. The Scheme of Work (pages 76–102) suggests where the material for this unit could be integrated into the overall teaching programme.

Candidates develop their skills by carrying out some investigations based on the content of Unit 2.

The content of the unit is based on the skills needed by microbiologists, analytical chemists and materials scientists. Candidates should appreciate the vocational significance of the type of skills that they develop and use. Delivery of the unit should centre around the theme of 'the skills that particular scientists use' together with 'real-life' applications of those skills to provide the vocational context (Skill Area E of the assessment grid).

This guidance should be used in conjunction with the statements of what candidates need to be able to do and need to find out as well as the assessment criteria for the unit.

It is important that candidates appreciate the importance of carrying out risk assessments (link with Unit 1). Therefore they should be able to complete a risk assessment template for each investigation. They should be allowed access to appropriate information in order to complete the risk assessment.

Candidates need to be aware that scientists work by following standard procedures. As well as following instructions correctly, they need to be able to take appropriate action when problems arise and think about the significance of their results. Added vocational relevance could be illustrated by using standard procedures obtained from local organisations (eg hospital laboratories).

In Unit 3 candidates are required to carry out a number of practical investigations, which should be designed to allow them to:

- complete risk assessments
- use standard procedures and follow instructions
- select and use appropriate laboratory equipment and techniques
- learn skills and practise techniques in the laboratory that are used in the scientific workplace (see below for examples) and that can be used in Unit 4
- work confidently and independently
- formulate appropriate conclusions and evaluation of their work, including comparison of results with secondary sources.

Where appropriate, investigations should also allow candidates to:

- use appropriate ICT techniques to record and analyse results (eg data-logging equipment)
- calibrate an instrument – (eg pH meter, colorimeter, electrical meter) to record, analyse and present data.

The investigations, procedures and techniques used by candidates should have vocational relevance and reflect practice in the workplace.

Candidates should be given the opportunity to consider the skills and equipment used by:

- microbiologists
- analytical chemists
- materials scientists.

The skills and equipment used by microbiologists

When working with microorganisms using aseptic techniques candidates should understand the use of such equipment as Petri dishes, inoculating loops and incubators. Candidates should also be able to use microscopes skilfully when observing materials and organisms to, for example:

- investigate the effectiveness of antibiotics on bacteria
- investigate the effect of disinfectants and antiseptics on bacteria
- investigate the effectiveness of antifungal treatments on fungi (eg athlete's foot powder)
- prepare and observe a slide of onion epidermis, cheek cells, banana cells.

The skills and equipment used by analytical chemists

When using qualitative or quantitative techniques to determine the nature of substances or to determine the amount of substances present in an 'unknown', candidates should be able to use standard equipment such as pipettes, burettes, volumetric flasks and measuring cylinders. Candidates should also be able to use appropriate equipment when heating and stirring, using chromatographic techniques and carrying out flame tests, for example:

- to carry out a chemical analysis, for example of pond water
- using chromatography (eg in the investigation of dyes that can be commercially produced by growing plants)
- when analysing a fertiliser for purity using titration
- when determining the link between acid rain and fossil fuels.

The skills and equipment used by materials scientists

When measuring physical or electrical properties of various materials candidates should be able to use appropriate measuring devices such as balances, rulers, callipers, timing devices and thermometers. Candidates should also be to use and read appropriate meters in electrical circuits to, for example:

- compare the thermo conductivity of materials
- determine and compare densities of materials
- compare the strengths of different materials
- determine how current varies with voltage in different devices.

Vocational context

Activities should be set in an appropriate vocational context in order to demonstrate the vocational relevance of scientific activities and processes. Ways of doing this include:

- culturing and study of microorganisms – yeasts, moulds or bacteria – and a study of their uses in society. Examples include pathology in a hospital laboratory or public health department, the brewing industry, pests in agriculture and horticulture and development of antibiotics in the pharmaceutical industry
- carrying out qualitative chemical analysis of samples. Examples include qualitative tests of ions dissolved in de-ionised water, analysis of crushed rock samples, dissolving a sample of soil to obtain nutrients, the separation and analysis of mixtures in forensic science and the analysis of river water samples (local water companies will often provide details of accepted values)
- carrying out quantitative chemical analysis. An example would be the use of titration as an analysis technique to test for purity of economically important products such as fertilisers and foodstuffs
- a study of the thermal conductivity of materials used in the insulation of houses, clothing and cooking utensils, with clear examples detailing reasons for their use

- a study of the materials used in buildings, cars or boats. The study could include looking at metals, polymers, composites and ceramics in terms of density, strength, etc, with clear examples detailing reasons for their use
- the electrical properties of materials used in domestic appliances (eg toaster resistors or bulb filaments) or security equipment (eg sprinkler systems, fire alarms).

6.4 Examples of Suitable Activities for Unit 3

How Microbiologists Investigate Living Organisms

- The study of cheek cells, onion cells, banana cells. Integrate with Module 2 (see Scheme of Work, page 87).
- The effect of disinfectants and antiseptics on microorganisms. Integrate with Module 2 (see Scheme of Work, page 87).
- The effect of different antibiotics on microorganisms. Integrate with Module 2. (see Scheme of Work, page 87).

How Analytical Chemists Find Out About Substances

- Qualitative tests for ions. This could be set in a number of contexts (eg forensic, agricultural and environmental): see Module 7. Possibilities also exist for integration into Module 4 (see Scheme of Work, page 91).
- Investigation of acid rain using volumetric techniques. See Module 7; possibilities also exist for integration into Module 4 (see Scheme of Work, page 91).
- Determining the concentration of various vinegars or acidity of various fruit drinks as a quality control procedure. See Module 7 (Scheme of Work, page 96).

How Materials Scientists Investigate The Properties Of Materials

- Electrical properties of materials/metal wires and their uses in different situations. Integrate with Module 8 (see Scheme of Work, page 96).
- Measuring the physical properties of various materials and suggesting appropriate uses for them. Integrate with Module 6 (see Scheme of Work, page 94).

6.5 Guidance on Delivery for Unit 4

Unit 4 may be delivered discretely, although delivery will be more effective if is integrated into the overall Scheme of Work (the Scheme of Work on pages 76–102 suggests where the material from this unit could be integrated into the overall teaching programme). Candidates should receive formal teaching of the scientific principles and skills contained in the unit before being set assignments for assessment. (The skills used are based on those developed in Unit 3.) When creating suitable assignments a problem-solving approach, where appropriate, often generates the best assessment evidence.

The content of the unit is based on:

- how biologists or medical scientists monitor living organisms
- some of the processes used by chemists to make useful products
- the function of the components used when engineers make and test an electronic or electrical device
- the advantages of using machines in the workplace.

Vocational context

Assignments should be set in a vocational context in order to demonstrate the vocational relevance of scientific activities and processes.

This guidance should be used in conjunction with the statements of what candidates 'need to know and be able to do' as well as the assessment criteria for the unit.

Monitoring Living Organisms
Candidates should carry out a meaningful, extended, investigation that is monitored over a period of at least 1–2 weeks, although many investigations with living organisms may take longer.
Investigations carried out over a restricted period of time will not generally provide sufficient data for this investigation.

Experience suggests that investigations involving plants, with all the inherent problems, still provide the most reliable results with plenty of scope for analysis.

Investigations could include:

- a study of the biotic and abiotic factors affecting an organism over a period of time (eg a seedling)
- the needs of particular microorganisms and conditions under which they normally grow. Careful choice of microorganism and media will greatly reduce the chance of contamination by pathogens
- the development of a fitness programme. This programme should be of a suitable duration to allow meaningful results to be obtained.

The candidate's report should include detailed plans that explain exactly what is to be investigated and monitored and the method/approach to be used.

Making a Useful Product

The product produced should have real use that candidates can appreciate and, ideally, should be chosen to enhance the delivery of an appropriate section in Unit 2 (although this is not essential).

The type of reaction to be used is not stipulated within the specification but it should allow candidates to address all points of the assessment grid, including those involving the rate of chemical reaction.

At Stage 1 and Stage 2 candidates should have an awareness of the use of their product and be able to describe the use. At Stage 3 candidates should be able to explain an industrial application of the product and its impact on society.

The actual costs of producing the product in the laboratory could be based on prices of chemicals quoted by suppliers to schools and colleges. A consideration of other overheads involved is not expected.

Candidates working at Stage 3 are expected to be able to describe the qualitative factors that affect the rate of the reaction. They are also expected to be able to explain them at Stage 3. Candidates at this level should also be able to calculate the percentage yield of the product given the theoretical yield and using the actual mass of product obtained; at Stage 1 they are simply required to measure the mass of product obtained.

Assembling an Electronic/Electrical Device

Suitable electronic or electrical devices include:

- thermostats
- burglar alarms
- sprinkler systems
- simple control systems
- various monitoring equipment such as baby alarms.

Candidates are expected to know about the components listed below and the job that each does but they need not necessarily be able to describe how each component works. Components could include:

- transistors, integrated circuits, timers
- switches, thermistors, light-dependent resistors
- lamps, motors, heaters, buzzers, light-emitting diodes.

It is not essential that the device built in the laboratory should contain all of the components listed.

Candidates need to be able to test the device they have made. At Stage 2 and Stage 3 the tests should be performed under a range of conditions to enable effective evaluation of the device.

Using Machines

Candidates should be able to describe the use of a machine in a workplace, in terms of allowing a large force to be applied to an object by applying a smaller force. 'Machines' include levers, gears and pulleys.

The calculations at Stage 3 should be based on the example selected at Stage 1. It is therefore important that the machine chosen gives sufficient scope for candidates to carry out the relevant calculations.

6.6 Examples of Suitable Activities for Unit 4

Monitoring Living Organisms

This investigation should be carried out over a period of time (at least 1–2 weeks)

- Monitoring of a plant (eg barley, radishes) in different nutrient regimes, or monitoring microorganisms under different conditions in the production of foods and drinks. Integrate with Module 1 (see Scheme of Work, page 85).
- Monitoring of an animal, for example a human in fitness training. Integrate with Module 3 (see Scheme of Work, page 90).

Making a Useful Product

- Production of ammonium salts. Integrate with Module 5 (see Scheme of Work, page 93). Could also link with Module 3.
- Extraction of copper or lead. Integrate with Module 5 (see Scheme of Work, page 93). Could also link with Module 6.

Assembling an Electronic/Electrical Device

- Light, temperature or irrigation control, for example in a greenhouse. Integrate with Module 10 (see Scheme of Work, page 100).
- Assembling various types of alarm system. Integrate with Module 10 (see Scheme of Work, page 100).

Using Machines

- In the first instance this is a workplace activity. The laboratory activities could be based on the machine in the workplace (eg hydraulic jacks) but this is not essential. Activities based on pulleys, ramps, and gears are acceptable. Integrate with Module 9 (Scheme of Work, page 98).

7 Scheme of Work

7.1 Introduction

The AQA scheme of work for GCSE Applied Science is intended as an overview for Applied Science teachers to check and prepare their own schemes of work and lesson plans. The scheme of work is neither exhaustive nor prescriptive; it is one suggested scheme among many others available.

It is envisaged that teachers will tailor the scheme to use within their own centres, for example by adding their own preferred activities and resources. Factors that should be considered when doing this include:

- resources available in the centre
- number of teachers delivering the course
- location of centre and type of work places available in the area
- type of student on the course.

Note: There are no 'Learning Objectives' that are assessed only in the Higher Tier paper.

7.2 Teaching Modules

In this suggested scheme of work the course content is divided into 12 teaching modules. These modules form the **core** of the course and are based primarily on the examined unit (Unit 2). Those modules that link some common teaching themes from other units are expanded to show the links. The entire two-year course is covered using this approach. The **expanded core** gives details of each module.

Centres are encouraged to deliver the course as an integrated programme and not as individual units. By delivering the course in this way the assessment of the practical tasks in Unit 3 and Unit 4 may take place as part of the overall teaching programme and need not be treated as a discrete, unrelated exercise.

Centres are also encouraged to deliver the course in terms of 'What scientists do' and 'The way that they do it', together with the skills, knowledge and understanding required.

Within the tasks undertaken in Unit 3, candidates are assessed on some laboratory skills, which may be developed over a period of time. These skills are concerned with:

- producing and using risk assessments
- using standard procedures
- handling scientific equipment and materials
- recording and analysing scientific data.

It is expected that candidates will be able to use these skills when completing the investigations in Unit 4.

Centres may wish to consider an introduction to the course covering the basic requirements listed above. This may be possible at the end of Year 9 following the Key Stage 3 tests.

An alternative starting point may be considered using Module 12, thus providing a basic appreciation of health and safety aspects when working in the laboratory.

Module 12 may be delivered as part of a work experience programme at the end of Year 10 or at the beginning of Year 11.

In this scheme of work, criteria from each unit have been taken from the specification. These are listed in the 'Learning Objectives' column of the expanded core.

7.3 Teaching Plan

There are many possible routes through the course, one of which is shown in the plan below.

Using this plan it should be possible to deliver the Unit 3 portfolio material ready for submission by the second deadline date in Year 10. Unit 1 may then be submitted by the first deadline date in Year 11 and the remaining portfolio unit (Unit 4) by the second deadline date in Year 11.

Those wishing to use both examination opportunities in Year 11 for Unit 2 should consider submitting the Unit 1 portfolio later to enable more time for the delivery of Unit 2.

Year 10 Modules	**Unit**	**Notes**
Module 12 Health and Safety in Science	Unit 1	Could form an introduction to the course or be delivered in conjunction with Module 11.
Module 2 The Unhealthy Body	Unit 2/3	These modules could be delivered in any order.
Module 3 Agricultural Science	Units 2/3/(4)	
Module 6 The Science of Materials Used for Construction	Unit 2/3	
Module 7 Useful Analysis	Unit 3	
Module 8 The Effective Use of Energy in the Home	Unit 2/3	
Module 11 Investigating Science at Work	Unit 1	Could be delivered in conjunction with Module 12. At the end of Year 10 or beginning of Year 11.

Year 11 Modules	Unit	Notes
Module 1 The Healthy Body	Units 1/4/(3)	These modules could be delivered in any order.
Module 4 Using Science in Environmental Management	Unit 2/3	
Module 5 Chemical Building Blocks and Their Use in Producing Useful Products	Units 2/4	
Module 9 Using Science in Transport	Unit 2	
Module 10 Using Science in Communication and Other Electronic Devices	Units 2/4	

THE CORE			
Module	**Based on**	**Module title**	**Possible links with other units**
Module 1	Unit 2	**THE HEALTHY BODY** • Cells • Circulatory and respiratory systems • Homeostasis • Genetics and inheritance	**Unit 4 – How medical scientists monitor living organisms to eg monitor the performance of a person in a mental or physical activity.** **Candidates need to be able to:** • monitor an organism for a particular purpose • produce a plan for the investigation • carry out the investigation, recording relevant data • analyse the results and explain what they show • evaluate the investigation • describe a useful application of the investigation.
Module 2	Unit 2	**THE UNHEALTHY BODY** • Disease and illness • Prevention of illness and disease • Diagnosis and treatment • The body at risk	**Unit 3 – How microbiologists investigate living organisms.** **Candidates need to be able to:** • set up a light microscope ready to use, choosing a suitable objective lens for the task • prepare samples for an investigation, including making a temporary slide and using a staining technique. **Candidates need to:** • understand the importance of aseptic techniques and be able to use these techniques to culture microorganisms and dispose of them safely • investigate the effects of antimicrobial agents on microorganisms **or** set up a culture that will produce a useful product, such as a food substance.

Module	Based on	Module title	Possible links with other units
Module 3	Unit 2	**AGRICULTURAL SCIENCE** • Agriculture and farming • Selective breeding and genetic engineering	**Unit 3 – How microbiologists investigate living organisms.** **Candidates need to:** • understand the importance of aseptic techniques and be able to use these techniques to culture microorganisms and dispose of them safely • investigate the effects of antimicrobial agents on microorganisms **or** set up a culture that will produce a useful product, such as a food substance. **Unit 4 – How biologists monitor living organisms to, eg, improve the yield of plants or microorganisms.** **Candidates need to be able to:** • monitor an organism for a particular purpose • produce a plan for the investigation • carry out the investigation, recording relevant data • analyse the results and explain what they show • evaluate the investigation • describe a useful application of the investigation.
Module 4	Unit 2	**USING SCIENCE IN ENVIRONMENTAL MANAGEMENT** • Extraction of resources • Energy resources • The Earth and environmental management	

Module	Based on	Module title	Possible links with other units
Module 5	Unit 2	**CHEMICAL BUILDING BLOCKS AND THEIR USE IN PRODUCING USEFUL PRODUCTS** • Atoms, molecules and ions • Chemical symbols • Chemical bonding • Useful mixtures in the home	**Unit 4 – How chemists make new useful products.** **Candidates need to be able to:** • describe the factors that affect how quickly a reaction occurs • explain the terms actual yield, theoretical yield and percentage yield • prepare a pure, dry product using a named type of chemical reaction • explain the underlying chemistry involved in the reaction • explain the use of the product and industrial importance of the reaction • know the type of reaction used • measure the actual yield of the product • present the product in a suitable sample tube, with its name, date of preparation and relevant hazard warnings • write a balanced chemical equation to describe the reactions, given the formulae of reactants and products • calculate the mass of product that could be obtained from a specified amount of reactant (theoretical yield) • calculate the percentage yield of a reaction from the theoretical yield and actual mass of product obtained • calculate the costs of making a given amount of product.

Module	Based on	Module title	Possible links with other units
Module 6	Unit 2	**THE SCIENCE OF MATERIALS USED FOR CONSTRUCTION** • Limestone • Metals • Other materials (polymers, ceramics, composites)	**Unit 3 – How materials scientists investigate the properties of materials.** **Candidates need to compare:** • the thermal conductivities of a range of materials • the densities of a range of materials • the strengths of materials of different size, shape and composition.
Module 7	Unit 3	**USEFUL ANALYSIS** • Qualitative analysis • Quantitative analysis	
Module 8	Unit 2	**THE EFFECTIVE USE OF ENERGY IN THE HOME** • Using energy • Using energy efficiently	**Unit 3 – How materials scientists investigate the properties of materials.** **Candidates need to investigate how:** • the nature, length and thickness of materials influence electrical resistance • current varies with voltage in a range of devices.

Module	Based on	Module title	Possible links with other units
Module 9	Unit 2	**USING SCIENCE IN TRANSPORT** • Forces, movement and transportation • Fuel for transport	**Unit 4 – The advantages of using machines in the workplace.** **Candidates need to be able to:** • identify a mechanical machine used in the workplace and explain how it works, and be able to: – measure the applied force and the force produced by the machine – calculate the amount by which the machine multiplies force – calculate the work done by the machine and its efficiency – describe the advantages and disadvantages of friction in machines.
Module 10	Unit 2	**USING SCIENCE IN COMMUNICATION AND OTHER ELECTRONIC DEVICES** • Communication devices	**Unit 4 – The function of components in devices that electronic/electrical engineers make and test.** **Candidates need to be able to:** • assemble and assess the effectiveness of **one** electrical or electronic device by: – selecting the components needed – safely assembling them to build the device – testing the assembled device under conditions of normal use – evaluating the performance of the device and commenting on its fitness for purpose • describe the function of the electrical or electronic device that they have made • explain the functions of the following components in the electrical or electronic device: – power source – processor – input components – output components.

Module	Based on	Module title	Possible links with other units
Module 11	Unit 1	**INVESTIGATING SCIENCE AT WORK** • Investigating scientific workplaces	
Module 12	Unit 1	**HEALTH AND SAFETY IN SCIENCE** • Investigating health and safety in scientific workplaces • Hazards and risks • First aid • Fire prevention	

THE EXPANDED CORE	
MODULE 1: THE HEALTHY BODY	
Topic	Learning Objectives
Cells	**Candidates need to be able to:** • describe living organisms as being made up of chemical compounds, and the cell as the common feature of all organisms • describe the main features of animal cells (nucleus, cytoplasm, cell membrane) • explain how substances enter and leave cells by diffusion and osmosis • describe how the process of respiration releases energy (glucose + oxygen → carbon dioxide + water) • describe the differences in the structures of some cells that enable them to carry out their functions (red blood cells, white blood cells, nerve cells).
Circulatory and respiratory systems	**Candidates need to be able to:** • describe the structure of the human circulatory system, including the function of the heart (a pump) and the composition and function of the blood (red blood cells, white blood cells, platelets, plasma) • describe the structure of the thorax (trachea, lungs, intercostal muscles, ribs, diaphragm, diaphragm muscles) • explain how ventilation of the lungs occurs and understand the pressure changes involved.

Topic	Learning Objectives
Homeostasis	**Candidates need to be able to:** • explain how the body maintains a constant temperature (by sweating and changing the diameter of capillaries) • describe how chemical substances called hormones control many processes within the body. Hormones are secreted by glands and are transported to their target organs in the bloodstream • explain how the hormone insulin controls blood glucose levels (production by the pancreas, conversion of glucose to glycogen by the liver) • describe how cells called receptors detect stimuli (changes in the environment) • give examples of receptor cells that detect stimuli (light, sound, smell, taste, touch) • describe how information from receptors passes along cells (neurones) to the brain • describe how an impulse is sent along a neurone to the effector (muscle or gland) that brings about the response (contraction or release of a chemical).
Genetics and inheritance	**Candidates need to know:** • that the nucleus of a cell contains chromosomes • that chromosomes carry genes that control the characteristics of the body • that genes have different forms called alleles, which produce different characteristics • the mechanism of monohybrid inheritance where there are dominant and recessive alleles. **Candidates need to be able to:** • explain that differences in the characteristics of individuals may be due to genetic causes or environmental causes or a combination of both. **Candidates should be able to use data, theories and explanations to:** • evaluate the use of current research in the treatment of genetic disorders.

MODULE 2: THE UNHEALTHY BODY	
Topic	**Learning Objectives**
Disease and illness	**Candidates need to know:** • that bacteria and viruses make us feel ill when they reproduce rapidly in the body (cell damage and production of toxins) • that diseases are likely to occur if large numbers of pathogens enter the body as a result of unhygienic conditions or contact with infected people. **Candidates need to be able to:** • name some examples of diseases caused by microorganisms (measles, mumps, rubella, tuberculosis) • describe how platelets help to form a barrier to infection through a cut • describe how white blood cells help to defend against pathogens.
Prevention of illness and disease	**Candidates need to be able to:** • give examples of a range of methods of protecting against infection by harmful microorganisms – personal hygiene (washing hands, protective clothing) – sterilisation (gamma rays, high temperature) – disinfectants (chemicals used on surfaces) – antiseptics (chemicals used on skin) • explain how vaccination protects humans from infection by specific microorganisms (MMR, TB, polio). **Candidates should be able to use data, theories and explanations to:** • evaluate the advantages and disadvantages of being vaccinated against a particular disease • explain how the occurrence of some diseases has changed as a result of increased use of vaccinations.

Topic	Learning Objectives
Diagnosis and treatment	**Candidates need to know:** • the characteristic properties of X-rays (penetration) that enable them to be used to diagnose medical disorders • the characteristics and properties of the three main types of nuclear radiation emitted by radioactive sources (alpha particles, beta particles and gamma rays) • the uses of high-energy radiation and the dangers associated with its use.

Topic	Learning Objectives
The body at risk	**Candidates need to know:** • that certain foods are considered healthy (fresh fruit and vegetables) and an excess of others is considered unhealthy (saturated fat, salt, sugar) • that disease may be treated with medicines that contain useful drugs (eg penicillin is an antibiotic, aspirin is anti-inflammatory) • that some medicines, including painkillers, help to relieve the symptoms of disease, but do not kill the pathogens (eg aspirin, paracetamol) • that some bacteria, but not viruses, may be killed by antibiotics • that some bacteria develop resistance to, or may not be easily treated by, antibiotics (eg MRSA) • examples of recreational drugs that may harm the body (alcohol, nicotine, antidepressants, amphetamines, barbiturates, heroin, cocaine) • that some people may become dependent on or addicted to recreational drugs because they change some of the chemical processes in the body, and these people suffer withdrawal symptoms without them (eg nicotine in tobacco) • that tobacco smoke contains substances that cause diseases of the respiratory and circulatory systems • that tobacco smoke also contains carbon monoxide, which reduces the oxygen-carrying capacity of the blood • that alcohol affects the nervous system by slowing down reactions (loss of self-control and long-term damage to the liver and brain). **Candidates should be able to use data, theories and explanations to:** • compare the impact of legal (alcohol and tobacco) and illegal drugs on the body • explain the link between smoking and respiratory and circulatory diseases. **Candidates should be able to assess the implications of science when:** • considering the issues of testing new drugs.

MODULE 3: AGRICULTURAL SCIENCE

Topic	Learning Objectives
Agriculture and farming	**Candidates need to be able to:** • describe the differences in the structures of some plant cells that enable them to carry out their function (leaf cell, root hair cell) • describe the similarities and differences between animal and plant cells (chloroplasts, cell wall, large vacuole) • describe how intensive farming increases crop yields by using artificial fertilisers, pesticides, herbicides and fungicides, and increases meat production by using controlled environments • describe how organic farming uses the alternative methods of natural fertilisers, natural pesticides and mechanical methods of eliminating weeds in crop production and keeps animals under more natural conditions • identify useful products that can be made from living things and name the organism used to produce a particular product • describe the use of bacteria, yeast and other fungi in food and medicine production (bread, beer, wine, cheese, yoghurt) and antibiotics (eg penicillin). **Candidates need to understand:** • how plants make food by photosynthesis and how the rate of photosynthesis may be changed in horticulture in commercial glass houses (carbon dioxide + water → glucose + oxygen) • why plants need, among other things, the minerals (nitrate, phosphate, potassium and magnesium) which they obtain from soil for healthy growth. **Candidates need to know:** • that nitrates are required for proteins, which are needed for cell growth, and that magnesium is required for chlorophyll. **Candidates should be able to assess the applications and implications of science when:** • comparing the advantages and disadvantages of both types of farming. **Candidates should be able to use data, theories and explanations to:** • evaluate the effect on the environment of the continued use of artificial fertilisers, pesticides, herbicides and fungicides, and the effect of other factors associated with intensive farming (eg field size, monoculture).

Topic	Learning Objectives
Selective breeding and genetic engineering	**Candidates need to be able to:** • explain that selective breeding involves selecting the parents with desired traits, crossing them, selecting from their offspring, and then repeating the process over several generations • explain that genetic engineering involves the transfer of 'foreign' genes into the cells of animals or plants at an early stage in their development so that they develop with desired characteristics. **Candidates should be able to assess the applications and implications of science when:** • making informed judgements about the economic, social and ethical issues concerning cloning and genetic engineering and suggest possible long-term evolutionary problems, eg seedless fruits.

MODULE 4: USING SCIENCE IN ENVIRONMENTAL MANAGEMENT

Topic	Learning Objectives
Extraction of resources	**Candidates need to be able to:** • classify materials as elements, compounds or mixtures • give examples of substances used straight from the ground (gold, sulfur, limestone and marble) • describe how some substances are separated before use (salt from rock salt, fractional distillation of crude oil) • give examples of reducing agents for the extraction of metals (carbon and carbon monoxide) • describe how a metal may be made from its oxide by reduction (iron from iron oxide and lead from lead oxide). **Candidates should be able to assess the applications and implications of science when:** • considering and evaluating the social, economic and environmental impacts of exploiting metal ores.

Topic	Learning Objectives
Energy resources	**Candidates need to:** • know that fossil fuels (natural gas, oil, coal) are useful energy resources • appreciate the problems of burning fossil fuels (global warming and its effect on climate, limited deposits) • know that nuclear fuels and renewable energy resources (wind, solar, hydroelectric, wave, tidal) may be used as alternatives to fossil fuels • appreciate the problems of using nuclear fuels (problems of radioactive emissions, disposal of waste) and of using renewable sources (unreliability and possible effects on the environment) **Candidates need to know:** • how electricity is generated from the burning of fossil fuels.
The Earth and environmental management	**Candidates need to know:** • that changes in the Earth's atmosphere were originally produced from gases escaping from the Earth's interior and that gases were changed by the emergence of green plants. **Candidates need to be able to use data to:** • explain the position of the Earth in the solar system. **Candidates should be able to assess the applications and implications of science when:** • evaluating the effects of human activity on the Earth based on environmental measurements • evaluating changes to the composition of water and air as a consequence of industrial and geological activity • evaluating the environmental effects over time of pollution and waste disposal • evaluating the environmental impact over time of energy production and comparing the advantages and disadvantages of using alternative energy sources.

MODULE 5: CHEMICAL BUILDING BLOCKS AND THEIR USE IN PRODUCING USEFUL PRODUCTS	
Topic	Learning Objectives
Atoms, molecules and ions	**Candidates need to be able to:** • describe the structure of the atom in terms of numbers of protons, neutrons and electrons • explain the difference between atoms, molecules and ions. **Candidates need to know:** • that atoms of a particular element have the same number of protons (atomic number).
Chemical symbols	**Candidates need to know:** • the chemical symbols for the elements listed in Appendix D (specification pages 92–93) • the chemical formulae for the simple molecules listed in Appendix D (specification pages 92–93). **Candidates need to be able to:** • write symbol equations for the chemical reactions in the unit (eg extraction of metals from ores, combustion of hydrocarbons, chemicals from limestone). **Candidates should be able to use data to:** • write the chemical formulae of some simple ionic compounds.
Chemical bonding	**Candidates need to know:** • the characteristic properties of metals and non-metals (electrical conductivity, density, melting point, appearance). **Candidates need to be able to:** • explain that compounds with small molecules (covalent bonding) have low boiling points (water, methane, carbon dioxide) • explain that compounds with ionic bonding (eg sodium chloride) or giant molecules (eg silica) have high melting points and boiling points. **Candidates should be able to use data and theories to:** • explain the differences in the physical properties of compounds in terms of the types of forces of attraction between the particles in the structure.

Topic	Learning Objectives
Useful mixtures in the home	**Candidates need to be able to:** • describe the composition of a solution, suspension, gel, emulsion, foam and aerosol • give an example of each type of mixture and explain why its composition makes it useful • know examples of solvents other than water, eg organic solvents used in paints, and ethanol used in cosmetics and toiletries • explain the changes that occur when some mixtures are left undisturbed or are left open to the atmosphere (settling of suspension, escape of gas from solution, evaporation of solvent, separation of emulsion).

MODULE 6: THE SCIENCE OF MATERIALS USED FOR CONSTRUCTION

Topic	Learning Objectives
Limestone	**Candidates need to know:** • the chemical formulae of limestone, calcium oxide and calcium hydroxide • the meanings of the terms endothermic reaction and exothermic reaction. **Candidates need to be able to:** • give some uses of limestone in the building industry • describe the conversion of limestone into quicklime and quicklime into slaked lime • outline the manufacturing processes for the production of quicklime, cement and glass • describe the composition and use of mortar and concrete. **Candidates should be able to use data, theories and explanations to:** • evaluate the environmental, social and economic effects of producing building materials from limestone.

Topic	Learning Objectives
Metals	**Candidates need to know:** • the characteristic properties of metals (eg electrical conductivity, malleability and hardness) and be able to relate them to their uses. **Candidates need to be able to:** • give examples of metals (copper, lead, aluminium) and metal alloys (steel, brass, solder) used in construction • describe some uses of metals in the building industry.
Other materials (polymers, ceramics, composites)	**Candidates need to know:** • the characteristic properties of polymers (eg flexibility, behaviour on heating, poor conductors of heat and electricity) and be able to relate their properties to their uses • the characteristic properties of ceramics (eg brittle, high melting point) and be able to relate their properties to their uses. **Candidates need to be able to:** • classify materials as metals, polymers, ceramics and composites • describe the uses of these materials in the building industry and their advantages and disadvantages over naturally occurring materials • explain the properties of composites in terms of the properties of their components and be able to relate their properties to their uses. **Candidates should be able use data to:** • find the physical properties of materials. **Candidates should be able to use data, theories and explanations to:** • select materials for making a particular product given a specification for the product • evaluate the developments in modern building materials, and their advantages and disadvantages compared with traditional materials.

MODULE 7: USEFUL ANALYSIS	
Topic	**Learning Objectives**
Qualitative analysis	**Candidates need to be able to:** • carry out qualitative chemical tests for eg Na^+, K^+, Ca^{2+}, Cu^{2+}, Pb^{2+}, Fe^{2+}, Cl^-, SO_4^{2-}, CO_3^{2-} ions using reagents and/or flame tests • draw appropriate conclusions from their results.
Quantitative analysis	**Candidates need to be able to:** • prepare solutions of specified concentrations using the units g/dm^3 and mol/dm^3 • carry out titrations • carry out calculations to determine the concentration of a substance in solution.

MODULE 8: THE EFFECTIVE USE OF ENERGY IN THE HOME	
Topic	**Learning Objectives**
Using energy	**Candidates need to be able to:** • explain why an appropriate source of energy is selected for a particular task (natural gas, oil, mains electricity, batteries) • recall and use the formula: power (watt) = voltage (volt) × current (ampere) to calculate the power of an electrical circuit • calculate the current through an appliance from its power and the potential difference of the supply, and from this determine the size of the fuse needed for the appliance • describe the use of fuses and circuit breakers to protect the users of faulty electrical appliances • carry out simple calculations using the formula: $\text{power} = \frac{\text{energy}}{\text{time}}$ to calculate power in watts (W) and to calculate the energy usage in kilowatt-hour (kWh) for electrical appliances • calculate the costs of using different electrical appliances using the formula: total cost = number of kilowatt-hours × cost per kilowatt-hour.

Topic	Learning Objectives
Using energy efficiently	**Candidates need to know:** • the advantages to the user, and to society, of making and using devices with high efficiency, by considering the benefits of low energy lamps compared with filament lamps • the meaning of the term *efficiency* when applied to simple energy transfers in electrical appliances. **Candidates need to be able to:** • describe how heat is transferred by conduction, convection and radiation • explain how to minimise heat loss in the home • calculate the percentage efficiency of a device using the formula: $\% \text{ efficiency} = \frac{\text{useful energy transferred by the device}}{\text{total energy supplied to the device}} \times 100$ **Candidates should be able to use data, theories and explanations to:** • evaluate the effectiveness and cost-effectiveness of methods used to reduce domestic energy consumption.

MODULE 9: USING SCIENCE IN TRANSPORT

Topic	Learning Objectives
Forces, movement and transportation	**Candidates need to be able to:** • recall and use the formula: speed (m/s) = distance travelled (m) / time (s) to calculate the speed, distance travelled, or journey time, for a vehicle moving with a steady speed in a straight line • recall and use the formula: acceleration (m/s^2) = change in velocity (m/s) / time taken for change (s) for vehicles moving in a straight line with a steady acceleration. • describe how the stopping distance of a vehicle depends on: – the distance the vehicle travels during the driver's reaction time – the distance the vehicle travels under braking force • explain how the overall stopping distance is affected by: – the speed of the vehicle – the type of road surface – the driver's reaction time – the weather conditions (eg wet / icy roads, poor visibility) – the condition of the vehicle's brakes and tyres – how heavily loaded the vehicle is • appreciate that tiredness, drugs and alcohol may affect a driver's reaction time • describe how transport safety can be improved by providing information and carrying out tests on vehicles and drivers. **Candidates should be able to use data, theories and explanations to:** • evaluate the impact of environmental factors, improvements in technology and changes in rules and regulations on transport safety.

Topic	Learning Objectives
Fuel for transport	**Candidates need to know:** • that petrol and diesel are fuels obtained from crude oil • that the compounds in crude oil consist of molecules made up of hydrogen and carbon atoms only (hydrocarbons) • the meaning of the term *efficiency* when applied to energy transfers in mechanical systems • the advantages of developing the use of alternative fuels (eg hydrogen, gasohol) to replace fossil fuels used for transport. **Candidates need to be able to:** • describe how, in processes of energy transfer, energy is conserved but tends to spread out and become less useful • write symbol equations for the combustion of hydrocarbon fuels and explain the patterns in the equations • explain how incomplete combustion results in lower energy output and the formation of toxic combustion products (carbon monoxide and soot). **Candidates should be able to use data, theories and explanations to:** • evaluate the social, economic and environmental impacts of the uses of fuels for transport • compare the energy content of different fuels • evaluate developments in the production and use of better fuels.

MODULE 10: USING SCIENCE IN COMMUNICATION AND OTHER ELECTRONIC DEVICES

Topic	Learning Objectives
Communication devices	**Candidates need to know:** • that electromagnetic radiation travels as waves and moves energy from one place to another • that the number of waves per second produced by a source is called the frequency and is measured in hertz (Hz) • that the higher the frequency of the wave, the higher the energy of the wave • the different types of waves that make up the electromagnetic spectrum (gamma rays, X-rays, ultraviolet, visible light, infrared, microwaves, radio waves). **Candidates need to be able to:** • describe the uses of different types of waves in communication devices: – radio waves – TV and radio – microwaves – mobile phones – infrared – remote control for TV and DVD players – visible light – fibreoptic cables • describe the change in frequency when a wave source is moved away from an observer • describe the evidence for the expanding universe provided by observations using telescopes. **Candidates should be able to use data, theories and explanations to:** • explain how the uses of different types of waves depend on their properties. **Candidates should be able to assess the applications and implications of science when:** • evaluating the social and environmental impact of the use of communication devices • evaluating the possible hazards associated with the use of different types of electromagnetic radiation.

MODULE 11: INVESTIGATING SCIENCE AT WORK	
Topic	**Learning Objectives**
Investigating scientific workplaces	**Candidates need to:** • identify local, national and international businesses and service providers that use science • identify and describe the types of scientific activity that are carried out • describe the importance of the activity to society or the community • find out where organisations are located and why • put the employees into one of three classes: major; significant; and small users of science • identify the job titles and qualifications of the people who perform them • find out what skills are used by the people employed • find out what skills scientists need in addition to their qualifications • find out what careers are available in science and science-related areas.

MODULE 12: HEALTH AND SAFETY IN SCIENCE	
Topic	**Learning Objectives**
Investigating health and safety in scientific workplaces	**Candidates need to find out about:** • health and safety checks in the workplace • risk assessments for activities performed in the workplace • what can be done to prevent accidents from hazards in a scientific workplace • emergency procedures to be followed if an accident from these hazards happens.

Topic	Learning Objectives
Hazards and risks	**Candidates need to be able to:** • identify hazard warning signs • identify biological, chemical and physical hazards, including radioactive substances, and their associated risks • follow health and safety procedures • understand the use of risk assessments. **Candidates need to find out:** • about the safety measures employed for handling radioactive materials and the procedures adopted to ensure that people who work with radioactive materials are not exposed to unacceptable risk • about how unwanted or waste materials, including radioactive substances, are disposed of safely.
First aid – heat burns and scalds – chemical burns – breathing in fumes – swallowing chemicals – electric shock – cuts – damage to eyes by particles or chemicals	**For each of these injuries, candidates need to know:** • the basic first aid to give • the situations in which it would be dangerous to give first aid. **Candidates need to find out:** • why it is useful to have a first aid qualification • the names of organisations that give training for first aid qualifications and how to contact these organisations.
Fire prevention	**Candidates need to know:** • what must be done if they hear a fire alarm or smoke alarm • what must be done if they find a fire • how fire doors function • why different types of fire extinguisher (water, carbon dioxide, dry powder, foam, a fire-blanket) are used on different types of fire • about the use of automatic sprinkler systems.

8 Resources

8.1 Introduction

Many of the main science educational publishers are producing materials that are well matched to the new GCSE Applied Science specifications. A general list of publishers may be of help in helping teachers to choose textbooks and other materials to support their teaching.

Many of the resources that were available for the original specification will still be valuable resources for the new specification.

8.2 Publishers of Textbooks/ Resources

Nelson Thornes

AQA is working in partnership with Nelson Thornes, who are producing a range of teaching materials to support the new AQA GCSE Applied Science course:

- Students' book
  ISBN 0748796576
- Teacher's book
  ISBN 0748796584
- Revision guide
  ISBN 0748783202
- e-science
  ISBN 0748796592
- Test & Assessment
  ISBN 0748796614

http://www.nelsonthornes.com

Folens

Applied Science GCSE (Double Award)

- Students' book
  ISBN 1843039710
- Teachers' support pack (including Teachers' Guide, CD-ROM and site license)
  ISBN 1843039739

Completely revised and updated to meet the new content and assessment requirement of the new GCSE Applied Science specification. The students' book covers AQA and OCR specifications. The teacher support material is split into separate packs that are specific to the exam boards. Teachers should note that the worksheets provided are good resources for C/D candidates but that A/B candidates need to work in a more unstructured way.

http://www.folens.com

Heinemann

GCSE in Applied Science for OCR

- Student book and CD-ROM
  ISBN 0435470914
- Teacher CD-ROM pack
  ISBN 0435470906

The Heinemann course is designed to support only the OCR course. It is designed to make the Applied Science accessible and challenging to students of all levels. In addition, material is provided to support the implementation of the course.

http://www.heinemann.co.uk

Hodder and Stoughton

AQA GCSE Applied Science

- Student's book
  ISBN 0340907142
- Teacher's Guide with CD-ROM
  ISBN 0340914378
- Interactive Presentations CD-ROM
  ISBN 0340914386
- Interactive Assessment
- Worksheets CD-ROM
  ISBN 0340914394
- Coursework & Revision Book
  ISBN 0340914408

http://www.hoddereducation.co.uk

4Science

Awarding body specific materials:

- Course guide for teachers
- A revision guide
- Science guide for students

http://www.4Science.org.uk

8.3 Websites

This section lists a variety of websites that contain resources for GCSE Science – not necessarily specifically Applied Science. The list is far from exhaustive. Many of the websites listed are directed at the previous Applied Science GCSE (3861), but much of the material will be of use in teaching the new specification.

AQA does not endorse or approve the content and reliability of any of the publications and websites listed below, but teachers and candidates may find them a useful starting point for information. The material available on the websites listed has not been vetted by AQA and will inevitably change over time. Teachers are therefore advised to carry out their own research and selection.

Teachers should note that there may be a cost element involved in accessing data from some websites.

Association of the British Pharmaceutical Industry

http://www.abpischools.org.uk

Resources to support science in schools.

AVP

http://www.avp.co.uk

Educational software site. Many science-based CD-ROMs, offering specific titles in science with suitability level and prices. Very comprehensive site for the number of titles available. Not specifically Applied Science resources.

BBC Education

http://www.bbc.co.uk/learning

Includes GCSE and A level revision. Links to other parts of the BBC website on current topics.

John Beeby

http://www.beeby-education.co.uk

Dedicated resource for GCSE Applied Science.

The Biotechnology and Biological Sciences Research Council

http://www.bbsrc.ac.uk

Downloadable discussion documents on a number of current topics.

Boots Learning Store

http://www.bootslearningstore.com

Useful resources for a number of topics in biology.

British Educational Suppliers Association

http://www.besanet.org.uk

Lists member companies, together with links to their website addresses. The member companies produce training and education materials for many subjects, including science. Can be used as a launch pad to find other sites, contacts and sources.

British Nuclear Fuels

http://www.bnfleducation.com

Series of resources in print and on CD-ROM on a number of science topics.

BSI Education

http://www.bsieducation.org/Education/default.php

The section on Applied Science includes detailed assignments that can help in teaching the specification.

CATIE for Schools

http://www.catie.org.uk

Website sponsored by the Cosmetic, Toiletries and Perfumery Association. Good resource for key stages 3 and 4.

Channel 4

http://www.channel4.com/learning

The Channel 4 education site. Provides resources for all key stages. Includes a homework help section.

The Charis Project

http://www.stapleford-centre.org

Produces resources, with photocopiable sheets, to help develop the spiritual, moral, social and cultural aspects of the National Curriculum.

Chemical Industry Education Centre

http://www.uyseg.org

Joint initiative of the University of York and the Chemical Industries Association. Large numbers of links and resources for both students and teachers.

ChemSoc

http://www.chemsoc.org

The Royal Society of Chemistry's chemical science network. Contains a large number of resources to support teaching of Applied Science.

Crocodile Clips

http://www.crocodile-clips.com

Educational software for schools and colleges. Topics on physics, chemistry and technology.

Department of Health

http://www.doh.gov.uk

Statistical information and publications on a large range of health topics.

How Stuff Works

http://www.howstuffworks.com

Useful information about materials and inventions. Fun for homework/projects etc.

ICI

http://www.ici.com/ICIPLC/ici-schools/index.com

Section of ICI's website dedicated to providing information to teachers about resources and initiatives from the ICI group.

Kapili

http://www.kapili.com

Focuses on topics from science, technology and maths. Includes tutorials and activities.

Learning and Skills Development Agency (LSDA)

http://www.vocationallearning.org.uk

Provides resources, materials, publications and information from the Vocational Learning Support Programme, with help for practitioners and learners.

Medical Research Council

http://www.mrc.ac.uk

Contains articles on a number of topical issues, and a section on Schools initiatives.

National Centre for Biotechnology Education

http://www.ncbe.reading.ac.uk

A range of downloadable resources for practical biotechnology.

Nuffield Curriculum Centre

http://www.nuffieldcurriculumcentre.org

Offers a range of resources for Applied Science, including videos of case studies. Supported by the Nuffield Foundation.

Oldham Sixth Form College

http://sixthsense.osfc.ac.uk/

Contains useful worksheets and video clips aimed at various parts of the course.

REM

http://www.r-e-m.co.uk

An educational software supplier with a comprehensive list of titles. There is a page for each item covering the content and giving the National Curriculum level at which it is aimed.

4Science

http://www.4science.org.uk

Supports education and training in science, engineering and technology.

Science, Engineering, Manufacturing Technologies Alliance (SEMTA)

http://www.semta.org.uk

Works with education and employers to increase the awareness of applied subjects. Its website contains news, case studies, careers information and training frameworks withing the science, engineering and manufacturing sectors.

SEMTA has a separate website dedicated to Applied Science:

http://www.gcseinappliedscience.com

This contains a database of selected support and guidance materials currently available. Also has sections designed for teaching staff, students, parents and employers.

Sciencenet

www.sciencenet.org.uk

Information specific to National Curriculum key stages 2–4 Science. Demonstrations, animations, activities, news, games.

Specialist Schools and Academies Trust

Vocational learning homepage:

http://www.ssatrust.org.uk/vocationallearning/default.aspa

Offers a range of resources, case studies and links to support vocational learning. There is a particular focus on GCSEs in vocational subjects. Specific links for GCSE Applied Science lead to case studies and resources.

Viewtech Education Media

http://www.viewtech.co.uk

Supplier of educational and training material on DVD, CD-ROM and video.

WebElements

http://www.webelements.com

The periodic table on the internet.

A

Optional Progress Record Forms

Unit 1: Science in the Workplace

Investigating How Science is Used		Working Safely in Science		Research and Communication	
Criterion	**Notes**	**Criterion**	**Notes**	**Criterion**	**Notes**
1A.1		**1B.1**		**1C.1**	
1A.2					
1A.3		**2B.1**		**2C.1**	
2A.1					
2A.2		**3B.1**		**3C.1**	
2A.3					
2A.4			(Max. 11)		(Max. 3)
2A.5					
3A.1					
3A.2					
3A.3					
3A.4					
3A.5					
	(Max. 11)				

Unit 3: Developing Scientific Skills

Criterion	Investigating Living Organisms	Using Chemical Analysis Techniques	Investigating properties of Materials	Best mark for skill area
A: Planning and Following Instructions				
1A.1				
1A.2				
2A.1				
2A.2				
2A.3				
3A.1				
3A.2				
3A.3				
Mark	(Max. 12)	(Max. 12)	(Max. 12)	
B: Obtaining Evidence by Experimenting				
1B.1				
1B.2				
2B.1				
2B.2				
2B.3				
3B.1				
3B.2				
3B.3				
Mark	(Max. 12)	(Max. 12)	(Max. 12)	
C: Analysing and Considering Evidence				
1C.1				
1C.2				
2C.1				
2C.2				
2C.3				
3C.1				
3C.2				
3C.3				
Mark	(Max. 12)	(Max. 12)	(Max. 12)	
D: Evaluating Evidence				
1D.1				
2D.1				
2D.2				
3D.1				
3D.2				
Mark	(Max. 7)	(Max. 7)	(Max. 7)	
E: Vocational Application				
1E.1				
2E.1				
3E.1				
3E.2				
Mark	(Max. 7)	(Max. 7)	(Max. 7)	

Unit 4: Science at Work

Criterion	Notes	Criterion	Notes	Criterion	Notes
A: Monitoring Living Organisms					
1A.1		**2A.1**		**3A.1**	
1A.2		**2A.2**		**3A.1**	
1A.3		**2A.3**		**3A.2**	
1A.4		**2A.4**		**3A.3**	
1A.5		**2A.5**		**3A.4**	
1A.6		**2A.6**		**3A.5**	
				Mark for Investigation:	(Max. 17)
B: Making a Useful Product					
1B.1		**2B.1**		**3B.1**	
1B.2		**2B.2**		**3B.2**	
1B.3		**2B.3**		**3B.3**	
1B.4		**2B.4**		**3B.4**	
1B.6		**2B.5**		**3B.5**	
		2B.6		**3B.6**	
				Mark for Investigation:	(Max. 17)
C: Assembling an Electronic/Electrical Device					
1C.1		**2C.1**		**3C.1**	
1C.2		**2C.2**		**3C.2**	
		2C.3		**3C.3**	
		2C.4			
				Mark for Investigation:	(Max. 9)
D: Using machines					
1D.1		**2D.1**		**3D.1**	
		2D.2		**3D.2**	
				Mark for Investigation:	(Max. 7)