Oxford Cambridge and RSA Examinations

OCR AS GCE in Science (3885)

OCR Advanced GCE in Science (7885)

Approved Specifications – Revised Edition

First Advanced Subsidiary GCE certification was 2001 QAN (3885) 100/0629/1

First Advanced GCE certification was 2002 QAN (7885) 100/0460/9

Foreword to the Revised Edition

This Revised Edition has been produced to consolidate earlier revisions to these specifications and any changes contained within have previously been detailed in notices to centres. **There is no change to the structure or teaching content of the specification and most differences are cosmetic**. Sidelining will be used to indicate any significant changes.

The main changes are:

Re-sits of Units – The restrictions on re-sitting units have been removed, enabling candidates to re-take units more than once (for details see page 21).

Foreword (continued)

This booklet contains OCR's Advanced Subsidiary GCE (AS) and Advanced GCE (A level) Science specifications for teaching from September 2004.

The AS GCE is assessed at a standard appropriate for candidates who have completed the first year of study of a two year Advanced GCE course, i.e. between GCSE and Advanced GCE. It forms the first half of the Advanced GCE course in terms of teaching time and content. When combined with the second half of the Advanced GCE course, known as 'A2', the AS forms 50% of the assessment of the total Advanced GCE. However, the AS can be taken as a 'stand-alone' qualification. A2 is weighted at 50% of the total assessment of the Advanced GCE.

In these specifications the term **module** is used to describe specific teaching and learning requirements. The term **unit** describes a unit of assessment.

Each teaching and learning module is assessed by its associated unit of assessment.

These specifications meet the requirements of the Common Criteria (Qualifications and Curriculum Authority, 1999), the GCE AS and Advanced Level Qualification-Specific Criteria (QCA, 1999) and the relevant Subject Criteria (QCA, 1999).

This specification is one of a suite of linked specifications in the sciences. All have similar structures and schemes of assessment.

Biology	**3881 & 7881**
Human Biology	**3886 & 7886**
Chemistry	**3882 & 7882**
Physics	**3883 & 7883**
Geology	**3884 & 7884**
Science	**3885 & 7885**

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Specification Summary

Outline

The OCR AS GCE and Advanced GCE **Science** specifications are post-16 balanced science specifications; they extend GCSE balanced science and contain elements of biology, chemistry and physics, as well as earth science and environmental science. The specifications are purpose-built for those candidates who wish to continue with a broad study of science beyond GCSE but who choose not to specialise in the separate science disciplines.

Specification Content

All modules draw, as appropriate, on the content identified in the QCA Subject Criteria for Biology, Chemistry and Physics. The content is chosen to provide a balanced and coherent study of science. To this end, content from earth science and environmental science is also included. In addition, the specifications require candidates to develop abilities used in making sense of scientific information.

Scheme of Assessment

The AS GCE forms 50% of the assessment weighting of the full Advanced GCE. AS GCE is assessed at a standard between GCSE and Advanced GCE and can be taken as a stand-alone qualification or as the first half of the full Advanced GCE course. Assessment is by means of **3 Units of Assessment** for AS GCE and **6 Units of Assessment** for Advanced GCE:

AS GCE	Candidates take Units 2841, 2842 and 2843.
Advanced GCE	Candidates take Units 2841, 2842, 2843, 2844, 2845 and 2846.

Units of Assessment

Unit	Level	Name of unit	Duration	Mode of Assessment	Weighting	
					AS	Advanced GCE
2841	AS	Science and the Natural Environment	1 hour	Written Examination	30%	15%
2842	AS	Science and Human Activity	1 hour	Written Examination	30%	15%
2843	AS	Interpreting Scientific Information/ Experimental and Investigative Skills 1	1 hour	Written Examination	20%	10%
			-	Coursework	20%	10%
2844	A2	Science and Environmental Management	1 hour 30 min	Written Examination	-	15%
2845	A2	Synthesis of Scientific Concepts	1 hour 30 min	Written Examination	-	15%
2846	A2	Science and Global Processes/ Experimental and Investigative Skills 2	1 hour	Written Examination	-	10%
			-	Coursework	-	10%

Units 2843 and 2846 each consist of two components. Both components must be taken in each of these units.

Question Paper Requirements

The question papers for Units 2841, 2842 and 2844 have a common format. They contain both structured questions and questions which require more extended answers. All questions on these papers are compulsory. Quality of written communication is assessed within those parts of the questions which require more extended answers.

The written paper for Component 1 of Unit 2843 consists of questions based on the interpretation of scientific information in the form of, for example, a short article. All questions are compulsory.

The question paper for Unit 2845 consists entirely of questions covering synoptic assessment. All questions are compulsory. Quality of written communication is assessed within those parts of the questions which require more extended answers.

The written paper for Component 1 of Unit 2846 consists of structured questions, none of which require extended answers. All questions are compulsory.

Coursework Requirements

For both AS GCE and Advanced GCE, candidates are assessed on four experimental and investigative skills. One mark per skill must be submitted for each candidate, for AS GCE (Unit 2843, Component 2) and for A2 (Unit 2846, Component 2). Work is marked by the teacher, internally standardised in the Centre, and externally moderated by OCR. There is synoptic assessment in Unit 2846 Component 2.

Overlap with Other Qualifications

Some learning outcomes within these specifications are common to learning outcomes within OCR Biology, Chemistry and Physics specifications. There are also learning outcomes in common with the OCR GNVQ in Science. Full details are given in section 1.3.

1 Introduction

These OCR specifications lead to qualifications at AS GCE and Advanced GCE in **Science**. Candidates take three Units of Assessment for AS and a further three for A2. AS and A2 combined constitute the full Advanced GCE specification. There is coursework in both AS and A2.

These specifications alone define the assessment. However, the specifications are supported by packs of *Science in the Environment* materials, written and developed by the University of York Science Education Group in collaboration with OCR and with sponsorship from BP Amoco. Four packs of teaching and learning materials support the AS specification and a further four packs support the A2 specification. The packs of materials have been specifically written to support candidates following courses based on these specifications but other materials may equally well be used throughout the course.

Broad Aims

These Science specifications are intended to facilitate broadening of AS GCE and Advanced GCE programmes for candidates who wish to continue with a broad and balanced study of science after GCSE but who do not wish to specialise in the study of one (or more) of the separate science disciplines. The AS specification has also been used successfully by students following accelerated programmes in Key Stage 4.

For these non-specialist candidates, an important aim of learning science is to be able to reach a scientific understanding of situations which arise throughout life. It is intended that these specifications facilitate scientific understanding of this kind and promote a lifelong interest in science among members of the general public.

Broad objectives

The specifications contain aspects of chemistry, physics and biology as well as earth science and environmental science; however, the specification content is not organised in terms of chemistry, physics, biology etc. Many of the key principles of science, which form the essential foundation of the understanding of science for non-specialists, cross traditional subject boundaries and form part of more than one of the separate science disciplines. This is reflected in the organisation of the specification content.

Of particular relevance to the lives of non-specialists is the ability to reach scientifically informed opinions about articles and other sources of information which, as members of the general public, they are likely to encounter. The importance of interpreting scientific information is recognised in these specifications and is included in the AS assessment. Experience of the role of experiment is important in any course in science and is recognised in these specifications by the inclusion of coursework components, at both AS and A2, based on assessment of experimental skills. Scientific experimental work is, however, likely to play a far less significant role in the lives of members of the general public than it does in the professional work of science specialists.

Progression opportunities

Four principal candidate audiences are envisaged for AS GCE and Advanced GCE in Science. For the first audience, learning science will form part of their education as members of the general, lay public. These candidates are unlikely to continue a formal study of science into their adult lives. The AS Science specification has been designed to meet the needs of such candidates and to promote their lifelong interest in science. Some candidates will find post-16 science attractive and will continue for a further year, taking their study of science deeper and extending their course to Advanced GCE.

The second principal audience consists of those who are likely to make more direct use of science in their lives, for example, those whose jobs, although not primarily in science, will involve some contact with science. The A2 specification has been designed to provide them with a more detailed, but still broad, study of science.

The two aforementioned types of candidate may progress to Higher Education but it is not envisaged that they will specialise in any of the science disciplines.

The third candidate audience comprises those taking AS Science as part of an accelerated programme in Key Stage 4; they may do so having taken GCSE Science early or as an alternative to it. Such able candidates may progress to courses leading to GCE A/AS sciences post - 16.

The fourth candidate audience comprises adult learners who may find it helpful to study broad and balanced science at AS GCE or Advanced GCE when re-entering the education system with a view to making career changes. Thus both specifications serve to encourage and facilitate lifelong learning.

The two latter types of candidate may progress to Higher Education to specialise in one of the science disciplines.

Recommended prior learning

The AS GCE and Advanced GCE specifications build on the knowledge, understanding and skills set out in the National Curriculum Key Stage 4 programme of study for Double Science. However, it is accepted that a proportion of candidates will enter the AS specification from routes other than the National Curriculum in Science, for example as adult lifelong learners. For this reason, recommended prior knowledge within the modules of teaching and learning is described in detail in Section 5, Specification Content, rather than simply in terms of National Curriculum statements.

The assessment of experimental and investigative skills builds from GCSE. The skills are the same as in Sc1 of GCSE, and the mark descriptors are formulated in the same way as the GCSE mark descriptors.

Conclusion

All modules in these specifications cover content identified in the QCA Subject Criteria for Biology, Chemistry and Physics. Content is drawn from these subject criteria as appropriate for the non-specialist candidates for whom the specifications have been developed.

Environmental situations are of particular concern to the general public and these Science specifications provide candidates with opportunities to apply the science they learn to a range of environmental phenomena and issues. It is expected that social, economic, environmental, ethical, medical and technological aspects of science will be incorporated into the delivery of these specifications. References to these aspects of science are integrated into the Units of Assessment.

1.1 Certification Title

These specifications are shown on a certificate as:

- OCR Advanced Subsidiary GCE in Science.
- OCR Advanced GCE in Science.

1.2 Language

These specifications and associated assessment materials are in English only.

1.3 Overlap with other qualifications

These specifications draw on the Subject Criteria for Biology, Chemistry and Physics. Inevitably there are learning outcomes in common with AS GCE and Advanced GCE specifications with the titles Biology, Chemistry and Physics. There are also learning outcomes in common with the Advanced GNVQ in Science. Those Units of the OCR Biology, Chemistry and Physics specifications, and those compulsory Units of the Advanced GNVQ in Science, in which there are some learning outcomes in common with this specification are summarised below.

Unit 2841 **Biology Unit 2801 - cell structure, energy and ecosystems**

Chemistry Unit 2811- atoms, atomic structure

Physics Unit 2823 Component 1 - waves

Physics Unit 2824 - radioactivity and the nuclear atom

Physics Unit 2825 - nuclear fission and nuclear fusion

Unit 2842 **Biology Unit 2801 - biological molecules, enzymes**

Chemistry Unit 2811 - molecules and bonding

Chemistry Unit 2813 Component 1 - reaction rates

Chemistry Unit 2815 Component 2 - biological molecules, enzymes

Chemistry Unit 2815 Component 3 - the atmosphere

Physics Unit 2822 - electricity

Physics Unit 2824 - fields, ideal gases

GNVQ Science Unit 7437 - chemical manufacture, reaction rates

GNVQ Science Unit 7439 - enzymes

Unit 2844 **Biology Unit 2801 - nuclear division**

Biology Unit 2804 - meiosis, adaptation to environment

Biology Unit 2805 Component 1 - asexual reproduction, sexual reproduction in plants

Biology Unit 2805 Component 2 - selective breeding, genetic engineering

Chemistry Unit 2811 - atomic structure (electronic)

Chemistry Unit 2814 - enthalpy change, chemical equilibrium, infrared spectroscopy

Chemistry Unit 2815 Component 2 - nucleic acids

Physics Unit 2824 - spectra

GNVQ Science Unit 7437 - enthalpy change, chemical equilibrium

GNVQ Science Unit 7439 - genetic engineering

Unit 2846, Component 1 **Chemistry Unit 2811 - intermolecular bonding**

Physics Unit 2821 - motion

Physics Unit 2823 Component 1 - optics

Physics Unit 2826 Component 1 - motion, fields

GNVQ Science Unit 7438 – motion

The specification for the AS GCE in Science for Public Understanding also draws from the Subject Criteria for Biology, Chemistry and Physics, and the specification for Environmental Science draws on the Subject Criteria for Biology. There are also learning outcomes in common with these specifications.

However, these OCR AS GCE and Advanced GCE specifications in Science share **no** Units in common with any of the specifications mentioned above.

These OCR specifications in Science are complementary to specifications in Environmental Science and in Science for Public Understanding. The OCR Science specification leads to courses in science, in which the understanding of science is illustrated and enhanced by its application to selected environmental contexts as appropriate. Conversely, a specification in Environmental Science leads to courses about the environment, which use selected biological principles as appropriate. The specification for Science for Public Understanding leads to courses about the nature of science, which use a foundation of selected scientific principles on which to base the understanding of the nature of science.

These OCR Science specifications occupy a contrasting position in post-16 provision from Advanced GCE specifications in Biology, Chemistry and Physics and Advanced GNVQ in Science, which are designed for candidates who intend to become specialists in one or more of the sciences. The OCR Science specification is designed for non-specialist candidates. It presents a broad treatment of science and provides opportunities for candidates to gain experience of the links between different areas of science. Courses based on the OCR AS GCE specification in Science can therefore complement and enhance the programmes of candidates who are specialising in sciences. Because of its contrasting nature, it is not recommended that the OCR Science specification is taught in common with these other specifications.

1.4 Exclusions

Every 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 GCE 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 these specifications is 1310.

1.5 Code of Practice Requirements

These specifications will comply in all respects with the 2004 revised Code of Practice.

2 Specification Aims

The aims of these AS GCE and Advanced GCE specifications are to encourage candidates to:

- develop essential knowledge and understanding of the concepts of science, and the skills needed for the use of these in new and changing situations throughout life;
- develop an understanding of scientific methods, including the link between theory and experiment and how scientific models develop;
- be aware of advances in technology, including information technology and instrumentation, relevant to science;
- recognise the value and responsible use of science in society;
- recognise that science is a human endeavour that interacts with social, economic and industrial matters;
- sustain and develop their enjoyment of, and interest in, science.
- recognise the quantitative nature of science and understand how mathematical expressions relate to scientific principles.

In addition, the Advanced GCE specification aims to encourage candidates to:

- show knowledge and understanding of facts, principles and concepts from different areas of science and to make and use connections between them.

2.1 Spiritual, Moral, Ethical, Social and Cultural Issues

These specifications provide an opportunity for candidates to appreciate the following aspects of the natural world:

- the endeavour of science in describing its structure and functioning (throughout modules 2841, 2842, 2844 and 2846);
- the scale and impact of natural processes and phenomena (module 2841, sections 5.1.1, 5.1.3, 5.1.4 and 5.1.5; module 2842, sections 5.2.1 and 5.2.2; module 2844, section 5.4.5; module 2846, Component 1, sections 5.6.1, 5.6.2 and 5.6.4);
- the importance of the Sun, plant life and micro-organisms to processes on Earth (module 2841, sections 5.1.3 and 5.1.4; module 2842, section 5.2.1; module 2844, section 5.4.1);
- moral, ethical, social and cultural aspects of some of the applications of science and technology (module 2844, sections 5.4.1, 5.4.3 and 5.4.6).

2.2 Environmental Education

Aspects of environmental education permeate the whole course of study, but the following are explicitly covered:

- use of satellite imagery to view the environment (module 2841, section 5.5.1);
- existence of natural, background radioactivity (module 2841, section 5.1.2);
- importance of the Sun in sustaining life on Earth (module 2841, section 5.1.3);
- interdependence of living things (module 2841, section 5.1.3);
- importance of steady state and feedback in environmental situations (module 2841, section 5.1.4);
- biodiversity (module 2841, section 5.1.5);
- atmospheric circulation and climate (module 2842, section 5.2.1);
- greenhouse effect and global warming (module 2842, section 5.2.1);
- acid deposition (module 2842, section 5.2.2);
- transfer of atmospheric pollution across national boundaries (module 2842, section 5.2.2);
- clean technology and industrial processes (module 2842, section 5.2.4);
- sustainable agricultural practices (module 2844, section 5.4.2);
- analytical techniques in environmental monitoring (module 2844, section 5.4.5);
- life-cycle assessment (module 2844, section 5.4.5);
- structure of the Earth (module 2846, Component 1, section 5.6.2);
- ocean circulation system and climate (module 2846, Component 1, section 5.6.4).

2.3 European Dimension

Although these specifications do not make specific reference to scientific aspects of the European Dimension, it may be drawn into the course of study in a number of ways. For example, the *Science in the Environment* materials, which may be used to support the teaching of courses leading to this specification, use examples and case studies drawn from European contexts which are related to the following Units of this specification:

- acid deposition and trans-boundary pollution in Europe (module 2842, sections 5.2.1 and 5.2.2);

- water purification and European Union water quality regulations (module 2844, section 5.4.4);
- control of nutrient levels and algal blooms in the North Adriatic Sea (module 2844, section 5.4.5).

2.4 Health Education

The following aspects of Health Education feature in these specifications:

- radioactivity (module 2841, section 5.1.2);
- use of epidemiological studies to investigate possible adverse effects on health of power frequency fields (module 2842, section 5.2.3).

2.5 Economic and Industrial Understanding

These specifications promote understanding of the following industrial activities:

- genetic engineering (module 2844, section 5.4.3);
- agricultural industry (module 2844, section 5.4.1);
- transmission and distribution of electricity (module 2842, section 5.2.3);
- chemical manufacture (module 2842, section 5.2.4);
- use of enzymes in industry (module 2842, section 5.2.5);
- water purification (module 2844, section 5.4.4).

2.6 Avoidance of Bias

OCR has taken great care in the preparation of these specifications and assessment materials to avoid bias of any kind.

3 Assessment Objectives

Knowledge, understanding and skills are closely linked. These specifications require that candidates demonstrate the following assessment objectives in the context of the content and skills prescribed. Assessment Objectives AO1-AO3 are the same for AS GCE and Advanced GCE; AO4 applies only to the A2 part of the Advanced GCE course.

AO1 Knowledge with Understanding

Candidates should be able to:

- recognise, recall and show understanding of specific scientific facts, terminology, principles, relationships, concepts and practical techniques;
- draw on existing knowledge to show understanding of the ethical, social, economic, environmental and technological implications and applications of science;
- select, organise and present relevant information clearly and logically, using appropriate vocabulary where appropriate.

AO2 Application of Knowledge and Understanding, Analysis, Synthesis and Evaluation

Candidates should be able to:

- describe, explain and interpret phenomena and effects in terms of scientific principles and concepts, presenting arguments and ideas clearly and logically, using specialist vocabulary where appropriate;
- interpret and translate, from one form into another, data presented as continuous prose or in tables, diagrams, drawings and graphs;
- carry out relevant calculations;
- apply scientific principles and concepts to unfamiliar situations including those which relate to the ethical, social, economic, and technological implications and applications of science;
- assess the validity of scientific information, experiments, inferences and statements.

AO3 Experiment and Investigation

Candidates should be able to:

- devise and plan experimental and investigative activities, selecting appropriate techniques;
- demonstrate safe and skilful practical techniques;
- make observations and measurements with appropriate precision and record these methodically;
- interpret, explain, evaluate and communicate the results of their experimental and investigative activities clearly and logically using scientific knowledge and understanding and using appropriate specialist vocabulary.

AO4 Synthesis of Knowledge, Understanding and Skills

Candidates should be able to:

- bring together knowledge, principles and concepts from different areas of science and apply them in a particular context, expressing ideas clearly and logically and using appropriate specialist vocabulary;
- use scientific skills in contexts which bring together different areas of the subject.

The assessment objectives are weighted as follows:

	AS GCE	A2	Advanced GCE
AO1	48.0%	25.0%	36.5%
AO2	32.0%	25.0%	28.5%
AO3	20.0%	10.0%	15.0%
AO4	0.0%	40.0%	20.0%

3.1 Specification Grid

The relationship between the assessment objectives and the units of assessment is shown in the specification grid below.

Unit of Assessment		Percentage of Advanced GCE					Total
		Level	AO1	AO2	AO3	AO4	
2841		AS	12.0	3.0	0.0	0.0	15.0
2842		AS	12.0	3.0	0.0	0.0	15.0
2843	Component 1	AS	0.0	10.0	0.0	0.0	10.0
	Component 2	AS	0.0	0.0	10.0	0.0	10.0
2844		A2	7.5	7.5	0.0	0.0	15.0
2845		A2	0.0	0.0	0.0	15.0	15.0
2846	Component 1	A2	5.0	5.0	0.0	0.0	10.0
	Component 2	A2	0.0	0.0	5.0	5.0	10.0
Total			36.5	28.5	15.0	20.0	100

3.2 Quality of Written Communication

The requirement for all AS GCE and Advanced GCE specifications to assess candidates' quality of written communication is met through all four assessment objectives. Questions which provide an assessment of quality of written communication are included in question papers for Units 2841, 2842, 2844 and 2845, and in the assessment of practical and investigative skills in Units 2843, Component 2 and 2846, Component 2.

4 Scheme of Assessment

Candidates take three units of assessment, including a coursework component, for AS GCE, followed by three units of assessment, including a coursework component, for A2 if they are seeking an Advanced GCE award.

Units of Assessment

Unit	Level	Name of unit	Duration	Mode of Assessment	Weighting	
					AS	Advanced GCE
2841	AS	Science and the Natural Environment	1 hour	Written Examination	30%	15%
2842	AS	Science and Human Activity	1 hour	Written Examination	30%	15%
2843	AS	Interpreting Scientific Information/ Experimental and Investigative Skills 1	1 hour	Written Examination	20%	10%
			-	Coursework	20%	10%
2844	A2	Science and Environmental Management	1 hour 30 min	Written Examination	-	15%
2845	A2	Synthesis of Scientific Concepts	1 hour 30 min	Written Examination	-	15%
2846	A2	Science and Global Processes/ Experimental and Investigative Skills 2	1 hour	Written Examination	-	10%
			-	Coursework	-	10%

Units 2843 and 2846 each consist of two components. Both components must be taken in the same session in each of these units.

If a candidate retakes one of these units within 12 months, they have the opportunity to carry forward the mark for the coursework component.

All candidates for units 2843 and 2846 should be entered under the relevant unit code with one of the following option codes:

Unit	Entry Option	Components to be taken		Mode of Assessment	Duration
2843	A	1	Interpreting Scientific Information	Written Examination	1 hour
		2	Experimental and Investigative Skills 1	Coursework	-
	B	1	Interpreting Scientific Information	Written Examination	1 hour
		82	Experimental and Investigative Skills 1 (mark carried forward)	Coursework	-
2846	A	1	Science and Global Processes	Written Examination	1 hour
		2	Experimental and Investigative Skills 2	Coursework	-
	B	1	Science and Global Processes	Written Examination	1 hour
		82	Experimental and Investigative Skills 2 (mark carried forward)	Coursework	-

Rules of Combination

Candidates must take the following combination of units:

AS GCE	Units 2841, 2842 and 2843
Advanced GCE	Units 2841, 2842, 2843, 2844, 2845 and 2846.

Unit Availability

There are two unit sessions each year, in January and June.

The availability of units is shown below.

Unit	Unit Title	Jan	June
2841	Science and the Natural Environment	✓	✓
2842	Science and Human Activity	✓	✓
2843	Interpreting Scientific Information/ Experimental and Investigative Skills 1		✓
2844	Science and Environmental Management	✓	✓
2845	Synthesis of Scientific Concepts		✓
2846	Science and Global Processes/ Experimental and Investigative Skills 2		✓

Sequence of Units

The normal sequence in which the units could be taken is Units 2841, 2842 and 2843 in the first year of a course of study, leading to an AS award, then Units 2844, 2845 and 2846 in the second year, together leading to the Advanced GCE award. However, units may be taken in other sequences.

Alternatively, candidates may take all units at the end of their AS GCE or Advanced GCE course in a 'linear' fashion, if desired.

Synoptic Assessment

Synoptic assessment involves the explicit drawing together of knowledge, understanding and skills learned in different parts of the Advanced GCE course. Assessment Objective AO4 relates specifically to synoptic assessment. It accounts for 20% of the total Advanced GCE marks and is assessed only in A2 Units 2845 and 2846, Component 2.

Synoptic assessment:

- requires candidates to make and use connections between different areas of science, for example, by applying knowledge of a number of areas to a particular situation or context, or by using knowledge and understanding of principles and concepts of science in planning experimental work and in the analysis and evaluation of data;
- provides opportunities for candidates to use ideas and skills which permeate science, for example, the analysis and evaluation of empirical data and other information in contexts which may be new to them.

The questions set in the examination paper for Unit 2845 require candidates to demonstrate these abilities. In Component 2 of Unit 2846, the descriptors for Skill P (planning) and Skill A (analysing evidence and drawing conclusions) require candidates to demonstrate these abilities.

Units 2845 and 2846 should normally, therefore, be taken at the end of the course, but this is no longer a requirement.

Certification

Candidates may enter for:

- AS GCE certification.
- AS GCE certification, bank the result, and complete the A2 assessment at a later date.
- Advanced GCE certification.

Candidates must enter all six AS and A2 units to qualify for the full Advanced GCE award.

Individual unit results, prior to certification of the qualification, have a shelf life limited only by that of the qualification.

Re-sits of Units of Assessment

The restrictions on re-sitting units have been removed, enabling candidates to re-take units more than once. Upon making an entry for certification, the best attempt will be counted towards the final award. This change applies to all candidates, including those who have already been entered for any units or full qualifications.

Re-sits of AS and Advanced GCE

Candidates may still enter for the full qualification an unlimited number of times.

4.1 Question Papers

4.1.1 AS GCE

AS GCE is the level expected to be reached at the end of the first year of a two year Advanced GCE course.

Unit 2841 - Science and the Natural Environment (1 hour) (60 marks)
Unit 2842 - Science and Human Activity (1 hour) (60 marks)

The question papers for Units 2841 and 2842 have a common format. They contain questions comprising both structured parts and parts which require more extended answers. The distribution of marks is approximately 50 marks for the structured parts and 10 marks for extended answers. All questions on these examination papers are compulsory. Quality of written communication is assessed within those parts of the questions which require more extended answers.

Unit 2843 Component 1 - Interpreting Scientific Information (1 hour) (45 marks)

The question paper requires candidates to make use of knowledge and understanding of the learning outcomes of Modules 2841 and 2842 of this specification to interpret scientific information and data. In addition, the paper requires candidates to apply scientific principles and concepts in an unfamiliar situation. Questions are structured and are based on an article (or extract) about a scientific topic, and which may include scientific information in another form, such as a graphic or table of data. All questions on this examination paper are compulsory.

Packs 1 - 4 of the *Science in the Environment* materials may be used to provide candidates with opportunities to interpret sources of scientific information of a similar kind to those which will be used in the question papers. It is envisaged that candidates will be carrying out activities of this kind throughout their study for Units 2841 and 2842 but they should spend some time practising reading and interpreting scientific information in the form of continuous prose, annotated diagrams and tables of data in preparation for the examination on this component of Unit 2843.

4.1.2 A2

Unit 2844 - Science and Environmental Management (1 hour 30 min) (90 marks)

The question paper for Unit 2844 has the same format as the question papers for Units 2841 and 2842. It contains questions comprising both structured parts and parts which require more extended answers. The distribution of marks is approximately 80 marks for the structured parts and 10 marks for extended answers.

All questions on this examination paper are compulsory. Quality of written communication is assessed within those parts of the questions which require more extended answers.

Unit 2845 - Synthesis of Scientific Concepts (1 hour 30 min) (90 marks)

The question paper requires candidates to bring together knowledge and understanding of the learning outcomes of Modules 2841, 2842, 2844 and 2846, Component 1 of this specification and apply them, sometimes in unfamiliar contexts. There are two structured questions, two questions requiring brief extended answers, and two questions requiring longer extended answers. All questions on this examination paper are compulsory. All marks are allocated to synoptic assessment. Marks are awarded for the quality of candidates' written communication in those questions requiring extended answers.

Unit 2846 Component 1 - Science and Global Processes (1 hour) (60 marks)

The question paper consists entirely of structured questions, none of which require extended answers. All questions are compulsory.

4.2 Coursework

Unit 2843, Component 2 - Experimental and Investigative Skills 1 (60 Marks)
Unit 2846, Component 2 - Experimental and Investigative Skills 2 (60 Marks)

Assessment of candidates' experimental and investigative work is made by the teacher (as coursework) and moderated externally by OCR.

In Unit 2843 Component 2, marks contribute towards Assessment Objective AO3, Experiment and Investigation.

In Unit 2846 Component 2, marks contribute equally to Assessment Objectives AO3 and AO4, Synthesis of Knowledge, Understanding and Skills. There is assessment of AO4 because:

- candidates are required to use scientific knowledge and understanding from other parts of the specification in planning their experimental and investigative work, and in analysing evidence and drawing conclusions;
- in the assessment of all four experimental and investigative skills in Unit 2846 Component 2, taken at the end of the course of study, candidates are expected to draw on their experience of such work throughout the course, and in particular on the outcome of the assessment of these skills in Unit 2843 Component 2.

The Skills

The experimental and investigative skills to be assessed are:

Skill P Planning

Candidates should:

- identify and define the nature of a question or problem using available information and knowledge of science;
- choose effective and safe procedures, selecting appropriate apparatus and materials and deciding the measurements and observations likely to generate useful and reliable results;
- consider ethical implications in the choice and treatment of organisms and the environment and safety aspects of the proposed procedures.

Skill I Implementing

Candidates should:

- use apparatus and materials in an appropriate and safe way;
- carry out work in a methodical and organised way with due regard for safety and with appropriate consideration for the well-being of living organisms and the environment;
- make and record detailed observations in a suitable way, and make measurements to an appropriate degree of precision, using IT where appropriate.

Skill A Analysing Evidence and Drawing Conclusions

Candidates should:

- communicate scientific information and ideas in appropriate ways, including tabulation, line graphs, histograms, continuous prose, annotated drawings and diagrams;
- recognise and comment on trends and patterns in data;
- identify sources of error and recognise the limitations of experimental measurement;
- draw valid conclusions by applying scientific knowledge and understanding.

Skill E Evaluating Evidence and Procedures.

Candidates should:

- assess the reliability and precision of experimental data and the conclusions drawn from them;
- evaluate the techniques used in the experimental activity, recognising their limitations.

Skills P and A are each marked out of 8 and Skills I and E are each marked out of 7. One mark per skill must be submitted for each candidate for AS (Unit 2843, Component 2) and for A2 (Unit 2846, Component 2). Thus, a mark out of 30 is initially calculated for each candidate for each of these components. These marks are then doubled so that the final mark submitted for each component is out of 60.

In AS and in A2 the skills may be assessed in the context of separate practical exercises, although more than one skill may be assessed in any one exercise. The skills may also be assessed all together in the context of a single ‘whole investigation’ in which the task is set by the teacher, or using individual investigations in which each candidate pursues his or her own choice of assignment.

The skills may be assessed at any time during the course using suitable practical activities, based on laboratory or field work, related to or part of the content of the teaching course. The context(s) for the assessment of the coursework for Unit 2843, Component 2 should be drawn from the content of AS Modules 2841, 2842 and 2843, Component 1; the context(s) for the assessment of the coursework for Unit 2846, Component 2 should be drawn from the content of A2 Modules 2844, 2845 and 2846, Component 1, in which the level of demand of the related scientific knowledge and understanding is higher.

A similar set of mark descriptors is used for both AS and A2 (see Appendix C). These descriptors have been written to provide clear continuity from the assessment of Sc1 in GCSE Science. The difference in standard of AS and A2 is a product of the level of demand of the related scientific knowledge and understanding and the complexity and level of demand of the tasks set.

In each of AS and A2 the time required for the internal assessment of experimental and investigative work is normally expected to be between 5 and 10 hours.

Notes for Guidance on Coursework submission and assessment are given in Appendix B. Mark descriptors for the experimental and investigative skills are fully detailed in Appendix C.

Copies of relevant coursework forms are included in the Science Coursework Guidance booklet.

4.2.1 Experimental and Investigative Work at AS and A2

The assessment descriptors given in Appendix C are used for the assessment of coursework in both AS and A2.

Assessments at AS and A2 are differentiated by the complexity of the tasks set and the contexts of the underlying scientific knowledge and understanding. In A2, candidates will be required to apply knowledge, understanding and skills from the AS and A2 parts of the specification in planning experimental work and in the analysis of results to reach conclusions.

At AS, experimental and investigative work is likely to be qualitative or require processing in a context that is familiar to candidates.

- **Planning** exercises, although novel, focus on apparatus and techniques which have previously been encountered, based on knowledge and understanding from a limited part of the AS specification.
- **Implementing** involves the manipulation of simple apparatus and the application of easily recognised safety procedures.
- **Analysing and concluding** involves simple data handling, reaching conclusions based on a limited part of the AS specification.
- **Evaluation** expects the recognition of the main sources of error and direct methods for improving accuracy.

At A2, assessments expect a greater level of sophistication and higher levels of skill.

- **Planning** exercises require research to provide a satisfactory solution to a problem which can be addressed in more than one way. The underlying knowledge, understanding and skills are likely to be drawn from several different parts of the AS and A2 specifications.
- **Implementing** involves a detailed risk assessment and the careful use of sophisticated techniques or apparatus to obtain results that are precise and reliable.
- **Analysing and concluding** involves sophisticated data handling and the synthesis of several strands of evidence. In developing conclusions, candidates have the opportunity to demonstrate their skills in drawing together principles and concepts from different parts of the AS and A2 specifications.
- **Evaluation** requires recognition of the key experimental limitations and other sources of error as well as an understanding of the methods that may be used to limit their effect. The evaluation is likely to draw together principles and concepts from different parts of the specification.

Detailed advice on the choice of experimental and investigative work suitable for AS and A2, and guidance on the application of the assessment descriptors to exemplar tasks, is provided in coursework guidance material published separately.

4.2.2 Assessment and Moderation

All coursework is marked by the teacher and internally standardised by the Centre. Marks are then submitted to OCR by a specified date, after which postal moderation takes place in accordance with OCR procedures. The purpose of moderation is to ensure that the standard for the award of marks in coursework is the same for each Centre, and that each teacher has applied the standards appropriately across the range of candidates within the Centre.

Coursework submissions should be clearly annotated by the Centre to support the marks awarded to the candidates.

The sample of work which is submitted to the Moderator for moderation must show how the marks have been awarded in relation to the marking criteria.

4.2.3 Minimum Coursework Requirements

If a candidate submits no work for a coursework component, then the candidate should be indicated as being absent from that component on the coursework mark sheets submitted to OCR. If a candidate completes any work at all for a coursework component then the work should be assessed according to the mark descriptors and marking instructions and the appropriate mark awarded, which may be 0 (zero).

4.2.4 Authentication of Coursework

As with all coursework, the teacher must be able to verify that the work submitted for assessment is the candidate's own. Sufficient work must be carried out under direct supervision to allow the teacher to authenticate the coursework marks with confidence.

4.3 Special Arrangements

For candidates who are unable to complete the full assessment or whose performance may be adversely affected through no fault of their own, teachers should consult the *Inter-Board Regulations and Guidance Booklet for Special Arrangements and Special Consideration*. In such cases advice should be sought from OCR as early as possible during the course. Applications for special consideration in coursework components should be accompanied by Coursework Assessment Forms giving the breakdown of marks for each skill.

4.4 Differentiation

In the question papers, differentiation is achieved by setting questions which are designed to assess candidates at their appropriate levels of ability and which are intended to allow all candidates to demonstrate what they know, understand and can do.

In coursework, differentiation is by task and by outcome. Candidates undertake assignments which enable them to display positive achievement.

4.5 Awarding of Grades

The AS has a weighting of 50% when used in an Advanced GCE award. The Advanced GCE award is based on the certification of the weighted AS (50%) and A2 (50%) marks.

Both AS and Advanced GCE qualifications are awarded on the scale A to E, or U (unclassified).

4.6 Grade Descriptions

The following grade descriptions indicate the level of attainment characteristic of the given grade at **Advanced GCE**. They give a general indication of the required learning outcomes at each specified grade. The descriptions should be interpreted in relation to the content 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 objectives overall. Shortcomings in some aspects of the examination may be balanced by better performances in others.

Grade A

Candidates recall and consistently use scientific knowledge, facts, principles and concepts from the whole specification with few significant omissions and show good understanding of the principles and concepts they use. They select scientific knowledge relevant to most situations and present their ideas clearly and logically, making use of appropriate scientific terminology, particularly when referring to specific technical terms and in expressing more general concepts and ideas.

Candidates carry out accurately a range of calculations in a logical manner with little guidance and, where appropriate, support their solutions by logical explanation. They demonstrate good understanding of principles and apply them in familiar and new contexts.

They show insight into problems and suggest a number of possible solutions using techniques, arguments or knowledge and understanding from more than one area of the specification and other areas of experience. Most responses are correct, relevant and logical. In particular, longer questions are answered to an appropriate depth, communicating ideas effectively with coherent and detailed explanations.

In experimental activities, candidates independently formulate a clear and accurate plan. They use a range of manipulative techniques safely and skilfully, making and recording observations with appropriate precision. They interpret and describe the trends and patterns shown by data presented in tabular or graphical form, indicating, where appropriate, anomalies and inconsistencies. They provide coherent, logical and comprehensive explanations using appropriate scientific knowledge and terminology. They comment critically on data, evaluate it and use it to support or reject various hypotheses. They present clearly and concisely both sides of an argument by weighing up the evidence.

Grade C

Candidates recall and show a sound use of scientific knowledge, facts, principles and concepts from many parts of the specification and show understanding of some fundamental principles and concepts. They frequently select scientific knowledge relevant to a particular situation or context and present their ideas clearly and logically, making use of appropriate scientific terminology.

Candidates carry out a range of calculations, making progress with minimal guidance. They show knowledge of fundamental principles and are often able to apply these in new contexts. They bring together information from more than one area of the specification. Many responses are correct, relevant and logical.

In experimental activities, candidates formulate a plan which may need some modification. They use a range of techniques safely, making and recording observations and measurements which are adequate for the task. They interpret and explain experimental results relating these to scientific knowledge and understanding and, with help, evaluate their results. They comment on data and use selected data to support a particular hypothesis.

Grade E

Candidates recall and use scientific knowledge, facts, principles and concepts from some parts of the specification and demonstrate some understanding of fundamental principles and concepts beyond that expected of sound GCSE candidates.

Candidates select discrete items of knowledge in response to structured questions and use basic scientific terminology. This may be displayed consistently across the questions set or may vary between quite good and poor on different questions.

Candidates select appropriate facts and principles to solve problems concerning familiar material. Where problems are concerned with unfamiliar material, answers relate to the appropriate subject area even if difficulties are experienced in applying the facts and principles involved.

With some guidance, candidates carry out accurately straightforward calculations involving the rules of number, such as calculations of percentages, making clear the steps in the calculations. They apply knowledge and scientific principles contained within the specification to material presented in a familiar or closely related context.

They make connections between some ideas encountered in different parts of the specification. Their answers show some logic and coherence although they include irrelevant material. They use correctly a limited range of scientific terminology.

In experimental activities, candidates formulate some elements of a practical approach when provided with guidance. They carry out frequently encountered practical procedures in a reasonably skilful manner, recognising the risks in familiar procedures and obtaining some appropriate results. They interpret broad trends shown by data presented in tabular or graphical form. They select appropriate facts and principles to produce limited but relevant explanations and make superficial conclusions from data. They may need assistance to relate these to scientific knowledge and understanding.

5 Specification Content

5.1 Module 2841: Science and the Natural Environment

Preamble

This Module is a bridge into the AS GCE in Science from the study of Science at GCSE. It is intended to provide candidates with a knowledge and understanding of key principles used in scientific explanations of the natural world.

Recommended Prior Knowledge

Candidates should be familiar with the idea of atoms, radioactive decay and radioactive emissions. They should also be aware of the wave model of light, of the behaviour (reflection and refraction) of waves, of the electromagnetic spectrum and of the different regions of electromagnetic radiation. They should know that the Sun is the major energy source for the Earth.

Candidates should have a simple understanding of photosynthesis and the structure of cells, of the importance of biomass as a source of energy and of the role of aerobic respiration in releasing energy from biomass consumed as food. They should be aware of the use of pyramids of numbers as a way of quantifying food chains, and of the importance of green plants in food chains. They should be aware that energy can be transferred and stored, and that when transferred, energy is conserved but also, to some extent, dissipate. They should have been introduced to evidence for evolution and the idea that evolution can arise from variation and selection, and that mutation is a source of variation. They should know that information, in the form of genes, is passed on from one generation to another.

Candidates should:

- have achieved Grade CC or above in GCSE Science: Double Award, or
- be able to demonstrate that (for example, in the case of adult learners) the science they have learned from earlier studies covers the prior knowledge listed above.

5.1.1. Electromagnetic Radiation and Remote Sensing Techniques

C3.3; IT3.1 IT3.2	LP3.1 LP3.2 LP3.3; PS3.1 PS3.2 PS3.3; WO3.1 WO3.2 WO3.3

Content

- Electromagnetic radiation
- The electromagnetic spectrum
- Satellite passive remote sensing

Learning Outcomes

Candidates should be able to:

(a) describe electromagnetic (em radiation) radiation in terms of a simple wave model, including use of the terms, wavelength, frequency and speed, and their units;

(b) state that em radiation is a form of energy;

(c) use the equation, $c = \lambda f$, in calculations of wavelength and frequency of electromagnetic radiation;

(d) describe how the wide and continuous range of wavelengths of em radiation is classified by means of the electromagnetic spectrum; **PS3 (all)**

(e) interpret the em spectrum in terms of the wavelength and frequency ranges of the regions of the spectrum: for example, uv, visible, near and thermal infrared; **PS3 (all)**

(f) describe the nature of visible light, and the behaviour of coloured light and coloured pigments; **PS3 (all), WO3 (all)**

(g) explain the differences in the emission spectra of the Sun and the Earth;

(h) describe how em radiation, once emitted, can be transmitted, reflected, absorbed and scattered;

(i) interpret simple grey-scale, true-colour and false-colour composite images: for example, images taken by Landsat TM and MSS, Meteosat, SPOT, ERS 1; **C3.3**

(j) describe in simple terms how images from passive remote sensing are captured, processed, enhanced and displayed: **C3.3, IT3.1, IT3.2**

  (i) satellite and airborne sensors,

  (ii) polar and geostationary satellite orbits,

  (iii) display of an image as an array of pixels;

(k) describe uses of satellite remotely sensed images.

5.1.2 Nuclear Atomic Structure and Radioactivity

C3.1a C3.1b C3.2 C3.3; IT3.1	**LP3.1 LP3.2 LP3.3**

Content

- The atomic nucleus
- Radioactivity
- Nuclear fission and nuclear fusion

Learning Outcomes

Candidates should be able to:

(a) describe a model for the structure of the atom in terms of a nucleus, composed of protons and neutrons, and surrounding electrons;

(b) use and explain the meanings of the following terms: proton, neutron, electron, atomic number, mass number, isotope, including use of the convention

mass number

chemical symbol for example, $^{1}_{1}\mathrm{H}$;

atomic number

(c) describe, in outline, the principles of operation of a mass spectrometer and its use in determining relative atomic masses and relative abundances of isotopes;

(d) describe the properties and identities of α, β, γ emissions;

(e) describe and compare the hazards associated with radioactive sources: radiation and contamination; **C3.1b, C3.2, IT3.1**

(f) explain the process of radioactive decay:

- (i) the exponential nature of radioactive decay,
- (ii) the concept of half-life,
- (iii) the origins of ionising radiations,
- (iv) accompanying chemical changes;

(g) describe methods used for the detection of ionising radiation:

- (i) photographic,
- (ii) Geiger-Muller tube,
- (iii) scintillation counter;

(h) describe the principal natural and artificial sources of ionising radiation;

(i) discuss how scientists are able to develop and use models of systems that cannot be investigated directly, with particular reference to the development of the theory of atomic structure and the use of appropriate models for the structure of the atom; **C3.1a, C3.2, C3.3**

(j) describe, in outline, the processes of nuclear fusion and nuclear fission;

(k) compare the processes of radioactive decay, nuclear fusion and nuclear fission.

5.1.3 Energy Transfer and Living Systems

C3.3	**LP3.1 LP3.2 LP3.3; WO3.1 WO3.2 WO3.3**

Content

- Photosynthesis and respiration
- Energy transfers in ecosystems
- Plant productivity
- Cell structure
- Ordered and disordered energy
- The First Law of Thermodynamics
- Entropy and disorder
- The Second Law of Thermodynamics

Learning Outcomes

Candidates should be able to:

(a) describe the overall processes occurring in the light-dependent and light-independent stages of photosynthesis:

(i) the trapping of light by pigments in chloroplasts,

(ii) word equations for the light-dependent and light-independent stages of photosynthesis;

(b) describe the fate of solar energy incident on the leaves of a plant: losses to the surroundings due to reflection and transmission, energy absorbed by the leaf, respiratory losses, energy stored as biomass;

(c) explain that stored chemical energy, in the form of ATP, is released during the process of respiration from the oxidation of food (glucose): the overall word equation should be known, but no biochemical detail is required;

(d) define and use the terms biome, ecosystem, community, population and habitat;
C3.3, WO3 (all)

(e) explain and use the term productivity;

(f) relate the productivity of a plant community to the environment in which it grows: to include climate, altitude, water and nutrient availability;

(g) describe how energy is transferred through an ecosystem;

(h) explain and use the terms:

(i) food chains and webs (including grazing and decay chains),

(ii) trophic levels;

(i) explain the relationship between biomass and energy;

(j) describe the importance to an individual organism of balancing energy input and output;

(k) perform calculations related to the energy balance of an individual organism and energy transfer in an ecosystem; **IT3.2**

(l) describe the characteristic features of the ultrastructure of:

- (i) prokaryotic and eukaryotic cells,
- (ii) plant cells and animal cells;

(m) describe the function in a cell of:

- (i) nucleus,
- (ii) rough endoplasmic reticulum,
- (iii) smooth endoplasmic reticulum,
- (iv) Golgi apparatus,
- (v) mitochondria,
- (vi) chloroplasts,
- (vii) vacuole,
- (viii) lysosomes;

(n) describe the fluid-mosaic model of a plasma membrane and its role in the passage of substances into and out of a cell;

(o) describe the relationship between cells, tissues, organs and systems in a multi-cellular organism;

(p) explain that energy can be stored in an ordered form as potential energy, kinetic energy of a whole object and chemical energy;

(q) explain that thermal energy is energy stored in the form of disordered kinetic energy of the particles of a substance;

(r) explain that in any energy transfer the total energy remains constant: the First Law of Thermodynamics;

(s) explain that entropy is a measure of the disorder of energy and that heating and increased disorder in the positions of particles lead to greater entropy;

(t) explain that any change leads to an increase in the disorder of energy and therefore to an increase in entropy: the Second Law of Thermodynamics;

(u) apply the First and Second Laws of Thermodynamics to the energy transfers in an organism and in an ecosystem.

5.1.4 *Steady States and Nutrient Cycling*

C3.1a C3.1b C3.2 C3.3; IT3.1 IT3.2 IT3.3	**LP3.1 LP3.2 LP3.3**

Content

- Steady states
- Feedback mechanisms
- Nutrient cycling in an ecosystem

Learning Outcomes

Candidates should be able to:

(a) explain that many living and non-living systems are maintained in a steady state; **C3.1b, C3.2, C3.3**

(b) use and explain the terms positive feedback and negative feedback;

(c) describe the general processes involved in the recycling of nutrients in a forest ecosystem:

  (i) the role of the root mat and decomposer organisms,

  (ii) the store of nutrients in plants,

  (iii) weathering and leaching;

(d) describe the effects of deforestation in forest ecosystems in terms of the general principles of nutrient cycling. **C3.1a, C3.3, IT3.1, IT3.2, IT3.3**

5.1.5 *Evolution and Biodiversity*

C3.1b C3.3	**LP3.1 LP3.2 LP3.3**

Content

- The Theory of Evolution by Natural Selection
- Biodiversity

Learning Outcomes

Candidates should be able to:

(a) describe, in outline, the theory of evolution by the process of natural selection:

  (i) random mutation,

  (ii) cumulative natural selection,

  (iii) phyletic and divergent speciation,

  (iv) geographical and reproductive isolation;

(b) describe the layered structure of a tropical rain forest and how plants and animals are adapted to tropical rain forest habitats. **C3.1b, C3.3**

5.2 Module 2842: Science and Human Activity

Preamble

This Module is intended to provide candidates with a knowledge and understanding of scientific ideas which underlie certain aspects of industrial and other human activity.

Recommended Prior Knowledge

Candidates should be familiar with solids, liquids and gases, with elements, compounds and mixtures, and with a description of these in terms of a particle model. They should be familiar with molecules and ions as types of particles, with metals and non-metals as types of elements, with symbols for atoms and elements and with the classification of elements into the Periodic Table. They should be aware that changes of state are accompanied by energy transfer, and they should have used a molecular-kinetic model to explain the simple behaviour of gases. They should have been introduced to a study of some chemical reactions, and be aware that reactions may be accompanied by energy changes and may occur at different rates which can be explained by a simple model of colliding particles. They should have been introduced to some types of chemical reaction (for example, oxidation) and to the reactions and properties of acidic solutions.

Candidates should have had an introduction to the quantities current, voltage and resistance, and to a.c. and d.c. electricity. They should be aware that the Earth has a gravitational field and that there are magnetic fields around magnets and current-carrying conductors, and that forces can act on objects placed in magnetic fields. They should have been introduced to ideas about forces and linear motion. They should have learned about oil as a mixture of hydrocarbons, about alkanes and alkenes, and about addition polymerisation. They should be aware that different chemical reactions proceed at different rates and that the rate of a given reaction can depend on temperature, concentration, surface area and the presence of a catalyst. They should have been offered a simple explanation of these effects in terms of collisions between particles.

From Module 2841 of this specification, candidates should have been introduced to the concept of entropy and have an understanding of the laws of thermodynamics.

Candidates should:

- have achieved Grade CC or above in GCSE Science: Double Award, or
- be able to demonstrate that (for example, in the case of adult learners) the science they have learned from earlier studies covers the prior knowledge listed above.

5.2.1 *Kinetic Theory, Atmospheric Circulation and Climate Change*

C3.2; IT3.1	**LP3.1 LP3.2 LP3.3**

Content

- Molecular-kinetic theory
- Chemical particles: atoms, molecules, radicals and ions
- Covalent and ionic bonding
- Shapes of simple molecules
- Tropospheric circulation and general climate zones
- Composition and heating of the troposphere and stratosphere
- Environmental effects of atmospheric change

Learning Outcomes

Candidates should be able to:

(a) use and interpret appropriate models for representing the particulate nature of solids, liquids and gases, and of elements, compounds and mixtures:

  (i) particles as hard spheres,

  (ii) particles as bonded atoms;

(b) describe and use the major principles of the molecular-kinetic theory of gases:

  (i) pressure as a result of collisions of particles with the walls of the container,

  (ii) relationship of temperature to translational, rotational and vibrational motion,

  (iii) the inter-relationship of pressure, volume and temperature for a gas,

  (iv) relationship between gas volumes and the numbers of particles,

  (v) relationship between gas densities and the relative masses of the particles present,

  (vi) distribution of energies,

  (vii) perform calculations using the relationship, $PV = nRT$,

  (viii) perform calculations using the relationship, $P = F \div A$;

(c) explain the energy transfers which accompany expansion, contraction, vaporisation and condensation;

(d) describe the important features of molecules, radicals and ions:

 (i) bonded atoms,

 (ii) paired and unpaired electrons,

 (iii) electrical charge;

(e) describe a simple model of an electron-pair bond;

(f) describe a simple model of an ionic solid and an ionic solution;

(g) use and interpret appropriate models for representing molecules, radicals and ions:

 (i) bonded atoms,

 (ii) chemical formulae,

 (iii) space-filled representations;

(h) explain that molecules may possess non-bonded pairs (lone pairs) of electrons;

(i) draw and interpret diagrams to represent the shapes of simple molecules with up to four outer pairs of electrons around the atoms (bonding pairs or lone pairs, single or multiple bonds);

(j) predict and interpret the shapes of simple molecules with up to four outer pairs of electrons around the atoms using electron pair repulsion theory (distinctions over the relative magnitudes of interactions involving lone pairs and bonding pairs are not required);

(k) describe and compare the main features of the structure, behaviour and composition of the troposphere and stratosphere:

 (i) the Sun as the source of energy for atmospheric circulation,

 (ii) the general movement of air masses in the troposphere,

 (iii) the circulation of air in the troposphere and the distribution of general climate zones,

 (iv) absorption of infrared radiation by gases in the troposphere,

 (v) natural and anthropogenic contributions to the 'greenhouse effect',

 (vi) the role of ozone in heating the stratosphere and absorbing ultraviolet radiation;

(l) explain how environmental issues can arise when the consequences of human activity become superimposed on natural atmospheric and climatic processes: **C3.2, IT3.1**

 (i) land degradation,

 (ii) drought,

 (iii) lake acidification.

5.2.2 Chemical Reactions and Atmospheric Pollution

C3.1a C3.2 C3.3; IT3.1 IT3.2 IT3.3	**LP3.1 LP3.2 LP3.3**

Content

- Chemical equations
- Acids
- Oxidation and reduction
- Ion-exchange
- Acid deposition and gaseous pollution

Learning Outcomes

Candidates should be able to:

(a) use and interpret chemical equations as a model for representing chemical reactions;

(b) explain how the feasibility of chemical reactions is governed by the following factors:

(i) conservation of atoms,

(ii) energy and entropy changes,

(iii) availability of route;

(c) use a model of an acid in terms of its ability to produce hydrogen ions;

(d) define and use the terms: acidic solution, strong and weak acid and pH;

(e) interpret oxidation and reduction in terms of gain and loss of oxygen;

(f) explain the process of ion-exchange; **C3.2**

(g) discuss the causes and effects of acid deposition: **C3.1a, C3.3, IT3.1, IT3.3**

(i) the roles of sulphur oxides and nitrogen oxides,

(ii) acidification of water and release of cations bonded to clays and humus in the soil,

(iii) susceptibility to acid deposition,

(iv) approaches to minimising damage from acid deposition;

(h) discuss the consequences of the release of pollutants: **IT3.2**

(i) conversion in the environment to other, harmful substances,

(ii) import and export of pollutants across national boundaries,

(iii) variations of susceptibility from place-to-place and from time-to-time,

(iv) environmental damage arising from the cumulative effects of several pollutants.

5.2.3 *Force Fields and Electricity Distribution*

C3.1a C3.2

LP3.1 LP3.2 LP3.3

Content

- Forces and mechanical energy
- Fields and their effects
- a.c. and d.c. electricity
- Electricity transmission and distribution

Learning Outcomes

Candidates should be able to:

(a) explain and use the terms: force, mass, velocity, acceleration, potential energy and kinetic energy;

(b) state and use the relationships between the following:

- (i) work, force and distance moved in direction of force,
- (ii) work, time and power;

(c) explain what is meant by a force field:

- (i) gravitational fields and masses,
- (ii) electric fields and electric charges,
- (iii) magnetic fields and magnets and current-carrying conductors;

(d) describe, in outline, the nature of an electromagnetic wave in terms of electric and magnetic fields;

(e) use field lines to describe the strength and effect of a field;

(f) state that the strength of an electric field from a charge depends on the distance from, and the size of, the charge;

(g) describe the relationship between force and field strength for:

- (i) the Earth's gravitational field and masses,
- (ii) electric fields and electric charges;

(h) describe how, when a current-carrying conductor is placed in a magnetic field, a force is exerted which is at right angles to the directions of the field and the current;

(i) describe the principal features of the electric and magnetic fields from overhead power lines, underground power cables and domestic wiring:

- (i) the alternating nature of the fields,
- (ii) insulation,
- (iii) dependence on voltage and distance (electric fields),
- (iv) dependence of magnetic fields on the geometrical arrangement of the conductors, and the size and pattern of current flow (details of fields from particular arrangements and current flows are not required);

(j) outline the use of epidemiological studies in the investigation of possible adverse health effects arising from power frequency fields and smoking; **C3.2**

(k) explain and use the terms current, voltage, resistance, power, a.c. and d.c.;

(l) state and use the relationships between the following:

- (i) charge, current and time,
- (ii) energy transfer, voltage and charge,
- (iii) power, voltage and current,
- (iv) resistance, voltage and current,
- (v) power loss, current and resistance,
- (vi) resistance, resistivity, length and cross-sectional area;

(m) describe the principal features of the electricity transmission and distribution system in the UK;

(n) outline the importance of technological networks to the present day way of living. **C3.1a**

5.2.4 *Rates of Chemical Reactions and Chemical Manufacture*

C3.2; IT3.1	**LP3.1 LP3.2 LP3.3**

Content

- Factors affecting reaction rates
- Collision theory of chemical reactions
- Catalysis
- Clean technology in the chemical industry
- Hydrocarbons
- Addition and condensation polymerisation

Learning Outcomes

Candidates should be able to:

(a) explain that chemical reactions usually occur as a series of steps and that one of these may be a rate-determining step;

(b) explain, qualitatively, the effects of concentration and temperature on reaction rate using a simple model of colliding particles;

(c) explain and use the terms: rate of reaction, rate equation, rate constant, order of reaction, half-life, rate-determining step, activation energy, catalysis and catalyst;

(d) describe the role of a catalyst in providing an alternative reaction route of lower activation energy;

(e) relate the siting of a chemical plant to the following factors: land, skills, communications, water, raw materials;

(f) relate the design of a chemical plant to the following factors: fuel costs, material costs, maintenance and labour costs, cost of capital, safety, environmental considerations; **C3.2**

(g) discuss the economic importance of catalysts and how the choice of catalyst can be an important factor in the development of new, 'cleaner' processes; **C3.2**

(h) describe strategies used for minimising the environmental burden of chemical processes: **IT3.1**

(i) waste reduction at source,

(ii) recovery recycling,

(iii) waste release;

(i) recognise and describe the structures of molecules of alkanes and alkenes;

(j) describe, in outline, the processes of addition and condensation polymerisation.

5.2.5 Biological Molecules and the Biochemical Industry

LP3.1 LP3.2 LP3.3

Content

- Carbohydrates, lipids and proteins
- Enzymes

Learning Outcomes

Candidates should be able to:

(a) describe the basic structures and cellular roles of carbohydrates, proteins and lipids;

(b) distinguish between the primary, secondary and tertiary structure of a protein;

(c) interpret ribbon and space-filled models of proteins;

(d) explain that enzymes are ‘biological catalysts’:

  (i) enzymes as proteins,

  (ii) enzymes as catalysts,

  (iii) the lowering of activation energy;

(e) describe the mode of enzyme action:

  (i) importance of the tertiary structure of enzymes,

  (ii) the lock and key mechanism,

  (iii) the active site,

  (iv) enzyme specificity;

(f) describe the factors that affect enzyme action: pH, temperature, enzyme concentration, substrate concentration, competitive and non-competitive inhibition;

(g) describe, in outline, the use of enzymes in industry.

5.3 Module 2843, Component 1: Interpreting Scientific Information

Assessment Objectives

Component 1 of this module focuses on interpreting scientific information and the application of scientific principles and concepts in an unfamiliar situation.

Recommended Prior Knowledge

The recommended prior knowledge is that specified for Modules 2841 and 2842 of this specification.

Candidates should:

- have achieved Grade CC or above in GCSE Science: Double Award, or
- be able to demonstrate that (for example, in the case of adult learners) the science they have learned from earlier studies covers the prior knowledge described above.

Learning Outcomes

Candidates should be able to:

(a) read, with understanding, a source of scientific information and data, such as a scientific article, graphic or table of data;

(b) demonstrate knowledge and understanding of the learning outcomes of Modules 2841 and 2842 of this specification;

(c) demonstrate an overview of science;

(d) explain and interpret information in terms of scientific principles and concepts;

(e) interpret and translate, from one form into another, scientific information and data;

(f) apply knowledge and understanding of science to new situations;

(g) communicate scientific knowledge in a clear, logical and appropriate form;

(h) analyse and evaluate scientific information and data.

5.4 Module 2844: Science and Environmental Management

Preamble

This Module is intended to provide candidates with a knowledge and understanding of some of the ways in which science is applied in managing the environment.

Recommended Prior Knowledge

From previous science courses, candidates should be aware of variation and that it can be caused by inherited and environmental factors. They should know that organisms are made up of cells, and be aware that the cell nucleus contains chromosomes which contain genes. They should have been introduced to ideas about selective breeding and genetic engineering, and to factors which affect the sizes of populations.

From Module 2842 of this specification, candidates should know about models used for representing the structures of molecules, and have been introduced to ideas about how matter and em radiation interact. They should have learned that chemical reactions are accompanied by temperature and energy changes, and that these are related to the making and breaking of bonds.

5.4.1 Reproduction, Inheritance and Improvement of Crops

IT3.1	**LP3.1 LP3.2 LP3.3**

Content

- Mitosis
- Types and uses of asexual reproduction
- Meiosis
- Sexual reproduction in plants
- Alleles and characteristics
- Dominant and recessive alleles

Learning Outcomes

Candidates should be able to:

(a) describe, in outline, the process of mitosis (names of stages are not required):

  (i) chromosomes are duplicated,

  (ii) the behaviour of the chromosomes during nuclear division,

  (iii) the production of two identical diploid daughter cells;

(b) explain that mitotic cell division results in genetic uniformity and is important in growth and as a means of asexual reproduction;

(c) explain that sexual reproduction is a source of variation and that asexual reproduction results in uniformity;

(d) describe how plants use asexual reproduction (vegetative propagation) in their natural environments: **IT3.1**

- (i) bulbs, corms, tubers and runners,
- (ii) the advantages and disadvantages of asexual reproduction;

(e) describe how our knowledge of natural vegetative propagation has led to the development of commercially used artificial techniques: for example, cuttings (soft tip and hardwood), grafting and tissue culture; **IT3.1**

(f) describe, in outline, the process of meiosis (names of stages are not required):

- (i) chromosomes are duplicated,
- (ii) chromosomes form homologous pairs between which genetic information can be exchanged,
- (iii) the behaviour of chromosomes during the two nuclear divisions resulting in segregation and the independent assortment of homologous pairs,
- (iv) the formation of haploid cells which are non-identical;

(g) explain that genetic information can be transferred between chromosomes during meiosis and that this increases variation;

(h) describe the roles of pollen and ovum in sexual reproduction in plants:

- (i) cross-pollination and self-pollination,
- (ii) wind pollination and insect pollination,
- (iii) the importance of haploid number,
- (iv) production of a unique zygote;

(i) describe inbreeding and its use in plant breeding programmes:

- (i) self-pollination,
- (ii) reduction of intraspecific variation,
- (iii) inbreeding depression;

(j) describe outbreeding and its use in plant breeding programmes:

- (i) cross-pollination,
- (ii) creation of new, improved varieties,
- (iii) hybrid vigour;

(k) explain that the expression of genes determines the characteristics of the individual:

- (i) genes carry information which determines characteristics,
- (ii) the use of the term allele to describe each of the alternative factors responsible for a character difference;

(l) describe how the expression of characteristics (the phenotype) will depend on the combination of alleles present in the genotype (the genetic make-up);

(m) explain differences in characteristics in terms of the expression of dominant and recessive alleles.

5.4.2 Adaptation to Environment and Sustainable Agriculture

C3.1b; IT3.1 IT3.3	LP3.1 LP3.2 LP3.3

Content

- Choice of plants as crops
- Sustainable agriculture
- Variation and selective breeding
- Adaptation to environment: water availability, light intensity and temperature

Learning Outcomes

Candidates should be able to:

(a) describe and explain factors associated with the choice of plant species used for food production: **C3.1b, IT3.1, IT3.3**

  (i) differences in plant diversity in natural and agricultural environments,

  (ii) geographical origins of some common crop species,

  (iii) constraints of climate,

  (iv) political, social and technological influences;

(b) explain why certain cereal crops are suited to particular agroecological zones and account for the differences between the expected and observed distribution of these crops;

(c) describe the causes of natural variation both between and within species: environmental and inherited aspects;

(d) explain how water moves into and out of cells by osmosis:

  (i) the function of semi-permeable membranes,

  (ii) turgid and flaccid plant cells;

(e) describe how plants respond to water stress:

  (i) wilting,

  (ii) reduced transpiration,

  (iii) mechanisms to reduce water stress in drought resistant species;

(f) describe, in outline, the C3 and C4 pathways in photosynthesis:

  (i) the light-dependent and light-independent stages,

  (ii) carbon dioxide fixation and photorespiration,

  (iii) transport of carbon dioxide to bundle sheath cells in C4 plants;

(g) explain the advantages of the C4 adaptation in conditions of high temperature and high light intensity;

(h) describe, in outline, how laboratory investigations can be used to set up a predictive model for use in the outside world:

  (i) choice of controlled and dependent variables,

  (ii) design of experiments,

  (iii) input and output variables, verification and validation of the model.

5.4.3 DNA Structure and Function and Genetically Modified Foods

C3.1a | **LP3.1 LP3.2 LP3.3; WO3.1 WO3.2 WO3.3**

Content

- Genes and chromosomes
- The structure and replication of DNA
- DNA, RNA and protein synthesis
- Genetic engineering

Learning Outcomes

Candidates should be able to:

(a) describe the structure of DNA, and understand that genes are made up of sequences of nucleotides:

  (i) the outline structure of nucleotides in terms of sugar, phosphate and base units (actual formulae are not required),

  (ii) the significance of base pairs and interactions between them,

  (iii) the structure of the double helix;

(b) explain how the DNA molecule is replicated;

(c) describe, in outline, the role of DNA in protein synthesis:

  (i) the triplet code,

  (ii) messenger and transfer RNA and ribosomes,

  (iii) the link between the proteins produced and the phenotype of the organism;

(d) describe the techniques used in genetic engineering:

  (i) restriction and ligase enzymes,

  (ii) the use of vectors (both plasmids and viral) in the production of recombinant DNA,

  (iii) the transfer and incorporation of recombinant DNA into the genome of the receiving organism;

(e) describe, in outline, the use of genetic engineering in the food industry and discuss the ethical implications of this technique. **C3.1a, WO3 (all)**

5.4.4 *Reversible Processes and Drinking Water Quality*

C3.2 IT3.2	**LP3.1 LP3.2 LP3.3**

Content

- Enthalpy changes
- Bond formation and bond breaking
- Entropy and disorder of energy
- Entropy changes in systems and surroundings
- Overall entropy change and reaction
- Reversible processes
- Factors affecting direction of change
- Chemical equilibrium
- Sources of freshwater and water purification

Learning Outcomes

Candidates should be able to:

(a) use and explain the terms: exothermic, endothermic and enthalpy change;

(b) use and interpret enthalpy level diagrams;

(c) explain that enthalpy is a measure of the sum of the chemical and thermal energy possessed by a substance and that, at constant temperature, an enthalpy change is equal to the change in chemical energy;

(d) explain that breaking of bonds is endothermic and formation of bonds is exothermic;

(e) describe the dissolving of an ionic compound in terms of the enthalpy changes associated with the break up of the ionic lattice and the hydration of ions;

(f) explain that entropy is a measure of disorder of energy, and that this depends both on the distribution of energy among the molecules in a sample and on the distribution of the molecules in the space occupied by the sample;

(g) explain that entropy arising from the distribution of energy among molecules depends on temperature, and that entropy arising from disorder in the positions of molecules depends on physical state and concentration;

(h) explain the relative magnitudes of the entropies of a solid, a liquid, a gas and a solution;

(i) explain that processes occur for which there is an overall increase in entropy, and that the overall entropy change is the sum of the entropy change in the system and the entropy change in the surroundings;

(j) explain that energy transferred as heating to or from the surroundings, as a result of enthalpy changes in systems, is important in determining entropy changes in the surroundings;

(k) explain that increased disorder in the positions of particles (molecules or ions) is important in determining entropy changes in systems;

(l) describe dissolving in terms of:

(i) entropy changes in the system associated with changes of state from solid to dissolved, spreading out of ions, hydration of ions,

(ii) entropy changes in the surroundings arising from heating or cooling caused by the dissolving process;

(m) describe the temperature dependence of freezing, melting, condensation and boiling in terms of enthalpy and entropy changes;

(n) describe diffusion and osmosis in terms of the behaviour of particles (molecules or ions) and of the change in entropy;

(o) describe the use of reverse osmosis, multi-effect distillation and multi-stage flash distillation in water purification; **C3.2**

(p) explain and use the terms: reversible reaction (or process) and dynamic equilibrium;

(q) explain that the direction of a reversible process and the position of chemical equilibrium can be affected by changes in pressure, temperature and concentration: to include the use of Le Chatelier's Principle to predict the effects of these factors, given appropriate information;

(r) describe the global availability of water as seawater and freshwater, and describe the composition of seawater in terms of the most abundant ions present (Na^+, Mg^{2+}, Ca^{2+}, Cl^-, SO_4^{2-});

(s) interpret the water balance of an area in terms of precipitation, evapotranspiration, run-off, storage and use; **IT3.2**

(t) describe the occurrence of confined and unconfined aquifers in terms of the porosity and permeability of rocks.

5.4.5 *Population Dynamics and Marine Water Quality*

C3.1a C3.2 C3.3; IT3.3	**LP3.1 LP3.2 LP3.3; PS3.1 PS3.2 PS3.3**

Content

- Factors affecting population growth
- Algal blooms
- Management of seawater quality

Learning Outcomes

Candidates should be able to:

(a) describe and explain the shape of a typical population growth curve;

(b) define the term abiotic factor, and describe how factors of this type affect the growth and distribution of a population;

(c) define the term biotic factor and describe how factors of this type affect the growth and distribution of a population;

(d) describe the conditions which can favour the formation of algal blooms and the effects and environmental problems which can arise from such blooms; **C3.2**

(e) outline strategies which can be used for the management of nutrient levels in water sources and for the prevention of eutrophication: **C3.1a, C3.3, IT3.3**

(i) point and diffuse sources,

(ii) control of nutrient releases from domestic and industrial activity and from farming;

(f) describe, in outline, how the application of life-cycle assessment can lead to reductions in pollutant releases and the development of 'cleaner technologies'. **PS3 (all)**

5.4.6 *Analytical Techniques and Environmental Monitoring*

	LP3.1 LP3.2 LP3.3

Content

- Infrared spectroscopy
- Chromatography
- Environmental monitoring

Learning Outcomes

Candidates should be able to:

(a) describe the elementary principles of recording an infrared spectrum;

(b) explain that absorption of infrared radiation is related to changes in the vibrations of groups of atoms in molecules;

(c) explain that particular groups of bonded atoms absorb in a narrow band of infrared radiation;

(d) interpret infrared spectra;

(e) describe, in outline, the techniques of gas-liquid chromatography and thin-layer chromatography;

(f) describe, in outline, the scientific principles on which gas-liquid chromatography is based:

- (i) distribution between vapour and dissolved states,
- (ii) use of a carrier gas and a liquid phase coated on a solid support,
- (iii) separation by successive distributions as the sample passes through the column packing;

(g) describe, in outline, the scientific principles on which thin-layer chromatography is based:

- (i) use of a mobile, solvent phase and of grains of polar or ionic material as a stationary phase,
- (ii) the relationship between polarity of sample molecules and retention on the stationary phase;

(h) interpret gas-liquid and thin-layer chromatograms;

(i) describe the use of physical methods of analysis in monitoring the environment;

(j) explain the role of sampling in investigations of environmental processes:

- (i) the importance of correct location, frequency, duration and technique of measurement,
- (ii) interpretation of results of sampling;

(k) describe, in outline, the nature of risk and risk-assessment:

- (i) our perception of risk,
- (ii) risk in everyday life and technological activity,
- (iii) estimating risk,
- (iv) the uncertainty of risk estimates.

5.4.7 Electronic Atomic Structure and Geochemical Surveying

LP3.1 LP3.2 LP3.3

Content

- The electronic structure of atoms
- Absorption and emission spectra
- Geochemical surveying

Learning Outcomes

Candidates should be able to:

(a) state that energy of one particular value, related to the frequency of the electromagnetic wave, is transferred when em radiation is absorbed or emitted;

(b) use the equation, $E = hf$, in calculations of the frequency and energy of em radiation;

(c) describe the photon model of em radiation;

(d) describe and use the electron shell model for the electronic structure of atoms:

- (i) the relationship of the position of an electron to its energy,
- (ii) the maximum numbers of electrons that can occupy each shell,
- (iii) the sequence of filling of shells,
- (iv) electron shell configurations;

(e) use energy level diagrams for electrons in atoms to explain absorption and emission of electromagnetic radiation;

(f) state that energy is quantised and that changes of energy level are brought about by gain or loss of energy of precise values;

(g) describe, in outline, techniques which are used to estimate the concentration of metal ions in water from rivers and lakes:

- (i) colorimetry,
- (ii) atomic absorption spectroscopy;

(h) use the relationship, $A = \log(I_o \div I)$ for absorbance of light;

(i) use other logarithmic scientific relationships:

- (i) for pH,
- (ii) in the Richter scale for earthquakes.

5.5 Module 2845: Synthesis of Scientific Concepts

This Module addresses assessment objective AO4.

Recommended Prior Knowledge

Recommended prior knowledge is that specified for Modules 2841, 2842, 2844 and 2846, Component 1 of this specification.

Learning Outcomes

Candidates should be able to:

(a) read with understanding a source of scientific information and data, such as a scientific article, graphic or table of data;

(b) demonstrate knowledge and understanding of the learning outcomes of Modules 2841, 2842, 2844 and 2846, Component 1 of this specification;

(c) demonstrate an overview of science;

(d) bring together principles and concepts from different areas of science;

(e) apply scientific knowledge, understanding and skills to a particular context;

(f) communicate scientific ideas clearly and logically using specialist vocabulary.

5.6 Module 2846, Component 1: Science and Global Processes

Preamble

This Module is intended to provide candidates with a knowledge and understanding of scientific ideas which explain certain global processes.

Assessment Objectives

See Section 3. This Unit examines assessment objectives AO1 and AO2.

Recommended Prior Knowledge

From Module 2841 of this specification, candidates should know about passive remote sensing and the electromagnetic (em) spectrum. From Module 2842 of this specification, candidates should have learned about molecules and ions, and be familiar with a simple model of electron pair bonding in molecules. They should have learned models for solids, liquids, gases and solutions. They should know about the atmospheric circulation system and its relationship to climate in different regions of the Earth.

5.6.1 *Motion, Time and the Earth*

C3.2 C3.3; IT3.3	LP3.1 LP3.2 LP3.3

Content

- Linear motion
- Simple harmonic motion

Learning Outcomes

Candidates should be able to:

(a) draw and interpret displacement/time and velocity/time graphs for motion with constant velocity or constant acceleration;

(b) use the following equations to perform calculations for motion with constant velocity or constant acceleration:

(i) $v = s \div t$,

(ii) $v = u + at$,

(iii) $E_k = {}^1/_2 mv^2$,

(iv) $F = ma$,

(v) $v^2 = u^2 + 2as$ (this equation will be provided in questions which require its use),

(vi) $p = mv$;

(c) draw displacement/time graphs for simple harmonic motion;

(d) interpret displacement/time graphs for simple harmonic motion in terms of velocity and acceleration at different points;

(e) explain the use of the cosine function to describe situations where one quantity varies periodically with another;

(f) use the equation $x = A\cos 2\pi ft$ for simple harmonic motion (candidates will be provided with this equation in questions which require its use);

(g) describe the relative movement of the Sun, Earth and Moon and how these have been used to measure time; **C3.2**

(h) explain natural phenomena in terms of simple harmonic motion: for example, tide height, daylight hours; **C3.3, IT3.3**

(i) use the following relationships to perform calculations relating force and field strength:

(i) $g = F \div m$,

(ii) $E = F \div q$;

(j) use the following relationships to perform calculations involving the inverse square law for force:

(i) $F = Gm_1m_2 \div r^2$,

(ii) $F = kq_1q_2 \div r^2$;

(k) state and use the relationship between change in gravitational potential energy, mass, gravitational field strength and change in height.

5.6.2 Waves, Ocean Surveying and Development of Plate Tectonic Theory

C3.1a C3.2;	**LP3.1 LP3.2 LP3.3; WO3.1 WO3.2 WO3.3**

Content

- Behaviour of waves
- Use of remote sensing techniques in ocean surveying
- Development of Plate Tectonic Theory

Learning Outcomes

Candidates should be able to:

(a) describe how electromagnetic (em) radiation travels as transverse waves, sound as longitudinal waves, and shock waves (from an explosion or earthquake) comprise both types of wave;

(b) use ray diagrams to represent the paths of waves of em radiation in the processes of transmission, reflection, absorption and scattering;

(c) state and use the relationship that, in reflection, the angles of incidence and reflection are equal;

(d) explain that the speed and wavelength of a wave are dependent on the material through which it travels;

(e) describe refraction at a plane surface in terms of a wave model;

(f) describe, in outline, the technique of obtaining an image by active sensing: the use of RADAR, sonar and seismic techniques;

(g) describe the important evidence in support of the theory of continental drift: **WO3 (all)**

(i) continental fit,

(ii) relationships between mountain ranges on different land masses,

(iii) evidence from fossils and living organisms;

(h) discuss the methods by which evidence explaining the mechanism of continental drift was gathered: **C3.2**

(i) bathymetry;

(ii) gathering of palaeomagnetic data,

(iii) collection of sediment samples from the ocean floors;

(i) describe and explain in outline the theory of plate tectonics and its limitations;

(j) describe a layered model for the structure of the Earth: inner core, outer core, mantle (mesosphere and asthenosphere), lithosphere;

(k) explain that all scientific knowledge is the result of observation and experiment; **C3.1a**

(l) explain that scientific theories may need to be discarded or modified in the light of newly acquired data; **C3.1a**

(m) explain that advances in scientific understanding often depend on the availability of suitable technology. **C3.1a**

5.6.3 Interparticle Bonding and Properties of Materials

C3.1b	**LP3.1 LP3.2 LP3.3**

Content

- Bond polarity
- Electronegativity
- Types of dipole-dipole bonding
- Hydrogen bonding
- Structural types

Learning Outcomes

Candidates should be able to:

(a) explain that bonds can be polar and that molecules can possess a permanent dipole;

(b) use and interpret appropriate ways of representing bond polarity and molecular dipoles:

(i) use of $\delta+$ and $\delta-$,

(ii) the charge-cloud model;

(c) explain that instantaneous dipoles can arise from electron movements in molecules;

(d) explain that induced dipoles are created in a molecule by interaction with an instantaneous dipole or a permanent dipole in an adjacent molecule;

(e) use and explain the meaning of the term electronegativity;

(f) explain and use relative electronegativity values:

(i) dependence on atomic radius and atomic structure,

(ii) patterns among elements,

(iii) use to predict bond polarity;

(g) describe the intermolecular bonding which arises from interactions between dipoles:

(i) instantaneous dipole-induced dipole,

(ii) permanent dipole-induced dipole,

(iii) permanent dipole-permanent dipole;

(h) describe hydrogen bonding:

- (i) donation of an electron pair from an atom of N, O or F to a partially positive hydrogen atom on an adjacent molecule,
- (ii) the directional character of hydrogen bonding;

(i) describe, in outline, models for the types of structures into which substances can be classified:

- (i) molecular structures,
- (ii) giant molecular structures,
- (iii) ionic structures,
- (iv) metallic structures;

(j) relate the following properties of materials and their uses to models of their structures in terms of the particles and bonding present: melting point, boiling point, electrical conductivity, thermal conductivity, toughness. **C3.1b**

5.6.4 Properties of Water, Ocean Circulation and Climate

C3.1a C3.3; IT3.1	**LP3.1 LP3.2 LP3.3**

Content

- The structure and properties of water and ice
- Surface and deep water currents
- Ocean currents and climate

Learning Outcomes

Candidates should be able to:

(a) describe and explain the principal features of the structure of water: **C3.3**

- (i) the bonding and shape of water molecules,
- (ii) hydrogen bonding between molecules in water and ice;

(b) explain and use the term specific heating capacity;

(c) explain the properties of water in terms of hydrogen bonding:

(i) boiling point,

(ii) specific heating capacity,

(iii) enthalpy of vaporisation,

(iv) density change on freezing;

(d) use the relationship, density = mass ÷ volume, in calculations;

(e) describe and explain the general circulation of water in the oceans and its effects on climate: **C3.1a, IT3.1**

(i) surface currents and sub-tropical gyres,

(ii) sinking of water by cooling and increased salinity in the North Atlantic and South Atlantic,

(iii) deep water currents,

(iv) the Gulf Stream, the North Atlantic Drift, the Norwegian Current,

(v) El Niño events;

(f) describe, in outline, the significance of the properties of water to conditions on Earth.

6 Further Information and Training for Teachers

To support teachers using this specification, OCR will make the following materials and services available:

- a dedicated subject-specific telephone number
- a full programme of In-Service Training (INSET) meetings
- specimen question papers and marking guidelines
- past question papers and mark schemes after each examination session
- coursework guidance materials
- written advice on coursework proposals
- individual feedback to each Centre on the moderation of coursework
- a Report on the Examination, compiled by Principal Examiners and Moderators, after each examination session.

If you would like further information about the specification, please contact OCR.

7 Reading List

This specification is supported by the *Science in the Environment* course materials, written and developed by the University of York Science Education Group, endorsed by OCR and with sponsorship from BP Amoco. Four packs of teaching and learning materials support the AS specification and a further four packs support the A2 specification. Reading matter, and related activities, which can be used in the study of the specification content is included in the *Science in the Environment* materials.

Further details about the *Science in the Environment* materials can be obtained from:

The Project Secretary,

Science in the Environment

University of York Science Education Group

Department of Chemistry

University of York

York

YO10 5DD

Tel: (01904) 432524. Fax: (01904) 434078

These packs of materials have been specifically written with the needs of post-16, non-specialist science candidates in mind but other materials may equally well be used throughout the course.

Recommended Reading

Throughout their course of study, candidates should be encouraged to read popular scientific magazines such as *New Scientist*.

Further Reading

Candidates should have access, for reference purposes, to library copies of some standard advanced level texts in the separate science disciplines. The list below gives titles of some more specialised texts which teachers and candidates may find useful.

Atkins PW. *The Second Law*, Scientific American Library, HPHLP, New York, 1984.

Barnes CJ and Poore N. *Plant Science in Action*, Focus on Biology, Hodder and Stoughton, London, 1994.

Beckerstaff GF. *Enzymes in Industry and Medicine*, Arnold, London, 1987.

Brown GC, Hawkesworth CJ and Wilson, RCL (eds). *Understanding The Earth*, Cambridge University Press, Cambridge, 1992.

Carter M. *Genetics and Evolution,* Focus on Biology, Hodder and Stoughton, London, 1992.

Dawkins R. *The Blind Watchmaker,* Longman Scientific & Technical, Harlow, 1986.

Electricity Association. *Electric and Magnetic Fields*, Electricity Association, 1994.

Freeland P. *Habitats and the Environment,* Focus on Biology, Hodder and Stoughton, London, 1992.

Graedel TE and Crutzen PJ. *Atmosphere, Climate and Change*, Scientific American Library, HPHLP, New York, 1995

Hilton K. *Spaceship Earth,* World Publications Ltd, London, 1990.

Lamb S and Sington D. *Earth Story*, BBC Books, London, 1998.

National Radiological Protection Board. *Electric and Magnetic Fields*, NRPB, Chilton, Didcot, Oxfordshire, 1994.

Odum EP. *Ecology and our Endangered Life-Support Systems,* Sinauer Associates, Sunderland, Massachusetts, 1989.

Pickering KT and Owen LA. *An Introduction to Global Environmental Issues*, Routledge, London and New York, 1994.

Sattelle DB. *Biotechnology in Perspective*, Hobson Publishing, 1988.

Nicholl DST. *Introduction to Genetic Engineering*, Cambridge University Press, Cambridge, 1994.

Swedish Ministry of Agriculture. *Acidification Today and Tomorrow,* Stockholm Conference on the Acidification of the Environment, 1982.

Terborgh J. *Diversity and the Tropical Rain Forest,* Scientific American Library, HPHLP, New York, 1992.

Wood RM. *The Dark Side of the Earth,* Allen and Unwin, London, 1985.

Appendix A

Key Skills

These specifications provide opportunities for the development of the Key Skills of Communication, Application of Number, Information Technology, Working With Others, Improving Own Learning and Performance and Problem Solving.

Through classwork, coursework and preparation for external assessment, candidates may produce evidence for Key Skills at Level 3. However, the extent to which this evidence fulfils the requirements of the QCA Key Skills units at this level will be dependent on the style of teaching and learning adopted for each module. In some cases, the work produced may meet the evidence requirements of the Key Skills units at a higher or lower level.

Throughout section 5 the symbol is used in the margin to highlight where Key Skills development opportunities are signposted. The following abbreviations are used to represent the above Key Skills:

C = Communication

N = Application of Number

IT = Information Technology

WO = Working with Others

LP = Improving Own Learning and Performance

PS = Problem Solving

These abbreviations are taken from the Key Skills specifications for use in programmes starting from September 2000. References in section 5 and Appendix A, for example **IT3.1**, show the Key Skill (IT), the level (3) and subsection (1).

Centres are encouraged to consider the OCR Key Skills scheme to provide certification of Key Skills for their students.

Detailed opportunities for generating Key Skills evidence through this specification are posted on the OCR website, www.ocr.org.uk

Key Skills Coverage

For each module, the following matrix indicates those Key Skills for which opportunities for at least some coverage of the relevant Key Skills unit exist.

Module	Communication	Application of number	IT	Working with Others	Learning Performance	Problem Solving
	Level 3	Level 3	Level 3	Level 3	Level 3	Level 3
2841	✓		✓	✓	✓	✓
2842	✓		✓		✓	
2843		✓	✓			
2844	✓		✓	✓	✓	✓
2845						
2846	✓	✓	✓	✓	✓	

Appendix B

Notes for Guidance on Coursework Submission and Assessment

This section is intended to provide guidance for teachers in assessing experimental and investigative skills, but should not exert an undue influence on the methods of teaching or provide a constraint on the practical work undertaken by candidates. It is not expected that all of the practical work undertaken by candidates would be appropriate for assessment.

For examples of suitable tasks for assessing practical skills, and for examples of possible individual studies, teachers should refer to the Science Coursework Guidance booklet. Copies will be available from the OCR Publications Department from 2000.

The experimental and investigative skills to be assessed are:

P Planning;

I Implementing;

A Analysing Evidence and Drawing Conclusions;

E Evaluating Evidence and Procedures.

It is expected that candidates will have had opportunities to acquire experience and develop the relevant skills before assessment takes place.

The skills may be assessed at any time during the course using suitable practical activities, based on laboratory or field work, related to or part of the content of the teaching course. The context(s) for the assessment of the coursework for Unit of Assessment 2843, Component 2 should be drawn from the content of AS Modules 2841, 2842 and 2843, Component 1; the context(s) for the assessment of the coursework for Unit of Assessment 2846, Component 2 should be drawn from the content of A2 Modules 2844, 2845 and 2846, Component 1 in which the level of demand of the related scientific knowledge and understanding is higher.

In AS and in A2 the skills may be assessed in the context of separate practical exercises, although more than one skill may be assessed in any one exercise. They may also be assessed all together in the context of a single ‘whole investigation’ in which the task is set by the teacher, or using individual investigations in which each candidate pursues his or her own assignment.

Skills P and A are marked out of 8 and Skills I and E are marked out of 7. Thus, for each candidate entered for Unit 2843, Component 2, and for Unit 2846, Component 2, Centres are required to submit **one** mark for each of Skills **P**, **I**, **A** and **E**. Hence the maximum raw mark available for each of AS and A2 is 30. These marks are then doubled so that the final marks submitted are out of 60.

When a skill has been assessed on more than one occasion, in AS or in A2, the better or best mark for that skill should be submitted. However, Centres are recommended **not** to assess the skills on more than two occasions in each of AS and A2 since this may take up time which might better be devoted to other aspects of the specifications. In each of AS and A2 the time required for the internal assessment of experimental and investigative work is normally expected to be between 5 and 10 hours.

All coursework is marked by the teacher and internally standardised by the Centre. Marks are then submitted to OCR by a specified date, after which postal moderation takes place in accordance with OCR procedures. The purpose of moderation is to ensure that the standard for the award of marks in coursework is the same for each Centre, and that each teacher has applied the standards appropriately across the range of candidates within the Centre.

The Demand of an Activity

The demand of an activity is an important feature of the assessment. From the bottom to the top of the mark range in a skill area the activity should involve increasing demands of associated scientific knowledge and understanding, manipulation, precision and accuracy and complexity.

In A2, candidates are required to apply knowledge, understanding and skills from the AS and A2 parts of the specification in planning experimental work and in the evaluation of data (synoptic assessment). Details of the way in which tasks can be differentiated are given in Section 4.2 and further guidance on setting appropriate tasks is given in guidance material published separately.

The difference in standard of AS and A2 is a product of the level of demand of the related scientific knowledge and understanding and the complexity and level of demand of the tasks set. Also, the mark descriptors for Skills P and A at A2 include synoptic elements.

Teachers should appreciate that the choice of an activity that is comparatively undemanding (primarily in terms of the level of the scientific knowledge and understanding that can be linked to the activity, and in the range/complexity of the equipment/techniques used) may prevent access to the highest marks.

Teachers should be aware of this feature of the assessment so that, when considering the award of higher marks, the activity should require a sophisticated approach and/or complex treatment. Higher marks must not be awarded for work that is simplistic or trivial.

One of the factors that determine the demand of an activity is the level of guidance given to candidates. The use of a highly structured worksheet, for example, will reduce the number of decisions and judgements required by the candidate and will limit the range of marks available.

Marking Candidates' Work

A similar set of mark descriptors is used for both AS and A2 (see Appendix C). The descriptors should be used to make a judgement as to which mark best fits a candidate's performance.

The descriptors have been written to provide clear continuity from the assessment of Sc1 for GCSE. This should ensure an effective continuation of the development of candidates' skills from GCSE to AS and Advanced GCE.

The mark descriptors within a skill area have been written to be hierarchical. Thus, in marking a piece of work, the descriptors for the lowest defined mark level should be considered first and only if there is a good match should the descriptors for the next level up be considered. Therefore, if a teacher is considering awarding a high mark for a piece of work, the work must have demonstrated a good match to all the lower mark descriptors.

For each skill, the scheme allows the award of intermediate marks (between the defined mark levels). An intermediate mark may be awarded when the work of a candidate exceeds the requirements of a defined mark level but does not meet the requirements of the next higher defined mark level sufficiently to justify its award. Thus, an intermediate mark could be awarded if the work meets only one of the two descriptors at the higher defined mark level, provides a partial match to both or provides a complete match to one and a partial match to the other.

In Skills P and A, a mark above the highest defined mark level should be awarded for work which meets all the requirements of the descriptors for the highest defined mark level and is judged to be of exceptional merit in terms of originality, depth, flair or the use of novel or innovative methods.

A mark of zero should be awarded where there has been an attempt to address the skill but the work does not meet the requirements of the lowest defined mark level.

The marks awarded should be based on both the final written work and the teacher's knowledge of the work carried out by the candidate. In assigning a mark, attention should be paid to the extent of any guidance needed by, or given to, the candidate.

In defining the various mark descriptors it is recognised that practical tasks vary widely, both in the experimental procedures used, and in the nature of the observations and measurements which may be made by the candidate. The mark descriptors for each defined level are intended to provide guidance to teachers on how to recognise levels of achievement. It is acknowledged that the balance between the statements provided for a particular level of performance will vary with the nature of the activity. Whilst both statements for a particular defined level **must** be considered in awarding the marks, it is clear that teachers will need to judge for themselves the relative weightings they attach to each of the statements.

Synoptic Assessment

Synoptic assessment involves the explicit drawing together of knowledge, understanding and skills learned in different parts of the Advanced GCE course. Assessment Objective AO4 relates specifically to synoptic assessment, and marks from Unit 2846, Component 2 contribute to the assessment of AO4.

During experimental and investigative work, synoptic assessment

- allows candidates to apply knowledge and understanding of principles and concepts from different parts of the specification in planning experimental work and in the analysis and evaluation of data.
- allows candidates to apply skills and techniques learned during the course.

All practical work assessed internally by centres for the **A2 Unit 2846, Component 2** should draw on the range of experience that the candidate has acquired during the AS and A2 courses. It is particularly important that an exercise used to assess planning skills should involve an element of research which goes beyond the repetition of an experiment that simply reflects the use of ideas or techniques met within the module currently being studied. Likewise, an assessment involving analysing evidence and drawing conclusions must require a candidate to use knowledge and understanding acquired outside the confines of a standard experiment recently practised. During the process of moderation, evidence will be sought that such breadth has been achieved.

The assessment descriptors for the skills of Planning (P) and Analysing Evidence and Drawing Conclusions (A), include statements that relate specifically to synoptic assessment. These are shown in bold and should be applied only when assessing A2 work. Thus, in A2, a candidate will not be able to achieve more than 2 marks in each of Skills P and A without demonstrating aspects of synoptic assessment. Candidates will also bring to the assessment of Skill I (Implementing) their experience of practical and investigative work from throughout the course. In Skill E (Evaluating Evidence and Procedures) aspects of Skills P and A are evaluated. Overall, in A2, approximately 15 of the 30 available marks can thus be identified as contributing to an assessment of AO4 (synoptic assessment).

Quality of Written Communication

Coursework must include an assessment of candidates' quality of written communication. At Level 3 candidates are required to:

- select and use a form of writing that is appropriate to the purpose and complex subject matter;
- organise relevant information clearly and coherently, using specialist vocabulary when appropriate;
- ensure text is legible and spelling, grammar and punctuation are accurate, so the meaning is clear.

The mark descriptors for Skills P and A have been written to include these aspects and these skills carry an additional mark each in recognition of this.

Annotation of Candidates' Work

Each piece of assessed coursework must be annotated to show how the marks have been awarded in relation to the relevant skills.

The writing of comments on candidates' work can provide a means of dialogue and feedback between teacher and candidate and a means of communication between teachers during internal standardisation of coursework. The main purpose of annotating candidates'

coursework should be, however, to provide a means of communication between teacher and the Moderator, showing where marks have been awarded and why.

The sample of work which is submitted for moderation **must** show how the marks have been awarded in relation to the marking criteria.

Annotations should be made at appropriate points in the margins of the text. The annotations should indicate both where achievement for a particular skill has been recognised and the mark awarded. It is suggested that the minimum which is necessary is that the 'shorthand' mark descriptors (for example, P.5a) should be written at the point on the script where it is judged that the work has met the descriptors concerned.

For Skill I Implementing, more detail is necessary and the Moderator will require evidence concerning candidates' use of practical techniques and safe working practice. This evidence could take the form of checklists or written notes.

Health and Safety

In UK law, health and safety is the responsibility of the employer. For most establishments entering candidates for AS and Advanced GCE this is likely to be the education authority or the governing body. Employees, i.e. teachers and lecturers, have a duty to co-operate with their employer on health and safety matters.

Various regulations, but especially the COSHH Regulations 1996 and the Management of Health and Safety at Work Regulations 1992, require that before any activity involving a hazardous procedure or harmful micro-organisms is carried out, or hazardous chemicals are used or made, the employer must provide a risk assessment. A useful summary of the requirements for risk assessment in school or college science can be found in Chapter 4 of *Safety in Science Education* (see below). For members, the CLEAPSS guide, *Managing Risk Assessment in Science* offers detailed advice.

Most education employers have adopted a range of nationally available publications as the basis for their Model Risk Assessments. Those commonly used include:

Safety in Science Education, DfEE, 1996, HMSO, ISBN 0 11 270915 X;

Safeguards in the School Laboratory, 10th edition, 1996, ASE ISBN 0 86357 250 2;

Hazcards, 1995, CLEAPSS School Science Service*;

Laboratory Handbook, 1988-97, CLEAPSS School Science Service*;

Topics in Safety, 2nd edition, 1988, ASE ISBN 0 86357 104 2;

Safety Reprints, 1996 edition, ASE ISBN 0 86357 246 4.

* Note that CLEAPSS publications are only available to members or associates.

(Other publications have sometimes been suggested, e.g. the SSERC *Hazardous Chemicals Manual* or the DES *Microbiology, an HMI Guide for Schools and FE,* but both of these are now out of print).

Where an employer has adopted these or other publications as the basis of their model risk assessments, an individual school or college then has to review them, to see if there is a need to modify or adapt them in some way to suit the particular conditions of the establishment. Such adaptations might include a reduced scale of working, deciding that the fume cupboard provision was inadequate or the skills of the candidates were insufficient to attempt particular activities safely. The significant findings of such risk assessment should then be recorded, for example on schemes of work, published teachers guides, work sheets, etc.

There is no specific legal requirement that detailed risk assessment forms should be completed, although a few employers require this.

Where project work or individual investigations, sometimes linked to work-related activities, are included in specifications this may well lead to the use of novel procedures, chemicals or micro-organisms, which are not covered by the employer's model risk assessments. The employer should have given guidance on how to proceed in such cases. Often, for members, it will involve contacting the CLEAPSS School Science Service (or, in Scotland, SSERC).

When candidates are planning their own practical activities, whether in project work or more routine situations, the teacher or lecturer has a duty to check the plans before practical work starts and to monitor the activity as it proceeds.

Appendix C

Mark Descriptors for Experimental and Investigative Skills

In defining the various mark descriptors, it is recognised that practical tasks vary widely, both in the experimental procedures used and in the nature of the observations and measurements which may be made by the candidate. The mark descriptors within each defined level are intended to provide guidance to teachers on how to recognise levels of achievement. It is acknowledged that the balance between the statements provided for a particular level of performance will vary with the nature of the activity. Whilst both statements for a particular level **must** be considered in awarding the marks, it is clear that teachers will need to judge for themselves the relative weightings they attach to each of the statements.

For examples of suitable tasks for assessing practical skills, and for examples of possible individual studies, teachers should refer to the Science Coursework Guidance booklet. Copies will be available from the OCR Publications Department from 2000.

Skill P – Planning		Total 8
Mark	**Descriptor**	
		The candidate:
1	**P.1a**	develops a question or problem in simple terms and plans a fair test or an appropriate practical procedure, making a prediction where relevant.
	P.1b	chooses appropriate equipment.
2		
3	**P.3a**	develops a question or problem using scientific knowledge and understanding **drawn from more than one area of the specification**; identifies the key factors to vary, control or take account of.
	P.3b	decides on a suitable number and range of observations and/or measurements to be made.
4		
5	**P.5a**	uses detailed scientific knowledge and understanding **drawn from more than one module of the specification** and information from preliminary work or a secondary source to plan an appropriate strategy, taking into account the need for safe working and justifying any prediction made;
	P.5b	describes a strategy, including choice of equipment, which takes into account the need to produce precise and reliable evidence; produces a clear account and uses specialist vocabulary appropriately.
6		
7	**P.7a**	retrieves and evaluates information from a variety of sources, and uses it to develop a strategy which is well structured, logical and linked coherently to underlying scientific knowledge and understanding **drawn from different parts of the AS and A2 specification**; uses spelling, punctuation and grammar accurately.
	P.7b	justifies the strategy developed, including the choice of equipment, in terms of the need for precision and reliability.
8		

The statements in bold represent additional requirements for Unit 2846, Component 2; they are not to be used for Unit 2843, Component 2.

Both statements at a defined level must be satisfied in order that the mark for this level is awarded. All descriptors for lower defined levels must be satisfied before a higher mark is awarded. From the bottom to the top of the mark range the activity should involve increasing demands of related scientific knowledge and understanding, manipulation, precision, accuracy and complexity.

Skill I – Implementing		Total 7
Mark	**Descriptor**	
		The candidate:
1	**I.1a**	demonstrates competence in simple techniques and an awareness of the need for safe working.
	I.1b	makes and records observations and/or measurements which are adequate for the activity.
2		
3	**I.3a**	demonstrates competence in practised techniques and is able to manipulate materials and equipment with precision.
	I.3b	makes systematic and accurate observations and/or measurements which are recorded clearly and accurately.
4		
5	**I.5a**	demonstrates competence and confidence in the use of practical techniques; adopts safe working practices throughout.
	I.5b	makes observations and/or measurements with precision and skill; records observations and/or measurements in an appropriate format.
6		
7	**I.7a**	demonstrates skilful and proficient use of all techniques and equipment.
	I.7b	makes and records all observations and/or measurements in appropriate detail and to the degree of precision permitted by the techniques or apparatus.

Both statements at a defined level must be satisfied in order that the mark for this level is awarded. All descriptors for lower defined levels must be satisfied before a higher mark is awarded. From the bottom to the top of the mark range the activity should involve increasing demands of related scientific knowledge and understanding, manipulation, precision, accuracy and complexity.

Skill A - Analysing Evidence & Drawing Conclusions		Total 8
Mark	**Descriptor**	
		The candidate:
1	**A.1a**	carries out some simple processing of the evidence collected from experimental work.
	A.1b	identifies trends or patterns in the evidence and draws simple conclusions.
2		
3	**A.3a**	processes and presents evidence gathered from experimental work including, where appropriate, the use of appropriate graphical and/or numerical techniques.
	A.3b	links conclusions drawn from processed evidence with the associated scientific knowledge and understanding **drawn from more than one area of the specification.**
4		
5	**A.5a**	carries out detailed processing of evidence and analysis including, where appropriate, the use of advanced numerical techniques such as statistics, the plotting of intercepts or the calculation of gradients.
	A.5b	draws conclusions which are consistent with the processed evidence and links these with detailed scientific knowledge and understanding **drawn from more than one module of the specification**; produces a clear account which uses specialist vocabulary appropriately.
6		
7	**A.7a**	where appropriate, uses detailed scientific knowledge and understanding **drawn from different parts of the AS and A2 specifications** to make deductions from the processed evidence, with due regard to nomenclature, terminology and the use of significant figures (where relevant).
	A.7b	draws conclusions which are well structured, appropriate, comprehensive and concise, and which are coherently linked to underlying scientific knowledge and understanding **drawn from different parts of the AS and A2 specifications**; uses spelling, punctuation and grammar accurately.
	8	

The statements in bold represent additional requirements for Unit 2846, Component 2; they are not to be used for Unit 2843, Component 2.

Both statements at a defined level must be satisfied in order that the mark for this level is awarded. All descriptors for lower defined levels must be satisfied before a higher mark is awarded. From the bottom to the top of the mark range the activity should involve increasing demands of related scientific knowledge and understanding, manipulation, precision, accuracy and complexity.

Skill E - Evaluating Evidence and Procedures		Total 7
Mark	**Descriptor**	
		The candidate:
1	**E.1a**	makes relevant comments on the suitability of the experimental procedures.
	E.1b	recognises any anomalous results.
2		
3	**E.3a**	recognises how limitations in the experimental procedures and/or strategy may result in sources of error.
	E.3b	comments on the accuracy of the observations and/or measurements, suggesting reasons for any anomalous results.
4		
5	**E.5a**	indicates the significant limitations of the experimental procedures and/or strategy and suggests how they could be improved.
	E.5b	comments on the reliability of the evidence and evaluates the main sources of error.
6		
7	**E.7a**	justifies proposed improvements to the experimental procedures and/or strategy in terms of increasing the reliability of the evidence and minimising significant sources of error.
	E.7b	assesses the significance of the uncertainties in the evidence in terms of their effect on the validity of the final conclusions drawn.

Both statements at a defined level must be satisfied in order that the mark for this level is awarded. All descriptors for lower defined levels must be satisfied before a higher mark is awarded. From the bottom to the top of the mark range the activity should involve increasing demands of related scientific knowledge and understanding, manipulation, precision, accuracy and complexity.

Appendix D

Mathematical Requirements

Arithmetic and Computation

Candidates should be able to:

- recognise and use expressions in decimal and standard form;
- use ratios, fractions and percentages;
- make estimates of the results of calculations (without using a calculator);
- use calculators to find and use x^2, $\frac{1}{x}$, $\sqrt{x}$, $\log_{10}x$, cos x.

Handling Data

Candidates should be able to:

- use an appropriate number of significant figures;
- find arithmetic means and medians;
- construct and interpret bar charts, pie charts and histograms;
- use a technique for smoothing a set of data;
- understand the use of scatter plots and correlation coefficients to identify a relationship between two variables;
- interpret and use logarithmic scales.

Algebra

Candidates should be able to:

- understand and use the following symbols: $<$, $>$, Δ, $\approx$, $\propto$;
- understand use the prefixes: giga (G), mega (M), kilo (k), milli (m), micro (μ), nano (n);
- change the subject of an equation;
- substitute numerical values into algebraic equations using appropriate units for physical quantities.

Graphs

Candidates should be able to:

- translate information between graphical, numerical and algebraic forms;
- plot and interpret graphs of two variables from experimental or other data.

Appendix E

Glossary of Terms used in Science Question Papers

It is hoped that the glossary will prove helpful to candidates as a guide, although it is not exhaustive. The glossary has been deliberately kept brief not only with respect to the number of terms included but also to the descriptions of their meanings. Candidates should appreciate that the meaning of a term must depend in part on its context. They should also note that the number of marks allocated for any part of a question is a guide to the depth of treatment required for the answer.

(a) *Define (the term[s])*... is intended literally. Only a formal statement being required.

(b) *Explain / What is meant by*... normally implies that a definition should be given, together with some relevant comment on the significance or context of the term(s) concerned, especially where two or more terms are included in the question. The amount of supplementary comment intended should be interpreted in the light of the indicated mark value.

(c) *State* ... implies a concise answer with little or no supporting argument.

(d) *List* ... requires a number of points with no elaboration. Where a given number of points is specified, this should not be exceeded.

(e) *Describe* ... requires candidates to state in words (using diagrams where appropriate) the main points of the topic. The amount of description intended should be interpreted in the light of the indicated mark value.

(f) *Discuss* ... requires candidates to give a critical account of the points involved in the topic.

(g) *Deduce / Predict* ... implies that candidates are not expected to produce the required answer by recall but by making a logical connection between other pieces of information. Such information may be wholly given in the question or may depend on answers extracted in an earlier part of the question. Predict also implies a concise answer with no supporting statement required.

(h) *Outline* … implies brevity, i.e. restricting the answer to giving essential detail only.

(i) *Suggest* ... is used in two main contexts. It may either imply that there is no unique answer or that candidates are expected to apply their general knowledge to a ‘novel’ situation, one that formally may not be ‘in the specifications’.

(j) *Calculate* ... is used when a numerical answer is required. In general, working should be shown.

(k) *Measure* ... implies that the quantity concerned can be directly obtained from a suitable measuring instrument, for example, mass using a balance, or volume using a burette.

(l) *Determine* ... often implies that the quantity concerned cannot be measured directly but is obtained by calculation, substituting measured or known values of other quantities into a standard formula.

(m) *Estimate* ... implies a reasoned order of magnitude statement or calculation of the quantity concerned. Candidates should make such simplifying assumptions as may be necessary about points of principle and about the values of quantities not otherwise included in the question.

(n) *Sketch* ... when applied to graph work, implies that the shape and/or position of the curve need only be qualitatively correct. However, candidates should be aware that, depending on the context, some quantitative aspects may be looked for, for example, passing through the origin, or discontinuity at a particular value. On a sketch graph it is essential that candidates clearly indicate what is being plotted on each axis.

(o) *Sketch* ... when applied to diagrams, implies that a simple, freehand drawing is acceptable. Nevertheless, care should be taken over proportions and the clear exposition of important details.

Special Note

Candidates are expected to quote units wherever necessary and to quote answers to an appropriate number of significant figures. The number of significant figures used in a numerical problem should be used as a guide to candidates.