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ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Secondary Education

Applied Science (Double Award) 4861 2010

Special Features

- Clear statements about what candidates need to learn and do
- one assessment per unit

Material accompanying this Specification

- Specimen Papers and Mark Schemes
- Teachers' Guide

SPECIFICATION

This specification will be published annually on the AQA Website (www.aqa.org.uk). If there are any changes to the specification centres will be notified in print as well as on the Website. The version on the Website is the definitive version of the specification.

Further copies of this specification booklet are available from:

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Background Information

1 Revision of GCSE Sciences – An Outcome of the DfES 14–19 Strategy

Following the publication of the DfES '14–19: Opportunity and Excellence' policy document, changes to the key stage 4 National Curriculum for England have been announced. One change is a new programme of study for KS4 Science (published autumn 2004), and the consequent rewriting by QCA of the GCSE Criteria for Science. Further details of this are given in Section 1.1. Another change relevant to GCSE Science is a requirement to provide work-related learning for all students. This is described in the QCA document 'Changes to the key stage 4 curriculum – guidance for implementation from September 2004', and is discussed in Section 1.2. These changes have together necessitated the redevelopment of GCSE Science specifications by all awarding bodies for first teaching from September 2006.

1.1 Changes to the GCSE Criteria for Science

The new programme of study has been incorporated by QCA into the GCSE Criteria for Science. The revised Criteria outline the common characteristics and subject content for science GCSEs developed by all awarding bodies for first teaching from September 2006. The main points are as follows.

- There is a greater emphasis than before on the knowledge, skills and understanding of how science works in the world at large as well as in the laboratory.
- As a consequence there is an equal emphasis on knowing and understanding a body of scientific facts.
- There is a new single award GCSE Science incorporating all of the content in the programme of study.
- There is a new single award GCSE Additional Science, which, together with GCSE Science, allows progression to post-16 science courses.
- Alternative progression routes are available in the form of GCSE Biology, GCSE Chemistry and GCSE Physics, in addition to an applied science route leading to a new single award GCSE Additional Applied Science.
- There is provision for students wishing to follow an applied route from the outset of KS4 through a revised GCSE Applied Science (Double Award).

- Taken together, the three separate sciences cover the requirement to teach the new programme of study, as does the revised GCSE Applied Science (Double Award).
- Through these new specifications the opportunity exists for candidates to study GCSE Science and one or more of the separate science GCSE courses.

In parallel with the GCSE developments, a new Entry Level Certificate specification for Science is being produced. This covers the breadth of the programme of study but in less depth than required for GCSE Science.

Further details of the suite of specifications developed by AQA to meet these requirements are given in Section 4.2.

1.2 Changes to the KS4 Curriculum

Requirement to teach programme of study

The revised programme of study for KS4 Science has been designed by QCA as a small core of content relevant to all students. It is a statutory requirement to teach the programme of study to all students at maintained schools. Since the start of teaching of the new specifications (September 2006), it has no longer been possible to disapply KS4 students from this requirement for the purposes of extended work-related learning.

Work-related learning

The removal of the provision for disapplication is linked to the statutory requirement for work-related learning for all students that was introduced in September 2004. With the greater emphasis in the revised programme of study on 'How Science Works', science teachers are enabled, if they wish, to make a larger contribution to work-related learning through the teaching of science.

1.3 Other Regulatory Requirements

Key Skills

All GCSE specifications must identify, as appropriate to the subject, opportunities for generating evidence for the Key Skills of Application of Number, Communication, Information and Communication Technology, Working with Others, Improving own Learning and Performance, and Problem Solving. Details for this specification are given in Section 14.2.

ICT

The subject content of all GCSEs must require candidates to make effective use of ICT and provide, where appropriate, assessment opportunities for ICT. Details of how the teaching of this specification can encourage the application and development of ICT skills are given in Section 9.2. However, ICT skills are not assessed by any component of this specification.

Communication	All GCSE specifications must ensure that the assessment arrangements require that, when they produce extended written material, candidates have to: • ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear • present information in a form that suits its purpose • use a suitable structure and style of writing. Further details for this specification are given in Section 9.1.
Citizenship	Since 2002, students in England have been required to study Citizenship as a National Curriculum subject. Each GCSE specification must signpost, where appropriate, opportunities for developing citizenship knowledge, skills and understanding. Further details for this specification are given in Section 15.5.
Other issues	All specifications must identify ways in which the study of the subject can contribute to developing understanding of spiritual, moral, ethical, social and cultural issues, European developments, environmental issues, and health and safety. Further details for this specification are given in Sections 15.1, 15.2, 15.3 and 15.4.
Wales and Northern Ireland	There is no longer any additional material that centres in Wales or Northern Ireland have to teach in order to meet the different requirements of the National Curriculum in these countries. Therefore, centres may offer any of the AQA specifications without the need to supplement the teaching required in order to meet additional statutory orders applying to students outside England.

2

Specification at a Glance
Applied Science

This specification is one of a suite of GCSE Science specifications offered by AQA. The specification leads to GCSE Applied Science (Double Award). Unit 1 is common with GCSE Additional Applied Science. The award has four assessment units.

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

GCSE Applied Science (Double Award)
4861

3 Availability of Assessment Units and Entry Details

3.1 Availability of Assessment Units

Assessments based on this specification are available as follows.

	Externally Assessed Unit	Portfolio Moderation for each Unit	Qualification
January	✓	✓	✓
June	✓	✓	✓

3.2 Entry Codes

Normal entry requirements apply but the following information should be noted.

Each assessment unit has a separate unit entry code, as follows:

Unit 1 – APSC1
Unit 2 – APSC2F or APSC2H
Unit 3 – APSC3
Unit 4 – APSC4

These four units contribute to the subject award GCSE Applied Science (Double Award).

The Subject Code for entry to the GCSE Applied Science (Double Award) is 4861.

3.3 Entry Restrictions

Each specification is assigned to a national classification code, indicating the subject area to which it belongs. Centres should be aware that candidates who enter for more than one GCSE qualification with the same classification code will have only one grade (the highest) counted for the purpose of the School and College Performance Tables.

The classification code for this specification is 0008.

The subject award GCSE Applied Science (Double Award) has a common unit with GCSE Additional Applied Science. Unit 1 (Science in the Workplace) has exactly the same content in GCSE Applied Science (Double Award) and GCSE Additional Applied Science. Therefore concurrent entries for GCSE Applied Science (Double Award) and GCSE Additional Applied Science will not be accepted.

3.4 Private Candidates

This specification is available for private candidates in the following situations:

- where candidates have already received results for the centre-assessed units, the externally assessed unit and entry for the qualification is available
- where a GCSE award has already been made, the centre-assessed unit results may be reused within twelve months if the externally assessed unit is being retaken. Private candidates should write to AQA for a copy of *"Supplementary Guidance for Private Candidates"*.

3.5 Access Arrangements and Special Consideration

AQA pays due regard to the provisions of the Disability Discrimination Act 1995 in its administration of this specification.

Arrangements may be made to enable candidates with disabilities or other difficulties to access the assessment. An example of an access arrangement is the production of a Braille paper for a candidate with a visual impairment. Special consideration may be requested for candidates whose work has been affected by illness or other exceptional circumstances.

Further details can be found in the Joint Council for Qualifications (JCQ) document:

Access Arrangements and Special Consideration
Regulations and Guidance Relating to Candidates who are Eligible for Adjustments in Examinations
GCE, AEA, VCE, GCSE, GNVQ, Entry Level & Key Skills

This document can be viewed via the AQA website (www.aqa.org.uk)

Applications for access arrangements and special consideration should be submitted to AQA by the Examinations Officer at the centre.

3.6 Language of Examinations

All assessment will be through the medium of English. Assessment materials will not be provided in Welsh or Gaeilge.

Scheme of Assessment

4 Introduction

4.1 National Criteria

This GCSE Applied Science (Double Award) specification complies with the following:

- the Statutory Regulation of External Qualifications in England, Wales and Northern Ireland 2004, including the common criteria for all qualifications and the additional criteria for GCSE
- the GCSE Criteria for Science
- the GCSE, GCE and AEA Code of Practice April 2008.

4.2 Background

This GCSE Applied Science (Double Award) specification is part of the AQA GCSE Science suite, which comprises:

GCSE Science A
GCSE Science B
GCSE Additional Science
GCSE Additional Applied Science
GCSE Biology
GCSE Chemistry
GCSE Physics
GCSE Applied Science (Double Award) (this specification).

A matching Entry Level Certificate specification for Science is also available.

The suite enables centres to offer a range of flexible progression routes from KS3 through KS4 Science to further studies.

4.3 Rationale for GCSE Applied Science (Double Award)

Students embarking on KS4 and wishing from the outset to specialise in a vocational approach to science can be offered GCSE Applied Science (Double Award). This is a qualification that has been developed from the previous GCSE Applied Science specification but, unlike its predecessor, it covers the whole programme of study for KS4 Science, enabling the requirement to teach the programme to be met (see Section 1.2). The fundamental philosophy of this specification is that, in order to understand the nature of science, students must actively experience the scientific environment. This specification considers some of the knowledge required by scientists and the type of work and investigations that they might undertake. The core content of the specification looks at broad vocational areas to which science contributes. It also exemplifies the procedural and technical knowledge of science practice that medical and material scientists, microbiologists and analytical chemists may undertake. The specification also enables the study of science practice in the workplace. Following this

specification will introduce students to work-related learning and equip students with some of the skills used by scientists in the workplace. It will also empower students to take charge of their own learning and provide a range of teaching, learning and assessment styles to motivate students to achieve the best they can. The assessment comprises four units: three portfolio units and one externally assessed unit.

4.4 Other Specifications in the Suite

GCSE Science A and GCSE Science B

Students can begin KS4 with a general science course based on either GCSE Science A or GCSE Science B. These are both single award qualifications. They cover all aspects of a good science education: evaluating evidence and the implications of science for society; explaining, theorising and modelling in science; and procedural and technical knowledge of science practice, though with an emphasis on the first aspect, namely evaluating evidence and the implications of science for society. The weighting given to the procedural content in these specifications is higher than in the other general science specifications, and the substantive contexts lend themselves to engagement with the societal implications of scientific knowledge at a level which is appropriate to key stage 4. Both these specifications therefore provide the opportunity for all students to develop the scientific knowledge, understanding and skills needed for adult life, but they also give a good basis for further study of science.

These specifications have identical content, covering the whole programme of study for KS4 Science, with the subject areas of Biology, Chemistry and Physics presented separately so that they can be taught by subject specialists if this suits the staffing and/or teaching strategy in the centre. The assessment styles for Science A and Science B are different, though they share a common model for centre assessment. Students who are successful in GCSE Science could study a level 3 science qualification such as AS Science for Public Understanding, but would find progression to GCE Biology, Chemistry, Physics and Applied Science difficult without further preparation. Many will undertake a level 2 course such as GCSE Additional Science or GCSE Additional Applied Science before continuing to level 3 courses.

GCSE Science A

The specific feature of this specification is that external assessment is available in 'bite-size' objective tests. Each of the three units, Biology 1, Chemistry 1 and Physics 1, is divided into two equal sections and each section is examined in a separate 30 minute test. The tests are available in November, March and June. The objective tests are available as paper-based and on-screen tests in centres.

GCSE Science B	In contrast, GCSE Science B does not offer assessment through the 'bite-size' test route but has 45 minute written papers with structured questions. There is one paper for each of Biology 1, Chemistry 1 and Physics 1, available in January and June.
GCSE Additional Science	This is a single award GCSE, which could be taken after or at the same time as GCSE Science A or B. This award together with an award in GCSE Science provides the nearest equivalent to the previous GCSE Science: Double Award. The content follows on from that of GCSE Science, and the centre assessment follows the same model as used for Science A and Science B. However, the emphasis of this specification, and the three separate sciences, GCSE Biology, Chemistry and Physics, is somewhat different. Whereas GCSE Science A and B emphasise evaluating evidence and the implications of science for society, these specifications have a greater emphasis on explaining, theorising and modelling in science. There are three 45 minute written papers with structured questions, one paper for each of Biology 2, Chemistry 2 and Physics 2, available in January and June. Courses based on this specification form a firm basis for level 3 courses in the sciences such as AS and A Level Biology, Chemistry and Physics.
GCSE Additional Applied Science	This is another single award GCSE, which could be taken after or at the same time as GCSE Science A or B. It emphasises the procedural and technical knowledge of science practice, so is suitable for students who want to learn more about vocational contexts which are relevant to the modern world. The subject content is set in three vocational contexts: sports science, food science and forensic science. Together with GCSE Science, it would form a firm basis for level 3 courses in the sciences such as GCE Applied Science.
GCSE Biology, Chemistry, Physics	Each of these single award GCSEs would provide the basis for the study of the corresponding GCE science. Like GCSE Additional Science, they emphasise explaining, theorising and modelling in science. Taken together they include the whole programme of study for KS4 Science, enabling the statutory requirement to be met. Students could take courses based on these specifications directly after KS3 Science. Alternatively, some students may prefer to take GCSE Science to provide a general background in KS4 Science, then specialise in one or more separate science(s).

	ELC Science	Candidates who may not be ready to take GCSE Science at the same time as their contemporaries can study for the Entry Level Certificate in Science. This has the same breadth of content as GCSE Science, but less depth. Teaching for ELC Science can enable the requirement to teach the programme of study for KS4 Science to be met (see Section 1.2) and students can be taught alongside students preparing for GCSE Science (if they cannot be taught separately). Students who have succeeded in ELC Science can progress to GCSE Science. Assessment is through the completion of units of content with the success criteria being clearly focused on skills rather than depth of knowledge.
4.5	Prior Level of Attainment and Recommended Prior Learning	This key stage 4 GCSE specification builds on the knowledge, understanding and skills set out in the National Curriculum programme of study for key stage 3 science. While there is no specific prior level of attainment required for candidates to undertake a course of study based on this specification, a level of scientific, literacy and numeracy skills commensurate with having followed a programme of study at key stage 3 is expected.
4.6	Progression	This qualification is a recognised part of the National Qualifications Framework. As such, GCSE is a level 2 qualification and provides progression from key stage 3 to post-16 studies. A course based on this specification provides a worthwhile course for candidates of various ages and from diverse backgrounds in terms of general education and lifelong learning. It will follow naturally from one based on the programme of study for KS3 Science. From a GCSE Applied Science (Double Award) course, students could progress to courses at level 3 such as GCE Applied Science and AS Science for Public Understanding. Students wishing to progress to level 3 courses in AS and A level Biology, Chemistry and particularly Physics might need to undertake further study. This course also prepares students for other courses in the FE sector, including a range of NVQs, as well as employment.

5 Aims

A course based on this specification should encourage candidates to:

- develop their interest in, and enthusiasm for, science
- develop a critical approach to scientific evidence and methods
- acquire and apply skills, knowledge and understanding of how science works and its essential role in society
- acquire scientific skills, knowledge and understanding necessary for progression to further learning.

6 Assessment Objectives

The scheme of assessment will require candidates to demonstrate the abilities detailed under assessment objectives below in the context of the subject content in Sections 10–13.

6.1 Assessment Objective 1 (AO1)

Knowledge and understanding of science and how science works

Candidates should be able to:

a) demonstrate knowledge and understanding of the scientific facts, concepts, techniques and terminology in the specification
b) show understanding of how scientific evidence is collected and its relationship with scientific explanations and theories
c) show understanding of how scientific knowledge and ideas change over time and how these changes are validated.

6.2 Assessment Objective 2 (AO2)

Application of skills, knowledge and understanding

Candidates should be able to:

a) apply concepts, develop arguments or draw conclusions related to familiar and unfamiliar situations
b) plan a scientific task, such as a practical procedure, testing an idea, answering a question, or solving a problem
c) show understanding of how decisions about science and technology are made in different situations, including contemporary situations and those raising ethical issues
d) evaluate the impact of scientific developments or processes on individuals, communities or the environment.

6.3 Assessment Objective 3 (AO3)

Practical, enquiry and data handling skills

Candidates should be able to:

a) carry out practical tasks safely and skilfully
b) evaluate the methods they use when collecting first-hand and secondary data
c) analyse and interpret qualitative and quantitative data from different sources
d) consider the validity and reliability of data in presenting and justifying conclusions.

7 Scheme of Assessment

7.1 Assessment Units

The Scheme of Assessment comprises four units: Unit 1 – *Science in the Workplace,* Unit 2 – *Science for the Needs of Society,* Unit 3 – *Developing Scientific Skills,* and Unit 4 – *Using Scientific Skills for the Benefit of Society.*

Unit 1 – Science in the Workplace		
Centre-Assessed	Portfolio	
10% of the marks		25 marks

The unit comprises a portfolio of work assessing the content in Section 10.

Unit 2 – Science for the Needs of Society		
Externally Assessed	Written Paper	1½ hours
35% of the marks		90 marks

The unit comprises a written paper with short-answer questions. The questions assess the subject content in Section 11. The paper is available at Foundation and Higher Tier. All questions are compulsory.

Unit 3 – Developing Scientific Skills		
Centre-Assessed	Portfolio	
27½% of the marks		50 marks

The unit comprises a portfolio of work assessing the subject content of Section 12.

Unit 4 – Using Scientific Skills for the Benefit of Society		
Centre-Assessed	Portfolio	
27½% of the marks		50 marks

The unit comprises a portfolio of work assessing the subject content of Section 13.

7.2 Weighting of Assessment Objectives

The approximate relationship between the relative percentage weighting of the Assessment Objectives (AOs) and the overall Scheme of Assessment is shown in the following table:

Assessment Objectives	Unit Weightings (%)				Overall Weighting of AOs (%)
	Unit 1	Unit 2	Unit 3	Unit 4	
AO1	6	20	2	2	30
AO2	4	10	8	8	30
AO3	–	5	17.5	17.5	40
Overall Weighting (%)	10	35	27.5	27.5	**100**

Candidates' marks for each assessment unit are scaled to achieve the correct weightings.

7.3 Tiering and Assessment

The portfolio units are not tiered. In Unit 2, the papers are tiered, with Foundation Tier being aimed at Grades C–G, and Higher Tier being aimed at grades A*– D. Questions for the Higher Tier will be more demanding, requiring higher level skills allowing candidates to access the higher grades.

The level of demand of questions depends on factors such as the nature of the underlying scientific concepts being tested, amount of cueing provided including the plausibility of distractors, the context/application in which the question in contained, whether the response required is directed or open, and the extent to which reference material must be used in order to respond. Consideration of such factors allows GCSE Science questions to be allocated to one of three levels of demand (low, standard and high). Foundation Tier papers contain low and standard demand questions, while Higher Tier papers contain standard and high demand questions.

7.4 Mathematical and Other Requirements

The knowledge and skills in mathematics that are relevant to science and which are given below will not be exceeded in making assessments in this specification. Candidates will not be prevented from demonstrating achievement in science by mathematics that is excessively demanding.

FT and HT

- The four rules applied to whole numbers and decimals
- Use of tables and charts
- Interpretation and use of graphs
- Drawing graphs from given data
- Reading, interpreting and drawing simple inferences from tables
- Vulgar and decimal fractions and percentages
- Scales

- Elementary ideas and application of common measures of rate
- Averages/means and the purpose for which they are used
- Substitution of numbers for words and letters in formulae (without transformation of simple formulae).

HT only (in addition to the requirements listed above)

- Square and square root
- Conversion between vulgar and decimal fractions and percentages
- The four rules applied to improper (and mixed) fractions
- Expression of one quantity as a percentage of another; percentage change
- Drawing and interpreting related graphs
- Idea of gradient
- Transformation of formulae
- Simple linear equations with one unknown
- Elementary ideas and applications of direct and inverse proportion.

Units, symbols and nomenclature

Units, symbols and nomenclature used in examination papers will normally conform to the recommendations contained in the following:

- *Signs, Symbols and Systematics – the ASE companion to 16–19 Science.* Association for Science Education (ASE), 2000. ISBN 0 86357 312 6
- *Signs, Symbols and Systematics – the ASE companion to 5–16 Science.* Association for Science Education (ASE), 1995. ISBN 0 86357 232 4

Any generally accepted alternatives used by candidates will be given appropriate credit.

Data sheet and formulae list

Data sheets and formulae lists are **not** included with the question papers for this specification. Information of this kind should **not** be provided to candidates for use during examinations.

Communication skills

AQA takes care that candidates are not prevented from demonstrating achievement in science by the use of language in question papers which is inappropriately complex and hinders comprehension. Similarly, while the assessment of communication is not a primary function of this specification, candidates are required to demonstrate scientific communication skills. These are described in Section 10.4.

In addition, candidates will have difficulty in scoring the marks for science in any of the written assessments if they do not:

- ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear

- present information in a form that suits its purpose
- use a suitable structure and style of writing.

In presenting their answers, candidates will also need to use scientific conventions (including chemical equations) and mathematical language (including formulae) accurately and appropriately to score all the available marks.

Subject Content

8 Summary of Subject Content

9 Introduction to Subject Content

9.1 Communication Skills

Throughout their GCSE Applied Science (Double Award) course, candidates should be encouraged to develop and improve their scientific communication skills.

These include:

- recalling, analysing, interpreting, applying and questioning scientific information or ideas
- using both qualitative and quantitative approaches
- presenting information, developing an argument and drawing a conclusion, using scientific, technical and mathematical language, conventions and symbols and ICT tools.

These skills will be developed through the activities that candidates undertake during their course. Appropriate use of communication skills will enable candidates to be successful in the written and portfolio assessments for this specification. Communication is specifically assessed in Unit 1 and is included in the portfolio of evidence for the unit.

9.2 ICT Skills

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 skills within their study of Applied Science.

Candidates should be given opportunities 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
- 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 Applied Science (Double Award) for the use of ICT skills follow.

Candidates could:

- use multimedia sources to see things that cannot readily be observed at first hand, eg in vocational applications of scientific skills throughout the course
- use dataloggers in investigations, eg in Unit 4
- use the internet to find information about vocational applications of science, current developments, products, and processes throughout the course

- use spreadsheets for modelling or data analysis of results from investigations in Unit 3 or costs of electricity use in the home in Unit 2
- use software simulations to enhance their learning in Unit 2, eg in biological and chemical processes.

Whilst using ICT to support learning objectives it should be remembered that portfolios containing pages of notes printed from the internet or CD-ROMs as evidence will not be accepted.

10

Unit 1
Science in the Workplace

10.1 About this Unit

In this unit you find out about the types of people who work with science and use scientific skills. You will also find out that those who work with science are very aware of the safety implications of their work. You will need to use research skills to investigate:

- how science is used
- safe working in science.

You will need to decide how you are going to obtain your information and the sources of information that you use. You may wish to use, for example, information from visits, questionnaires, the internet or CD-ROMs.

10.2 Investigating how Science is Used

Vocational science is the science and skills used by people in a wide variety of jobs. Those with a major job role in science may classify things, obtain or make things, and monitor and control changes. The more scientists know about the materials and equipment they work with, the more effective they can be. Scientists tackle problems; sometimes straightforward, often complex. This requires employing scientific skills and knowledge, coupled with imagination and curiosity. However, there are many people who use science in their work, whom we do not think of as scientists. For some it is a significant part of their work (eg nurses, engineers); for others it plays a smaller part (eg photographers, chefs and gardeners).

You 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.

You 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.

10.3 Working Safely in Science

Scientific work can be dangerous, yet accidents among scientists are rare. This is because scientists are always aware of the hazards they deal with and of the need to work safely. You must be able to work safely and prevent accidents in the laboratory or wherever you are doing your scientific work. You must know what to do if an accident happens.

Hazards and risks

Potential hazards in scientific workplaces, including school and college laboratories, include:

- careless behaviour
- not using equipment properly
- not using protective and safety equipment
- not following correct procedures
- the possible risks that may arise from:
  - chemical substances classified as toxic, flammable, corrosive, oxidising and irritant
  - microorganisms
  - utilities (gas and electricity).

It is important that you are aware that workplaces are governed by health and safety regulations.

You 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.

You 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

Common injuries in laboratories are heat burns and scalds, chemical burns, injury from breathing in fumes or swallowing chemicals, electric shock, cuts and damage to the eyes from particles or chemicals.

For each of these injuries, you need to know:

- the basic first aid to give
- the situations in which it would be dangerous to give first aid.

You 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

In places of work, including your school or college, there are fire regulations. These regulations are to ensure that the numbers of casualties in fires are kept to a minimum. Although many people are killed or injured in fires each year, the vast majority occur in the home and only 6% of deaths and 10% of injuries occur in the workplace (*Fire Statistics United Kingdom 1999*: L. Watson, J. Gamble and R. Schofield). However, continued vigilance is essential if these figures are to be maintained or improved.

You need to know:

- what must be done if you hear a fire alarm or smoke alarm
- what must be done if you 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.

10.4 Assessment Evidence for Unit 1: *Science in the Workplace*

This unit is assessed entirely on evidence contained in your portfolio of work.

You need to produce a portfolio of evidence about workplaces that use science and how science and scientific skills are used in the workplace. You will need to consider safety precautions in the workplace and compare these with the health and safety precautions in your school or college. You should be able to use a variety of sources of information and present your findings in a clear and logical way.

Your portfolio of evidence should include the following:

- a report of an investigation on workplaces that use scientific skills, describing the work of scientists or those who use scientific skills and how science is important in a wide variety of jobs
- a report of an investigation carried out into working safely in a scientific workplace and a comparison with the health and safety precautions in your school or college.

Assessment Evidence Grid – Unit 1: *Science in the Workplace*

Candidates need to produce a portfolio of evidence about workplaces that use science and how science and scientific skills are used in the workplace. Candidates will need to consider safety precautions in the workplace and compare these with the health and safety precautions in their school or college. Candidates should be able to use a variety of sources of information and present their findings in a clear and logical way.

The portfolio of evidence should include the following:

- a report of an investigation on workplaces that use scientific skills, describing the work of scientists or those who use scientific skills and how science is important in a wide variety of jobs
- a report of an investigation carried out into working safely in a scientific workplace and a comparison with the health and safety precautions in their school or college.

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

Whilst completing this unit candidates will be assessed on the way that they research and communicate their evidence in their portfolio of work.

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

10.5 Guidance on Assessment

This unit is assessed entirely through evidence that candidates produce in their portfolios.

The descriptors in the Assessment Evidence Grid will allow teachers to determine levels of work appropriate for their candidates.

In general, when assessing portfolio work teachers should be aware of:

- an increasing breadth and depth of understanding
- an increasing ability to independently research for evidence.

Stage 1 Candidates should undertake research into the safe working practices required in a scientific workplace. Research and planning skills will be limited and they will need help in such things as choosing a suitable range of organisations and identifying hazards and risks.

Stage 2 In their research into health and safety issues candidates at this level should be able to use sources of information, gathered from outside the laboratory situation, some of which may have been suggested to them. They should be able to use information sources confidently and classify, for example, types of organisation using science given broad headings under which to work.

Stage 3 Candidates should be able to suggest and locate sources of information for use in their health and safety research. Their work should demonstrate a clear understanding of the health and safety issues involved and they should be able to compare work done in school or college with their research gained from other sources. They should be able to select their own research material and be able to compile an in-depth report. They should be able to classify and compare aspects of scientific industry independently.

11

Unit 2
Science for the Needs of Society

11.1 About this Unit

In this unit you will learn about how science is used to benefit us in our everyday lives. In particular you will learn about some of the science used by people working in specific science-based occupations in order to help us maintain and improve our quality of life.

This unit concentrates on some of the knowledge, understanding and skills that are needed by:

- medical professionals in order to maintain our health and treat illness and disease
- agricultural scientists in order to produce food efficiently and economically
- scientists involved in the large-scale production and supply of raw materials and energy
- environmental scientists who monitor pollution and the disposal of waste
- transport and communication engineers who maintain and improve our transport and communication systems
- scientists who contribute towards the production of the materials and electrical equipment found in our homes.

This unit is divided into four sections:

- Health and Medicine
- Countryside and Environmental Management
- The Home Environment
- Transport and Communication.

11.2 Health and Medicine

Those working in the medical professions use their knowledge to diagnose and treat disease and illness. They need to be aware of how the healthy body works as well as what may cause the body to become unhealthy.

In this section you will learn about:

- The Healthy Body
- Illnesses, Diseases, and their Diagnosis and Treatment
- The Body at Risk.

The Healthy Body

People working in the medical professions need to understand how living organisms function. Living organisms are made up of building blocks called cells. In humans, millions of cells work together to keep the body healthy. Although cells have common features, they are adapted to do different jobs and differences in their structure allow them to carry out specialist functions.

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).

Those working in the medical professions need a knowledge of the respiratory and circulatory systems.

You 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.

Homeostasis

The healthy body must keep itself at the right temperature and control the sugar content in the bloodstream. The body has automatic systems, which constantly monitor and control the internal environment of the body. The healthy body detects external changes using sense organs and then processes this information in the brain. The nervous system then coordinates a response to this information.

You 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

In the Human Genome project medical scientists have identified each of the 300 000 genes in the human body. Each gene codes for a protein in the body; in turn these proteins determine many things that happen in the body including whether the individual is a girl or a boy or what colour eyes they have. Offspring resemble their parents (have similar characteristics) because of information passed on to them in the sex cells (gametes) from which they have developed. The genes are found in the nucleus of the cell. Alleles are different versions of the same gene. They produce different characteristics and they may be dominant or recessive. Sometimes a change in the structure of a gene occurs; this is called a mutation. Some mutations can lead to disorders, which can then be inherited by offspring.

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.

You 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.

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

Disease and illness

Our bodies provide an excellent environment for microorganisms to grow. Some of these microorganisms are helpful but some can make us ill. Microorganisms that cause disease are called pathogens. Microorganisms quickly adapt to their environment and rapidly multiply. The human body has a number of defence mechanisms to help keep it in good health, to stop microorganisms getting in and also to deal with any which do get in.

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.

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.

Prevention

Although the human body is very efficient at fighting disease, those working in the medical professions have developed vaccination, which can prevent diseases occurring in the first place. A mild or dead form of the infecting microorganism is introduced. This causes white blood cells to produce antibodies. If the same organism later infects the individual it is recognised and the antibodies are produced quickly enough to destroy it.

The use of gamma rays, high temperature and chemicals to kill harmful microorganisms can also prevent infection.

You 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).

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.

Diagnosis and treatment

The medical professions rely on the use of X-rays and ionising radiation to identify and treat certain disorders. X-rays are a form of electromagnetic radiation (see Communication Devices) that can be detected using photographic film. They pass easily through flesh but not through denser material such as bone or metal. They are used in hospitals to take X-ray photographs to enable doctors to detect broken bones.

In addition to the treatment by drugs and vaccinations, doctors treat certain diseases, such as cancer, by using gamma rays. Radiotherapy is the treatment of cancer using high energy (ionising) radiation. The ionising radiation damages or destroys cells in the area being treated, making it impossible for the cancer cells to continue to grow.

You 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.

The Body at Risk

People frequently put their healthy body at risk because of what they choose to do. Medical scientists have found that an unhealthy diet and insufficient exercise can eventually result in increased risk from diseases such as diabetes, obesity and heart disease. Medical scientists develop drugs that can help cure and prevent disease; these drugs are extensively tested before use by doctors. Medical scientists have also collected evidence that links respiratory and circulatory disorders to the abuse of legal and illegal recreational drugs.

You need to know:

- that certain foods are considered healthy (fresh fruit and vegetables) and that 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).

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.

11.3 Countryside and Environmental Management

Agriculture is concerned mainly with the production of food. Agricultural scientists work to improve both the quality and the quantity of food produced. They devise farming techniques to increase crop production.

The manufacture of products requires raw materials obtained from the Earth. Environmental scientists seek to maintain a balance between the damage that extraction of these materials may cause and maintaining an environment in which we can all live and thrive comfortably.

In this section you will learn about:

- Agriculture and Farming
- Managing the Environment.

Agriculture and Farming

Agricultural scientists study how plants grow, determining which nutrients plants need and experimenting with selective breeding. This process can lead to higher crop yield. Two contrasting approaches to farming are intensive farming and organic 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)
- 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.

- **You 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.

You need to know:

that nitrates are required for proteins, which are needed for cell growth, and that magnesium is required for chlorophyll.

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).

In addition to food, we also obtain cotton, dyes, wool and leather from living things. Microoorganisms also play an important part in the production of some foods (eg yoghurt, cheese, bread, beer, wine) and medicines such as penicillin.

You need to be able to:

- 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).

Selective breeding and genetic engineering

Agricultural scientists have developed new methods of producing plants and animals with favourable characteristics. Both crops and livestock have been bred so that they produce more food or are more economical to harvest.

You 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.

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

The vast majority of chemical substances are found in the Earth as compounds and are extracted by mining and quarrying. A very small number exist as elements (eg gold and sulfur). Some deposits consist mainly of one compound (eg limestone, marble), while others consist of mixtures of compounds (eg rock salt, crude oil). Some are used as the starting material to make other useful substances (eg metals are extracted from their ores).

You 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).

Unreactive metals such as gold are found in the Earth in an uncombined state, but most metals are found as compounds that require chemical reactions to extract the metal. Ores are naturally occurring rocks that provide an economic starting point for the manufacture of metals. Metals that are less reactive than carbon can be extracted from their oxides by reduction with carbon. Iron and lead can be extracted in this way.

You need to be able to:

- 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).

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.

Energy resources

We need a source of energy to change things or to make things happen. Fossil fuels are examples of primary energy resources. They are valuable because they are concentrated sources of energy, which is released by burning them in oxygen. There is, however, only a limited amount of fossil fuel in the Earth's crust. We can use nuclear fuels or renewable energy resources instead of fossil fuels.

You 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).

In most power stations electricity is generated by burning a fuel to boil water, and then using the steam to turn a turbine, which rotates a generator to generate electricity. Generating electricity from a primary energy source is not usually a very efficient process. This results in electricity being relatively expensive.

You need to know:

- how electricity is generated from the burning of fossil fuels.

Environmental management

The Earth is part of the solar system. The processes that formed the Earth still continue today, and environmental scientists monitor the continual process responsible for making and destroying the Earth's crust. These processes result in earthquakes and volcanoes, which change the surface and atmosphere.

You 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.

You should be able to use data to:

- explain the position of the Earth in the solar system.

Human activity has measurable effects on the Earth's surface and atmosphere. These effects are caused by changes in population, use of resources, industrial pressures and increased levels of pollution and waste disposal. Changes to the land and water have taken place as a consequence of mining, quarrying and the manufacture of new materials. Changes to the atmosphere have taken place as a consequence of the burning of fossil fuels.

You 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.

11.4 The Home Environment

We expect our homes to be comfortable and efficient. House design involves many types of science. The materials scientist is responsible for developing the materials that are used in our homes for their construction as well as the fittings inside the home. Before deciding which material is suitable for a purpose, scientists must understand its properties. An energy consultant may be used to determine how to make our homes and the appliances in them more efficient and safe. Other types of scientist, eg chemists, develop the household products that we use in the home. To be able to do this, they need to understand how different substances interact with each other.

In this section you will learn about:

- Chemical Building Blocks
- Materials used for Construction
- Science in the Home.

Chemical Building Blocks

Scientists develop useful chemicals from natural raw materials. Metals, limestone and fossil fuels are examples of materials obtained from the Earth. The extraction and use of these materials is essential for our transport and construction industries. Understanding the chemical structure of these materials and their chemical reactions enables us to make the best use of them. Our understanding of chemical structure and chemical reactions comes from knowledge of the structure of atoms.

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.

You need to know:

- that atoms of a particular element have the same number of protons (atomic number).

Chemical symbols

Chemical symbols are the international shorthand notation for elements used by scientists. These symbols are put together in formulae to represent the atoms that are joined together in compounds.

You need to know:

- the chemical symbols for the elements listed in Appendix D
- the chemical formulae for the simple molecules listed in Appendix D.

You need to be able to:

- write symbol equations for the chemical reactions in this unit (eg extraction of metals from ores, combustion of hydrocarbons, chemicals from limestone).

You should be able to use data to:

- write the chemical formulae of some simple ionic compounds.

Chemical bonding

Compounds are held together by chemical bonds. The characteristic properties of substances depend on the type of chemical bonding and this can be used to classify them. Metallic elements conduct electricity because they have free electrons. Substances that consist of small molecules with strong covalent bonds between the atoms in the molecules have low melting and boiling points because the forces of attraction between the molecules are weak. Giant structures held together by ionic bonds or covalent bonds have high melting points because the chemical bonds between all their particles are strong.

You need to know:

- the characteristic properties of metals and non-metals (electrical conductivity, density, melting point, appearance).

You 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.

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

Materials scientists have adapted many of the materials that can be obtained from the Earth for use in the construction industry.

Limestone

Limestone (calcium carbonate) can be used to make quicklime (calcium oxide) and slaked lime (calcium hydroxide). Limestone also provides a starting point for the manufacture of cement, concrete and glass. Heating limestone with clay in a kiln produces cement. Cement is mixed with sand and water to make mortar. Cement is mixed with sand, crushed rock and water to make concrete. Glass can be made by heating a mixture of sand, limestone and sodium carbonate.

You need to know:

- the chemical formulae of limestone, calcium oxide and calcium hydroxide
- the meanings of the terms endothermic reaction and exothermic reaction.

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.

You should be able to use data, theories and explanations to:

- evaluate the environmental, social and economic effects of producing building materials from limestone.

Metals

Metals and metal alloys have many uses in construction depending on their properties. Copper is used for water pipes, hot water cylinders and wiring because it is malleable, strong, has a high melting point and is a good conductor of electricity. Lead is used for flashing on roofs because it is unreactive and malleable. Steel is used to make supporting structures and fixings because it has high tensile strength.

You need to know:

- the characteristic properties of metals (eg electrical conductivity, malleability and hardness) and be able to relate them to their uses.

You 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

The selection of a material for a particular use by a construction engineer depends on its properties. Polymers, ceramics and composites are examples of manufactured materials, whilst wood is an example of a material from a living thing.

You 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.

You 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.

You should be able to use data to:

- find the physical properties of materials.

You 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.

Science in the Home

Using energy

Energy is used for heating and to power electrical appliances in the home. Electrical appliances change electrical energy to another form of energy. The rate at which the energy is changed in an electrical appliance is called the power. It is useful for energy consultants to be able to compare the running costs of different electrical appliances in our homes. Mains electricity can be very dangerous. It is important to know how to use it safely. If an electrical fault causes too great a current, a fuse or a circuit breaker should switch off the circuit. When the current in a fuse wire exceeds the rating of the fuse the fuse wire will melt, breaking the circuit.

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.

Using energy efficiently

Energy is an expensive commodity and should not be wasted. There are a number of measures that may be taken to reduce energy costs. Energy consultants need to understand how heat is transferred in order to reduce the rate of heat loss in our houses.

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.

You 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:

$$\%\ \text{efficiency} = \frac{\text{useful energy transferred by the device}}{\text{total energy supplied to the device}} \times 100$$

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.

Useful mixtures

Chemists produce products for use in the home. These chemical products are seldom used in the form of pure substances, but consist of mixtures. Useful mixtures include cola, paint, toothpaste, hair gel, deodorant spray, shaving foam and food. The six different types of mixture are solutions, suspensions, gels, emulsions, foams and aerosols.

You 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

- 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).

11.5 Transport and Communication

Transport engineers work to design efficient vehicles that not only transport us safely and quickly but also use fuel efficiently. Communication engineers are responsible for the modern forms of communication devices that we enjoy. Communications engineers have developed these devices from the understanding of different types of waves whilst appreciating the potential hazards that may be connected with these waves.

In this section you will learn about:

- Forces, Movement and Transportation
- Fuel for Transport
- Communication Devices.

Forces, Movement and Transportation

Transport designers and engineers need to understand what affects the acceleration and braking of different types of vehicle. The movement of a vehicle can be described in terms of its speed or velocity and its acceleration or deceleration. The speed of a moving vehicle can be calculated from the distance moved in a certain time. The velocity of a vehicle is its speed in a given direction. Acceleration measures how quickly the velocity is changing.

You need to be able to:

- recall and use the formula:

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

  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:

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

  for vehicles moving in a straight line with a steady acceleration.

Transport engineers need to understand frictional forces in order to predict the stopping distances of moving vehicles.

You need to be able to:

- 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.

Accidents on the roads cause many deaths each year. A qualification test for drivers, road safety signs, the breathalyser test and MOT tests on older vehicles are some of the ways in which we attempt to improve transport safety.

You need to be able to:

- 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.

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.

Fuel for Transport

The chemical energy in hydrocarbon fuel is released when it is burned in air. Some of this energy is always wasted through heat loss. Most fuel for transport is obtained from crude oil.

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.

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 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

Communication engineers use electromagnetic radiation in the form of waves for radio, mobile phones, and cable and satellite television. Waves transfer energy from a source to other places without any matter being transferred. The various types of electromagnetic radiation form a continuous spectrum from high frequency (short wavelength) gamma rays to low frequency (long wavelength) radio waves. Different wavelengths of electromagnetic radiation are reflected, absorbed and transmitted differently by different substances and types of surface. The uses of different types of electromagnetic radiation depend on these and other properties.

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 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).

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.

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.

Astronomers observe the solar system and galaxies in the universe from Earth using telescopes that are made to detect visible light or other electromagnetic radiations such as radio waves or X-rays. The red-shift in light observed from the most distant galaxies is evidence that the universe is expanding. The further away galaxies are the bigger the red-shift.

You need to be able to:

- 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.

11.6 Assessment

This unit will be assessed by written examination, which is tiered into Foundation and Higher papers. Both tiers will reflect the full content of the Unit. Questions for the Higher Tier will be more demanding, requiring higher level skills and allowing candidates to access the higher grades. The questions 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. Occupational groups could 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
- farming
- the food industry
- the cosmetics industry
- the manufacturers of electrical appliances.

The questions will be based on the type of science that you will meet and use in your everyday life, for example the mixtures and electrical appliances used at home, the materials used in the construction of buildings, how food is produced, how electricity is generated and fuels obtained for transport, how we stay healthy and fight disease, and the importance of electromagnetic radiation for our entertainment and communication.

12

Unit 3
Developing Scientific Skills

12.1 About this Unit

In this unit you will learn how different types of scientists work when carrying out practical tasks. In particular you will learn about and use the skills that microbiologists, analytical chemists and materials scientists require in the work that they undertake.

You will carry out a range of practical tasks involving some of the skills used by these scientists, including:

- Following Standard Procedures
- Handling Scientific Equipment and Materials
- Recording and Analysing Scientific Data.

The practical tasks will illustrate some important uses of science in the workplace. Whilst completing the tasks you will be:

- learning and using the techniques of the microbiologist to investigate living organisms
- learning and using the skills of the analytical chemist to carry out chemical analysis
- learning and using the skills of the materials scientist to investigate the properties of materials.

These scientists, and others who work with science, use a wide range of materials and equipment. They need to be able to work with scientific equipment, apparatus and materials safely and accurately. Often they follow a standard procedure. At other times, scientists must devise procedures for themselves.

12.2 Following Standard Procedures

A 'standard procedure' describes exactly how to carry out an experiment or procedure. A 'standard procedure' also ensures that everyone who carries out a particular experiment does it in exactly the same way and collects the results in the same way. For these reasons, standard procedures are very important in the scientific workplace. Examples include procedures for carrying out measurements, preparing and purifying a compound, or monitoring a change. Standard procedures may be agreed within a company, or nationally, or internationally.

When following a standard procedure, you need to be able to:

- read the procedure and check to see if there is anything you do not understand
- carry out a health and safety check of your working area
- carry out a risk assessment for the activity that you are undertaking

- set out your work area appropriately and collect together the equipment and materials you need.
- follow the instructions one step at a time
- select instruments that give the appropriate precision and use them to make accurate observations or measurements
- identify possible sources of error and repeat observations and measurements, when necessary, to improve reliability.

Handling Scientific Equipment and Materials

There are certain practical skills that scientists use every day and practising them will help to improve your accuracy and build your confidence. Developing these skills will also help you to use less familiar equipment and materials. You will need to become familiar with general laboratory equipment and to carry out a range of operations carefully and accurately.

You need to know how to:

- recognise and use standard laboratory equipment and glassware
- select and prepare equipment safely for use, including datalogging equipment where appropriate
- calibrate instruments, when necessary.

Recording and Analysing Scientific Data

A 'standard procedure' often tells you how to obtain and record observations and measurements and what to do with them. However, you should know some basic methods for recording and presenting data and for carrying out calculations. You should use ICT, where appropriate, in this work. It is also important that you think about the results you obtain and are able to interpret them.

You need to be able to:

- present data in tables, bar charts, histograms, pictograms, pie charts, graphs and other visual images, as appropriate
- carry out simple numerical calculations
- analyse and interpret your results
- evaluate your investigation and suggest improvements.

Your practical tasks will be in the following broad areas of science:

- How Microbiologists Investigate Living Organisms
- How Analytical Chemists Find Out About Substances
- How Materials Scientists Investigate the Properties of Materials.

12.3 How Microbiologists Investigate Living Organisms

Microbiologists study living organisms to learn more about their composition, how they function and the way they behave. In their investigations of living organisms, they use standard techniques and equipment such as aseptic techniques and microscopes.

One of the challenges facing microbiologists is the small size of the organisms they study. Some organisms are too small to be seen by

the human eye. Scientists overcome the problem of small size by using microscopes to study these organisms. Microscopes are also used to study the cells and tissues that make up larger living organisms.

You need to be able to:

- set up a light microscope ready for use, choosing a suitable objective lens for the task
- prepare samples for an investigation, including making a temporary slide and using a staining technique.

Microorganisms can be found everywhere – eg on our hands, on the laboratory bench, and in hospitals. Some microorganisms can be beneficial to society – for example, those that are used in the production of bread, beer, wine, yoghurt and medicines such as antibiotics.

Other microorganisms are harmful to us, or to the plants and animals that are important to us. Microorganisms therefore need to be handled very carefully and scientists need to avoid handling them directly, as they can be dangerous. If scientists need to isolate a single microorganism, they need to make sure that contamination by other microorganisms does not occur. By using aseptic techniques, microbiologists can ensure that both of these needs are fulfilled.

You 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.

12.4 How Analytical Chemists Find Out About Substances

Analytical chemists need to be able to test for the presence of certain chemical compounds in substances and to determine their concentration in solutions. They may use these tests to find out what is present in a sample, or to test the purity of a substance, or to detect the presence of pollutants (eg in river water), banned substances (eg in athletes) or alcohol (eg people suspected of drinking and driving). Chemical analysis is also an important aspect of the work of eg the forensic scientist. Two types of analysis are used: ‘qualitative analysis’ and ‘quantitative analysis’.

The analytical chemist may need to find out which substances are present. This process is known as qualitative analysis.

You 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 your results.

In some cases the analytical chemist may need to find out how much of a substance is present. This process is known as quantitative analysis.

You 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.

12.5 How Materials Scientists Investigate the Properties of Materials

When materials scientists investigate the ways in which materials behave, they may need to take measurements of certain physical and electrical properties. In deciding which material to use for a purpose, materials scientists may need to take account of more than one property. The size and shape of the material used may also be important. The different properties of materials are exploited to perform different functions.

Some materials carry electricity better than others because they offer less resistance to the flow of electricity. Electrical and electronic circuits use a wide range of materials.

You need to investigate how:

- the nature, length and thickness of materials influence electrical resistance
- current varies with voltage in a range of devices.

Electrical properties are not the only properties a materials scientist has to consider. For example, if you were asked to select materials to build a house, some of the properties you would consider would be thermal conductivity, density and strength.

You 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.

12.6 Assessment Evidence for Unit 3: *Developing Scientific Skills*

This unit is assessed entirely on evidence contained in your portfolio of work.

You need to produce a portfolio of evidence, which should contain records of all practical activities covering each of the following sections:

- Investigating Living Organisms
- Using Chemical Analysis Techniques
- Investigating Properties of Materials.

Each activity should be set in a vocational context and include evidence that you have:

- carried out risk assessments
- followed standard procedures
- used appropriate scientific equipment and / or materials
- obtained, recorded and analysed scientific data appropriate to the task
- evaluated your practical activity.

Assessment Evidence Grid – Unit 3: *Developing Scientific Skills*

Candidates need to produce a portfolio of evidence, which should contain records of all practical activities covering each of the following sections:

- Investigating Living Organisms
- Using Chemical Analysis Techniques
- Investigating Properties of Materials.

Each activity should be set in a vocational context and include evidence that candidates have:

- carried out risk assessments
- followed standard procedures
- used appropriate scientific equipment and/or materials
- obtained, recorded and analysed scientific data appropriate to the task
- evaluated the practical activity.

Stage 1	Stage 2	Stage 3
Skill:	**Planning and Following Instructions**	
1A. Candidates for each investigation should be able to: **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. **1– 4 marks**	**2A.** Candidates for each investigation should be able to: **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. **5–8 marks**	**3A.** Candidates for each investigation should be able to: **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. **9–12 marks**
Skill:	**Obtaining Evidence By Experimenting**	
1B. Candidates for each investigation should be able to: **1B.1** make simple observations and measurements **1B.2** record them in tables and in charts or graphs with guidance. **1–4 marks**	**2B.** Candidates for each investigation should be able to: **2B.1** make careful and accurate measurements and observations **2B.2** recognise with some guidance when it is necessary to repeat measurements and observations **3B.3** record results accurately in tables and graphs where appropriate and using lines of best fit where appropriate. **5–8 marks**	**3B.** Candidates for each investigation should be able to: **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. **9–12 marks**

Assessment Evidence Grid – Unit 3: *Developing Scientific Skills (continued)*

Skill:		**Analysing and Considering Evidence**			
1C.	Candidates for each investigation should be able to:	**2C.**	Candidates for each investigation should be able to:	**3C.**	Candidates for each investigation should be able to:
		2C.1	identify and explain patterns within data	**3C.1**	identify relationships where appropriate
1C.1	carry out simple calculations with guidance	**2C.2**	carry out simple calculations	**3C.2**	manipulate data using a variety of sophisticated techniques
1C.2	offer simple explanations for their findings.	**2C.3**	draw conclusions which are consistent with the evidence.	**3C.3**	draw and present well-structured and accurate conclusions from the data which illustrate an in-depth understanding.
	1–4 marks		**5–8 marks**		**9–12 marks**
Skill:		**Evaluating Evidence**			
1D.	Candidates for each investigation should be able to:	**2D.**	Candidates for each investigation should be able to:	**3D.**	Candidates for each investigation should be able to:
1D.1	give a simple evaluation of their practical activity.	**2D.1**	give an evaluation of their practical activity	**3D.1**	review their practical activity by presenting a well-structured, logical evaluation of its strengths and weaknesses
		2D.2	suggest an improvement to their method that would allow the collection of more reliable data.	**3D.2**	describe improvements to their method that would allow the collection of more reliable evidence.
	1–2 marks		**3–4 marks**		**5–7 marks**
Skill:		**Vocational Application**			
1E.	Candidates for each investigation should be able to:	**2E.**	Candidates for each investigation should be able to:	**3E.**	Candidates for each investigation should be able to:
1E.1	give a use for this practical activity in a workplace that uses science.	**2E.1**	describe how the practical activity is used in a workplace that uses science.	**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.
	1–2 marks		**3–4 marks**		**5–7 marks**

12.7 Guidance on Assessment

Portfolios of evidence for this unit will be assessed in the following skill areas:

- Planning and Following Instructions
- Obtaining Evidence by Experimenting
- Analysing and Considering Evidence
- Evaluating Evidence
- Vocational Application.

Each skill area should be assessed at least three times, **once** for each section (Investigating Living Organisms, Using Chemical Analysis Techniques and Investigating Properties of Materials). The best mark in each skill area will be used in calculating the final mark for the unit. It is expected that candidates will complete all investigations. **Penalties** will apply to those candidates who complete only one or two sections.

This unit is assessed entirely through evidence that students produce in their portfolios. The descriptors contained in the Assessment Evidence Grid allow the determination of appropriate levels of work. It is assumed that candidates will progress through Stage 1 to Stage 2 and finally to Stage 3 as appropriate. In general, when assessing portfolio work teachers should be aware of:

- an increasing breadth and depth of understanding
- an increasing ability to plan an investigation and independently research for evidence
- an increasing ability to organise and carry out experimental work in the laboratory
- an increasing coherence and ability to analyse, record and evaluate research and laboratory work
- an increasing independence and originality in candidates' work.

Arrangements for Incomplete Portfolios

A maximum of two-thirds of the total of the best marks will be awarded to candidates who complete only **two sections**. A maximum of one-third of the total of the best marks will be awarded to candidates who complete only **one section**.

Stage 1

Candidates must complete the practical activities as listed in the assessment evidence requirements. 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 demonstrate an awareness of the vocational significance of the activity.

Stage 2 Candidates must complete the practical activities as listed in the assessment evidence requirements and 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 make comments about 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 the activity.

Stage 3 The practical activities listed in the assessment evidence requirements 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 results are obviously incorrect. 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.

13

Unit 4
Using Scientific Skills for the Benefit of Society

13.1 About this Unit

In this unit you will find out how science may be applied to benefit society. You will complete a range of scientific investigations to illustrate some ways that particular scientists and engineers use science for the benefit of society.

You will learn about:

- 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.

In Unit 3 you learnt about some of the skills that scientists use in the laboratory. You will need to use these practical, analysing and evaluating skills to complete your investigations. You will also need to be able to describe the importance of your investigations in terms of the use and benefits to society. You will be expected to produce an appropriate risk assessment before starting each investigation.

The unit is divided into four sections:

- Monitoring Living Organisms
- Making a Useful Product
- Assembling an Electronic / Electrical Device
- Using Machines.

13.2 Monitoring Living Organisms

Organisms are adapted to survive within a range of conditions. When biologists grow organisms to obtain products from them, they must provide the organisms with the conditions that suit them best, in order to maximise the amount of product obtained. To do this, they need to monitor the activities/responses of the organism and the conditions in which it is kept. Medical scientists have found that human organisms also operate best within a range of conditions. For example, athletes can improve their physical and mental performance by training and maintaining their health through monitoring their own activities.

You need to investigate the growth and/or development and/or responses of an organism under controlled conditions. (It is important that you show appropriate care and consideration to living organisms during this activity and follow procedures that are ethical.) Possible investigations may be to:

- improve the yield of a plant/microorganism
- monitor the performance of a person in a physical or mental activity
- monitor the effects of changing the environment on the behaviour and/or growth and/or development of an organism.

You need to be able to:

- monitor an organism for a particular purpose
- produce a plan for your investigation that includes information about:
  - the type of organism
  - the purpose of your monitoring activity
  - how you have considered the welfare of your organism, where appropriate, and taken into account any ethical issues
  - the conditions you will be providing and controlling
  - how you intend to monitor the organism's growth, development, and responses
  - a monitoring schedule for the duration of your investigation
  - how you will evaluate the results of your investigation
- carry out the investigation, recording relevant data
- analyse your results and explain what they show
- evaluate your investigation
- describe a useful application of your investigation.

13.3 Making a Useful Product

Chemists produce new products from naturally occurring starting materials, such as metals, rocks and minerals, by physical or chemical change. Chemical industries have to make profits and need to maximise the amount of product produced from the starting materials. For this reason, chemists often have to work quantitatively (ie to measure the amounts of chemical products accurately and to calculate the yield).

You 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.

Chemists make useful products in industry by using many different types of reaction.

You need to be able to:

- 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.

For the preparation, you need to:

- 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.

13.4 Assembling an Electronic / Electrical Device

Electronic and mechanical engineers produce many machines and devices to measure, observe, and move things. We use a vast number of electrical and electronic gadgets at home, at work or during our leisure time. All must be designed and built to do their job.

You need to be able to:

- assemble and assess the effectiveness of **one** electrical or electronic device by:
  - selecting the components you need
  - 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 you have made
- explain the functions of the following components in the electrical or electronic device:
  - power source
  - processor
  - input components
  - output components.

13.5 Using Machines

Mechanical engineers work to produce machines that are efficient and economical to use.

You 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.

13.6 Assessment Evidence for Unit 4: *Using Scientific Skills for the Benefit of Society*

This unit is assessed entirely on evidence contained in your portfolio of work.

You need to produce a portfolio of work which shows how you have used your scientific knowledge and skills to demonstrate how science is used for the benefit of society. This should include the following evidence:

- a report, including a plan, on your investigation into the growth and/or development and/or responses of a living organism under controlled conditions. (You must show appropriate care and consideration when investigating living organisms)
- a report on the production of a chemical product
- a report on making and assessing the effectiveness of one electrical or electronic device
- an example of the use of a mechanical machine in the workplace and its effectiveness.

You will be expected to undertake a risk assessment before each laboratory investigation and include it in your portfolio.

Assessment Evidence Grid – Unit 4: *Using Scientific Skills for the Benefit of Society*

Candidates need to produce a portfolio of work which shows how they have used their scientific knowledge and skills to demonstrate how science is used for the benefit of society. This should include the following evidence:

- a report, including a plan, on the investigation into the growth and/or development and/or responses of a living organism under controlled conditions. (Candidates must show appropriate care and consideration when investigating living organisms)
- a report on the production of a chemical product
- a report on making and assessing the effectiveness of one electrical or electronic device
- an example of the use of a mechanical machine in the workplace and its effectiveness.

Candidates will be expected to undertake a risk assessment before each laboratory investigation and include it in the portfolio.

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

Assessment Evidence Grid – Unit 4: *Using Scientific Skills for the Benefit of Society (continued)*

Stage 1	Stage 2	Stage 3
Making a Useful Product		
1B. Candidates should be able to:	**2B.** Candidates should be able to:	**3B.** Candidates should be able to:
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	**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	**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
1B.2 write a word equation for the reaction with guidance	**2B.2** write a word equation for the reaction	**3B.2** write a balanced chemical equation for the reaction and explain the type of reaction taking place
1B.3 measure the actual yield of the product	**2B.3** calculate the percentage yield of the product given the theoretical yield and using the actual mass of product obtained	**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
1B.4 give a use for the product	**2B.4** calculate the costs of making a given amount of the product	**3B.4** calculate the percentage yield of product obtained from a specified amount of reactant
1B.5 state one way that the rate of the reaction could be increased.	**2B.5** describe the use of the product	**3B.5** explain the industrial importance of the product and its impact on society
	2B.6 describe two factors that affect the rate of the reaction.	**3B.6** use scientific knowledge and understanding to explain the factors that affect the rate of the reaction.
1–5 marks	**6–11 marks**	**12–17 marks**

Assessment Evidence Grid – Unit 4: *Using Scientific Skills for the Benefit of Society (continued)*

Stage 1	Stage 2	Stage 3
Assembling an Electronic/Electrical Device		
1C. Candidates should be able to: **1C.1** safely assemble a useful electrical or electronic device with guidance **1C.2** test the electrical or electronic device with guidance. **1–2 marks**	**2C.** Candidates should be able to: **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. **3–6 marks**	**3C.** Candidates should be able to: **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. **7–9 marks**
Using Machines		
1D. Candidates should be able to: **1D.1** give and describe an example of how mechanical machines may be used in the workplace. **1 mark**	**2D.** Candidates should be able to: **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. **2–3 marks**	**3D.** Candidates should be able to: **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. **4–7 marks**

13.7 Guidance on Assessment

This unit is assessed entirely through evidence that candidates produce in their portfolios.

The descriptors in the Assessment Evidence Grid will allow you to determine levels of work appropriate for your candidates.

In general, when assessing portfolio work teachers should be aware of:

- an increasing breadth and depth of understanding
- an increasing ability to plan an investigation and independently research for evidence
- an increasing ability to organise and carry out experimental work in the laboratory
- an increasing coherence and ability to analyse, record and evaluate research and laboratory work
- an increasing independence and originality in candidates' work.

Stage 1 Candidates should work confidently in the laboratory and obtain products and data, but their use of living organisms and the incorporation of appropriate controls will need monitoring to ensure that it is useful and ethical. They should be aware of health and safety issues and of ethical issues when dealing with others during investigations. Candidates are likely to need help with any chemical calculations and with the design and assembly of electronic or electrical devices. They should be able to make simple evaluations concerning the outcomes of their work. They should be able to suggest a vocational application for their investigations.

Stage 2 Candidates should be able to plan their own investigations with little guidance. In the laboratory candidates should be able to confidently plan, carry out and evaluate their work producing accurate conclusions using the correct terminology. They should be able to undertake calculations arising from their investigations. They should be able to describe a vocational application of their investigations.

Stage 3 Candidates should be able to work independently although with some consultation. They will link evaluations and conclusions to theoretical work and suggest modifications to aspects of 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. They should be able to explain vocational relevance throughout their portfolio of work.

Key Skills and Other Issues

14 Key Skills – Teaching, Developing and Providing Opportunities for Generating Evidence

14.1 Introduction

The Key Skills Qualification requires candidates to demonstrate levels of achievement in the Key Skills of *Application of Number, Communication* and *Information and Communication Technology*.

The units for the 'wider' Key Skills of *Improving own Learning and Performance, Working with Others* and *Problem Solving* are also available. The acquisition and demonstration of ability in these 'wider' Key Skills is deemed highly desirable for all candidates, but they do not form part of the Key Skills Qualification.

Copies of the Key Skills units may be downloaded from the QCA web site (http://www.qca.org.uk/keyskills).

Copies of the Key Skills specification may be downloaded from the AQA website (www.aqa.org.uk).

14.2 Teaching, Developing and Providing Opportunities for Generating Evidence

Areas of study and learning that can be used to encourage the acquisition and use of Key Skills, and to provide opportunities to generate evidence, are signposted in the tables below. Key Skills signposting indicates naturally occurring opportunities for the development of Key Skills during teaching, learning and assessment. Candidates will not necessarily achieve the signposted Key Skill through the related evidence.

Application of Number Level 1

What you must do …	Signposting of Opportunities for Generating Evidence in Subject Content			
	Unit 1	**Unit 2**	**Unit 3**	**Unit 4**
N1.1 Interpret information from **two** different sources. At least **one** source must include a table, chart, graph or diagram.	–	✓	✓	✓
N1.2 Carry out and check calculations to do with: a. amounts or sizes b. scales or proportion c. handling statistics.	–	✓	✓	✓
N1.3 Interpret results of your calculations and present your findings – in **two** different ways using charts or diagrams.	–	✓	✓	✓

Application of Number Level 2

What you must do …	Signposting of Opportunities for Generating Evidence in Subject Content			
	Unit 1	**Unit 2**	**Unit 3**	**Unit 4**
N2.1 Interpret information from a suitable source.	–	✓	✓	✓
N2.2 Use your information to carry out calculations to do with: a. amounts or sizes b. scale or proportions c. handling statistics d. using formulae.	–	✓	✓	✓
N2.3 Interpret the results of your calculations and present your findings.	–	✓	✓	✓

Communication Level 1

What you must do …		Signposting of Opportunities for Generating Evidence in Subject Content			
		Unit 1	**Unit 2**	**Unit 3**	**Unit 4**
C1.1	Take part in either a **one-to-one** discussion or a **group** discussion.	✓	✓	✓	✓
C1.2	Read and obtain information from at least **one** document.	✓	✓	✓	✓
C1.3	Write **two** different types of documents.	✓	–	✓	✓

Communication Level 2

What you must do …		Signposting of Opportunities for Generating Evidence in Subject Content			
		Unit 1	**Unit 2**	**Unit 3**	**Unit 4**
C2.1a	Take part in a group discussion.	✓	✓	✓	✓
C2.1b	Give a talk of at least four minutes.	✓	✓	✓	✓
C2.2	Read and summarise information from at least **two** documents about the same subject. Each document must be a minimum of 500 words long.	✓	✓	✓	✓
C2.3	Write **two** different types of documents each one giving different information. One document must be at least 500 words long.	✓	–	✓	✓

Information and Communication Technology Level 1

What you must do …	Signposting of Opportunities for Generating Evidence in Subject Content			
	Unit 1	**Unit 2**	**Unit 3**	**Unit 4**
ICT1.1 Find and select relevant information.	✓	✓	✓	✓
ICT1.2 Enter and develop information to suit the task.	✓	✓	✓	✓
ICT1.3 Develop the presentation so that the final output is accurate and fit for purpose.	✓	✓	✓	✓

Information and Communication Technology Level 2

What you must do …	Signposting of Opportunities for Generating Evidence in Subject Content			
	Unit 1	**Unit 2**	**Unit 3**	**Unit 4**
ICT2.1 Search for and select information to meet your needs. Use different information sources for each task and multiple search criteria in a least one case.	✓	✓	✓	✓
ICT2.2 Explore and develop the information to suit the task and derive new information.	✓	✓	✓	✓
ICT2.3 Present combined information such as text with image, text with number, image with number.	✓	✓	✓	✓

Improving own Learning and Performance Level 1

What you must do …	Signposting of Opportunities for Generating Evidence in Subject Content			
	Unit 1	**Unit 2**	**Unit 3**	**Unit 4**
LP1.1 Confirm your targets and plan how to meet these with the person setting them.	✓	✓	✓	✓
LP1.2 Follow your plan, to help meet targets and improve your performance.	✓	✓	✓	✓
LP1.3 Review your progress and achievements in meeting targets, with an appropriate person.	✓	✓	✓	✓

Improving own Learning and Performance Level 2

What you must do …	Signposting of Opportunities for Generating Evidence in Subject Content			
	Unit 1	**Unit 2**	**Unit 3**	**Unit 4**
LP2.1 Help set targets with an appropriate person and plan how these will be met.	✓	✓	✓	✓
LP2.2 Take responsibility for some decisions about your learning, using your plan to help meet targets and improve your performance.	✓	✓	✓	✓
LP2.3 Review progress with an appropriate person and provide evidence of your achievements.	✓	✓	✓	✓

Working with Others Level 1

What you must do …	Signposting of Opportunities for Generating Evidence in Subject Content			
	Unit 1	**Unit 2**	**Unit 3**	**Unit 4**
WO1.1 Confirm you understand the given objectives, and plan for working together.	✓	–	✓	✓
WO1.2 Work with others towards achieving the given objectives.	✓	–	✓	✓
WO1.3 Identify ways you helped to achieve things and how to improve your work with others.	✓	–	✓	✓

Working with Others Level 2

What you must do …	Signposting of Opportunities for Generating Evidence in Subject Content			
	Unit 1	**Unit 2**	**Unit 3**	**Unit 4**
WO2.1 Plan work with others.	✓	–	✓	✓
WO2.2 Work co-operatively towards achieving identified objectives.	✓	–	✓	✓
WO2.3 Review your contributions and agree ways to improve work with others.	✓	–	✓	✓

Problem Solving Level 1

What you must do …	Signposting of Opportunities for Generating Evidence in Subject Content			
	Unit 1	**Unit 2**	**Unit 3**	**Unit 4**
PS1.1 Confirm with an appropriate person that you understand the given problem and identify different ways of tackling it.	✓	–	✓	✓
PS1.2 Confirm with an appropriate person what you will do and follow your plan for solving the problem.	✓	–	✓	✓
PS1.3 Check with an appropriate person if the problem has been solved and how to improve your problem solving skills.	✓	–	✓	✓

Problem Solving Level 2

What you must do …	Signposting of Opportunities for Generating Evidence in Subject Content			
	Unit 1	**Unit 2**	**Unit 3**	**Unit 4**
PS2.1 Identify a problem, with help from an appropriate person, and identify different ways of tackling it.	✓	–	✓	✓
PS2.2 Plan and try out at least one way of solving the problem.	✓	–	✓	✓
PS2.3 Check if the problem has been solved and identify ways to improve problem solving skills.	✓	–	✓	✓

15 Spiritual, Moral, Ethical, Social, Cultural and Other Issues

15.1 Spiritual, Moral, Ethical, Social and Cultural Issues

The study of science can contribute to an understanding of spiritual, moral, ethical, social and cultural issues. The following are examples of opportunities to promote candidates' development through the teaching of science.

Spiritual

Through candidates sensing the natural, material and physical world they live in, reflecting on their part in it, exploring questions such as when life starts and where life comes from, and experiencing a sense of awe and wonder at the natural world. Sections 11.2, 11.3, 11.4, 11.5, 12.2, 12.3, 12.4, 13.2, 13.3, 13.4 and 13.5 are relevant.

Moral and Ethical

Through helping candidates see the need to draw conclusions using observation and evidence rather than preconception or prejudice, and through discussion of the implications of the uses of scientific knowledge, including the recognition that such uses can have both beneficial and harmful effects. Exploration of values and ethics relating to applications of science and technology is possible. Sections 10.2, 10.3, 11.2, 11.3, 11.4, 11.5, 12.2, 12.3, 12.4, 13.2, 13.3, 13.4 and 13.5 are relevant.

Social

Through helping candidates recognise how the formation of opinion and the justification of decisions can be informed by experimental evidence, and drawing attention to how different interpretations of scientific evidence can be used in discussing social issues. Sections 10.2, 10.3, 11.2, 11.3, 11.4 and 11.5 are relevant.

Cultural

Through helping candidates recognise how scientific discoveries and ideas have affected the way people think, feel, create, behave and live, and drawing attention to how cultural differences can influence the extent to which scientific ideas are accepted, used and valued.
Sections 11.2, 11.3, 11.4 and 11.5 are relevant.

15.2 European Dimension

AQA has taken account of the 1988 Resolution of the Council of the European Community in preparing this specification and associated specimen papers.

There are opportunities in this specification to relate the study of topics to wider European or global contexts. In particular, a broader European context could be used in relation to Sections 10.2, 10.3, 11.2, 11.3, 11.4 and 11.5.

15.3 Environmental Issues

AQA has taken account of the 1988 Resolution of the Council of the European Community and the Report *Environmental Responsibility: An Agenda for Further and Higher Education* 1993 in preparing this specification and associated specimen papers.

This specification allows responsible attitudes to environmental issues to be fostered. In particular, environmental issues can be considered in relation to Sections.11.2, 11.3, 11.4 and 11.5.

15.4 Health and Safety

This specification will encourage the development of a sense of responsibility for the health and safety of the self and others. More general teaching requirements about health and safety are as applicable to science as to other subjects. Examples can be found in Sections 10.2, 10.3, 12.2, 12.3, 12.4, 13.2, 13.3, 13.4 and 13.5.

When working with equipment and materials, in practical activities and in different environments, including those that are unfamiliar, candidates should be taught:

- about hazards, risks and risk control
- to recognise hazards, assess consequent risks and take steps to control the risks to themselves and others
- to use information to assess the immediate and cumulative risks
- to manage their environment to ensure the health and safety of themselves and others
- to explain the steps they take to control risks.

Centres are reminded of requirements to make their own risk assessments under COSHH regulations in relation to the many materials and processes involved in the teaching of this subject.

15.5 Citizenship

This specification allows treatment of aspects of citizenship through the contribution made to candidates' moral, ethical, social and cultural development (see Section 15.1), through opportunities to teach about the European dimension (see Section 15.2) and through opportunities to promote an understanding of, and responsible attitudes towards, environmental issues (see Section 15.3).

15.6 Avoidance of Bias

AQA has taken great care in the preparation of this specification and associated specimen papers to avoid bias of any kind.

15.7 Use of Organisms

Nothing in this specification requires candidates or teachers to kill animals. Live animals brought into the laboratory for study should be kept unstressed in suitable conditions and should, wherever possible, be returned unharmed to their habitats. Studies of animals and plants in their habitats should aim at minimal disturbance.

Centre-Assessed Components

16 Guidance on Setting Centre-Assessed Units

Portfolio Advisers

Advisers will be available to assist centres with any matters relating to the portfolio units. Details will be provided when AQA knows which centres are following the specification.

Advice will normally be given in response to telephone or e-mail enquiries but will be restricted to:

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

Advisers do not mark work.

17 Supervision and Authentication

17.1 Supervision of Candidates' Work

Candidates' work for assessment must be undertaken under conditions which allow the teacher to supervise the work and enable the work to be authenticated. If it is necessary for some assessed work to be done outside the centre, sufficient work must take place under direct supervision to allow the teacher to authenticate each candidate's whole work with confidence.

17.2 Guidance by the Teacher

The work assessed must be solely that of the candidate concerned.

Internal assessors must record, on the Candidate Record Form, full details of the nature of any assistance given to individual candidates that is beyond that of the teaching group as a whole, but within the parameters laid down by the specification. Any assistance given must be taken into account when assessing candidates' work.

17.3 Unfair Practice

At the start of the course, the supervising teacher is responsible for informing candidates of the AQA regulations concerning malpractice. Candidates must not take part in any unfair practice in the preparation of portfolio unit work to be submitted for assessment, and must understand that to present material copied directly from books or other sources without acknowledgement will be regarded as deliberate deception. Centres must report suspected malpractice to AQA. The penalties for malpractice are set out in the AQA regulations.

17.4 Authentication of Candidates' Work

Both the candidate and the teacher are required to sign declarations confirming that the work submitted for assessment is the candidate's own. The teacher declares that the work was conducted under the specified conditions, and records details of any additional assistance.

18 Standardisation

18.1 Standardising Meetings

Annual standardising meetings will usually be held in the autumn term. Centres entering candidates for the first time must send a representative to the meetings. Attendance is also mandatory in the following cases:

- where there has been a serious misinterpretation of the specification requirements
- where the nature of portfolio unit tasks set by a centre has been inappropriate
- where a significant adjustment has been made to a centre's marks in the previous year's examination.

Otherwise attendance is at the discretion of centres. At these meetings support will be provided for centres in the development of appropriate portfolio unit tasks and assessment procedures.

18.2 Internal Standardisation of Marking

The centre is required to standardise the assessment across different teachers and teaching groups and within and across units to ensure that all work at the centre has been judged against the same standards. If two or more teachers are involved in marking units, one teacher must be designated as responsible for internal standardisation. Common pieces of work must be marked on a trial basis and differences between assessments discussed at a training session in which all teachers involved must participate. The teacher responsible for standardising the marking must ensure that the training includes the use of reference and archive materials such as work from a previous year or examples provided by AQA. The centre is required to send to the moderator the Centre Declaration Sheet, duly signed, to confirm that the marking of portfolio work at the centre has been standardised. If only one teacher has undertaken the marking, that person must sign this form.

A specimen Centre Declaration Sheet appears in Appendix B.

19 Administrative Procedures

19.1 Recording Assessments within each Unit

The candidates' work must be marked according to the assessment criteria. Teachers should keep records of their assessments during the course in a format which facilitates the complete and accurate submission of the final overall assessments at the end of the course on the Candidate Record Forms.

Candidate Record Forms are available on the AQA website in the Administration area. They can be accessed via the following link http://www.aqa.org.uk/admin/p_course.php. The exact design may be modified before the operational version is issued and the correct year's Candidate Record Forms should always be used.

19.2 Submitting Marks and Sample Work for Moderation

For each portfolio unit a mark for each candidate must be submitted to AQA by the date specified. Centres will be informed which portfolio units are required to be submitted in the samples to the moderator.

19.3 Factors Affecting Individual Candidates

Teachers should be able to accommodate the occasional absence of candidates by ensuring that the opportunity is given for them to make up missed assessments.

Special consideration should be requested for candidates whose work has been affected by illness or other exceptional circumstances. Information about the procedure is issued separately.

If work is lost, AQA should be notified immediately of the date of the loss, how it occurred, and who was responsible for the loss. AQA will advise on the procedures to be followed in such cases.

Where special help that goes beyond normal learning support is given, AQA must be informed so that such help can be taken into account when assessment and moderation take place.

Candidates who move from one centre to another during the course sometimes present a problem for a scheme of internal assessment. Possible courses of action depend on the stage at which the move takes place. If the move occurs early in the course the new centre should take responsibility for assessment. If it occurs late in the course it may be possible to accept the assessments made at the previous centre. Centres should contact AQA at the earliest possible stage for advice about appropriate arrangements in individual cases.

19.4 Retaining Evidence

The centre must retain the work of candidates, with Candidate Record Forms attached. These must be kept under secure conditions, from the time they are assessed, to allow for the possibility of an enquiry about results. The work may be returned to candidates after the issue of results provided that no enquiry about results is to be made which will include re-moderation of the work in the portfolio unit(s). If an enquiry about results is to be made, the work must remain under secure conditions until requested by AQA.

20 Moderation

20.1 Moderation Procedures

Moderation of the portfolio work is by inspection of a sample of candidates' work by a moderator appointed by AQA. The centre's marks must be submitted to AQA by the specified date. The moderator will normally inspect the work either by visiting the centre or by receiving the sample by post.

Following the re-marking of the sample work, the moderator's marks are compared with the centre marks to determine whether any adjustment is needed in order to bring the centre's assessments into line with standards generally. In some cases it may be necessary for the moderator to call for the work of other candidates. In order to meet this possible request, centres must have available the work and Candidate Record Form of every candidate entered for the examination and be prepared to submit it on demand. Mark adjustments will normally preserve the centre's order of merit, but where major discrepancies are found AQA reserves the right to alter the order of merit.

20.2 Post-Moderation Procedures

On publication of the GCSE Applied Science (Double Award) results, the centre is supplied with details of the final marks for the portfolio units.

Where moderation is not by a visit the candidates' work is returned to the centre after the examination. At the same time as the issue of results the centre receives a report form giving feedback on the appropriateness of the tasks set, the accuracy of the assessments made, and the reasons for any adjustments to the marks.

Some candidates' work may be retained by AQA for archive purposes.

Awarding and Reporting

21 Grading, Shelf-Life and Re-Sits

21.1 Qualification Titles

The qualification based on this specification has the following title: AQA General Certificate of Secondary Education in Applied Science (Double Award).

21.2 Grading System

The qualification will be graded on a 15-point grade scale: A*A*, A*A, AA, AB, BB, BC, CC, CD, DD, DE, EE, EF, FF, FG, and GG. Candidates who fail to reach the minimum standard for grade G will be recorded as U (unclassified) and will not receive a qualification certificate.

21.3 Grading of Unit Results and Subject Awards

The achievement of each candidate on each unit is reported as a grade on the scale A*–G and as a UMS (Uniform Mark Scale) score.

UMS scores are related to grades as follows:

	Range of UMS scores		
Unit 1	**Unit 2**	**Unit 3/Unit 4**	**Grade**
72–80	252–280	198–220	A*
64–71	224–251	176–197	A
56–63	196–223	154–175	B
48–55	168–195	132–153	C
40–47	140–167	110–131	D
32–39	112–139	88–109	E
24–31	84–111	66–87	F
16–23	56–83	44–65	G
0–15	0–55	0–43	U

The relationship of raw marks to UMS scores is determined separately for each unit, and where appropriate for each tier (see Section 21.4), through the awarding procedures for each series. This allows for any variation in the demand of the assessments between series to be taken into consideration. Raw marks that represent the minimum performance to achieve a grade are chosen, and these boundary marks are assigned the minimum UMS score for the grade. Between boundaries interpolation is used to relate raw marks to UMS scores.

When a candidate is entered for a subject award, the grade for the qualification is obtained by adding together the UMS scores for the units that contribute to the subject award, and using the following relationship between total UMS score and grade:

Range of total UMS scores	Grade
720–800	A*A*
680–719	A*A
640–679	AA
600–639	AB
560–599	BB
520–559	BC
480–519	CC
440–479	CD
400–439	DD
360–399	DE
320–359	EE
280–319	EF
240–279	FF
200–239	FG
160–199	GG

21.4 Grading and Tiers

The centre-assessed units are not tiered and the full range of grades A*–G is available to candidates for these units.

For Unit 2, candidates must be entered for either the Foundation Tier or the Higher Tier. For candidates entered for the Foundation Tier, grades C–G are available. For candidates entered for the Higher Tier, grades A*–D are available. There is a safety net for candidates entered for the Higher Tier, where an allowed grade E will be awarded if candidates just fail to achieve grade D. Candidates who fail to achieve a grade E on the Higher Tier or grade G on the Foundation Tier will be reported as unclassified.

For the tiered unit, candidates cannot obtain a UMS score corresponding to a grade that is above the range for the tier entered. Therefore the maximum UMS score for candidates on a Foundation Tier paper is 195. In other words, they cannot achieve a UMS score corresponding to grade B. Candidates who just fail to achieve grade E on the Higher Tier receive the UMS score corresponding to their raw mark, ie they do not receive a UMS score of zero.

		During the awarding procedures the relationship between raw marks and UMS score is decided for each tier separately. Where a grade is available on two tiers, for example grade C, the two raw marks chosen as the boundary for the grade on the two tiers are given the same UMS score. Therefore candidates receive the same UMS score for the same achievement whether this is demonstrated on the Foundation or the Higher Tier assessments. Individual assessment unit results will be separately reported.
21.5	Shelf-life of Unit Results	The shelf-life of individual unit results, prior to certification of the qualification, is limited only by the shelf-life of the specification.
21.6	Re-Sits	Each assessment unit may be re-taken an unlimited number of times within the shelf-life of the specification. The best result will count towards the final award.
21.7	Minimum Requirements	Candidates do not have to achieve a grade G or better on every unit to achieve overall qualification certification. Candidates will be graded on the basis of work submitted for assessment.
21.8	Awarding and Reporting	This specification complies with the grading, awarding and certification requirements of the GCSE, GCE and AEA Code of Practice April 2008, and will be revised in the light of any subsequent changes in future years.

Appendices

A Grade Descriptions

The following grade descriptors indicate the level of attainment characteristic of the given grade at GCSE. They give a general indication of the required learning outcomes at each specified grade. The descriptors should be interpreted in relation to the content and assessment evidence requirements outlined in the specification; they are not designed to define that content.

The grade awarded will depend in practice upon the extent to which the candidate has met the assessment evidence requirements overall. Shortcomings in some aspects of the assessment may be balanced by better performance in others.

Grade A Candidates demonstrate a detailed knowledge and understanding of science content and how science works, encompassing the principal concepts, techniques, and facts across all areas of the specification. They use technical vocabulary and techniques with fluency, clearly demonstrating communication and numerical skills appropriate to a range of situations.

They demonstrate a good understanding of the relationships between data, evidence and scientific explanations and theories. They are aware of areas of uncertainty in scientific knowledge and explain how scientific theories can be changed by new evidence.

Candidates use and apply their knowledge and understanding in a range of tasks and situations. They use this knowledge, together with information from other sources, effectively in planning a scientific task, such as a practical procedure, testing an idea, answering a question, or solving a problem.

Candidates describe how, and why, decisions about uses of science are made in contexts familiar to them, and apply this knowledge to unfamiliar situations. They demonstrate good understanding of the benefits and risks of scientific advances, and identify ethical issues related to these.

They choose appropriate methods for collecting first-hand and secondary data, interpret and question data skilfully, and evaluate the methods they use. They carry out a range of practical tasks safely and skilfully, selecting and using equipment appropriately to make relevant and precise observations.

Candidates select a method of presenting data appropriate to the task. They draw and justify conclusions consistent with the evidence they have collected and suggest improvements to the methods used that would enable them to collect more valid and reliable evidence

Grade C

Candidates demonstrate a good overall knowledge and understanding of science content and how science works, and of the concepts, techniques, and facts across most of the specification. They demonstrate knowledge of technical vocabulary and techniques, and use these appropriately. They demonstrate communication and numerical skills appropriate to most situations.

They demonstrate an awareness of how scientific evidence is collected and are aware that scientific knowledge and theories can be changed by new evidence.

Candidates use and apply scientific knowledge and understanding in some general situations. They use this knowledge, together with information from other sources, to help plan a scientific task, such as a practical procedure, testing an idea, answering a question, or solving a problem.

They describe how, and why, decisions about uses of science are made in some familiar contexts. They demonstrate good understanding of the benefits and risks of scientific advances, and identify ethical issues related to these.

They carry out practical tasks safely and competently, using equipment appropriately and making relevant observations, appropriate to the task. They use appropriate methods for collecting first-hand and secondary data, interpret the data appropriately, and undertake some evaluation of their methods.

Candidates present data in ways appropriate to the context. They draw conclusions consistent with the evidence they have collected and evaluate how strongly their evidence supports these conclusions.

Grade F

Candidates demonstrate a limited knowledge and understanding of science content and how science works. They use a limited range of the concepts, techniques and facts from the specification, and demonstrate basic communication and numerical skills, with some limited use of technical terms and techniques.

They show some awareness of how scientific information is collected and that science can explain many phenomena.

They use and apply their knowledge and understanding of simple principles and concepts in some specific contexts. With help they plan a scientific task, such as a practical procedure, testing an idea, answering a question, or solving a problem, using a limited range of information in an uncritical manner. They are aware that decisions have to be made about uses of science and technology and, in simple situations familiar to them, identify some of those responsible for the decisions. They describe some benefits and drawbacks of scientific developments with which they are familiar and issues related to these.

They follow simple instructions for carrying out a practical task and work safely as they do so.

Candidates identify simple patterns in data they gather from first-hand and secondary sources. They present evidence as simple tables, charts and graphs, and draw simple conclusions consistent with the evidence they have collected.

B

Record Forms

Candidate Record Forms and Centre Declaration Sheets are available on the AQA website in the Administration area. They can be accessed via the following link
http://www.aqa.org.uk/admin/p_course.php

C

Overlaps with other Qualifications

Specifications covering the Programme of Study

Many of the specifications in the AQA GCSE Sciences suite described in Section 4.2 cover the programme of study for KS4 Science, and there is therefore significant overlap between them. The content for GCSE Applied Science (Double Award) can be found in both GCSE Science A and GCSE Science B.

The entry restrictions in Section 3.3 reflect this overlap.

Relationship to Other Subjects

Some of the knowledge, skills and understanding included in this specification may also be encountered by candidates following courses leading towards other subject qualifications. This is a feature of National Curriculum provision and means that the specification can complement other subjects and enable candidates to consolidate their learning. Some overlap exists with the following GCSE subjects:

- Human Physiology and Health
- Environmental Science.

D Units, Symbols and Chemical Compounds

You need to know how to measure and/or calculate the following quantities, using the correct units and their symbols:

Quantity	**Units/symbols**
mass	kilogram, kg; gram, g; milligram, mg; microgram, µg
length	kilometre, km; metre, m; centimetre, cm; millimetre, mm; micrometre, µm
volume	cubic metre, m^3; cubic decimetre, dm^3 (litre, l); cubic centimetre, cm^3 (millilitre, ml)
time	hour, h; minute, min; second, s
temperature	degrees Celsius, °C
chemical quantity	mole, mol
potential difference (voltage)	volt, V
current	ampere, A; milliampere, mA
resistance	ohm, Ω; kilohm, kΩ; megohm, MΩ
force	newton, N
energy	kilojoule, kJ; joule, J; kilowatt-hour, kWh
power	kilowatt, kW; watt, W
density	gram per cubic centimetre, g/cm^3; kilogram per cubic metre, kg/m^3
concentration	gram per cubic decimetre, g/dm^3; (=g/l) mole per cubic decimetre, mol/dm^3 (=mol/l)
velocity	metres per second, m/s
acceleration	metres per second m/s^2

You need to know the chemical symbols for the following elements and be able to classify them as metals or non-metals:

Non-Metals		**Metals**	
Element	Chemical Symbol	Element	Chemical Symbol
Argon	Ar	Aluminium	Al
Bromine	Br	Calcium	Ca
Carbon	C	Gold	Au
Chlorine	Cl	Iron	Fe
Hydrogen	H	Lead	Pb
Nitrogen	N	Magnesium	Mg
Oxygen	O	Potassium	K
Phosphorus	P	Silver	Ag
Silicon	Si	Sodium	Na
Sulfur	S	Zinc	Zn

You need to know the names and formulae for some elements and compounds that consist of molecules.

Compound	Formula
Ammonia	NH_3
Carbon dioxide	CO_2
Chlorine	Cl_2
Ethanol	C_2H_5OH
Hydrogen	H_2
Hydrogen Chloride	HCl
Methane	CH_4
Nitrogen	N_2
Oxygen	O_2
Water	H_2O