Oxford Cambridge and RSA Examinations

RECOGNISING ACHIEVEMENT

OCR GCSE IN SCIENCE: DOUBLE AWARD B (STAGED ASSESSMENT) 1977

Key Features

- Unit based approach to assessment allowing resits.
- Staged assessment question paper available at end of Year 10.
- Common assessment approach with Science: Single Award B.
- Allows a co-ordinated teaching approach by subject specialists.
- Co-teachable with CoA; candidates can 'double enter' for GCSE and CoA Science.
- Separate teaching module for Sc1 'Ideas and Evidence'.
- Opportunities for Sc1 'Ideas and Evidence' signposted in the specification content.
- Key Skills and Citizenship issues signposted in the specification content.
- Specification content displayed to facilitate the production of differentiated schemes of work.

Support and In-Service Training for Teachers

- A full programme of In-Service training meetings arranged by the Training and Customer Support Division (telephone 01223 552950).
- Specimen question papers and mark schemes, available from the Publications department (telephone 0870 870 6622; fax 0870 870 6621).
- Past question papers and mark schemes, available from the Publications department (telephone 0870 870 6622; fax 0870 870 6621).
- Coursework guidance materials.
- Case study material available for 'Ideas and Evidence'.
- End of module tests available for formative and diagnostic testing.
- Written advice on coursework proposals.
- A report on the examination, compiled by senior examining personnel after each examination session.
- Individual feedback to each Centre on the moderation of internally assessed work.

CONTENTS

Throughout the specification the following icons are used to signpost teaching and learning opportunities in:

Citizenship

ICT

Key Skills

OCR GCSE IN SCIENCE: DOUBLE AWARD B (1977)

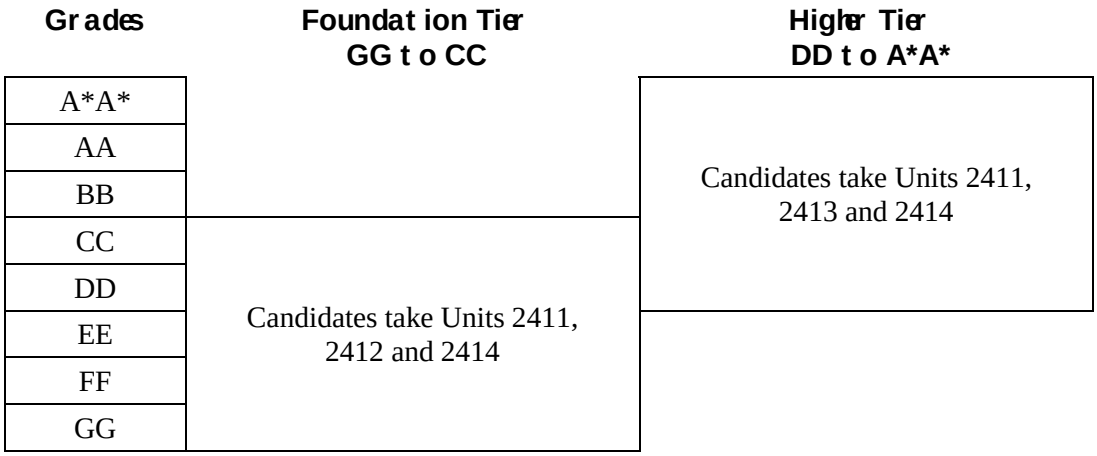
SECTION A: SPECIFICATION SUMMARY

TIERS

All written papers are set in one of two tiers: Foundation Tier papers assess grades GG to CC and Higher Tier papers assess grades DD to A*A*. In Unit 2411, candidates are entered for an option in either the Foundation Tier or the Higher Tier. Unit 2412 is at Foundation Tier and Unit 2413 is at Higher Tier. Unit 2414 (Coursework) is not tiered.

Candidates entered for final specification certification are entered at Foundation Tier or Higher Tier.

Candidates are not required to be entered for the same tier in Unit 2412 or 2413 as the tier entered in Unit 2411. However, the tier entered for final certification **must** be the same as that entered in Unit 2412 or 2413.



UNITS OF ASSESSMENT

The specification provides staged assessment using a unit based scheme. Candidates take three Units of Assessment – 2411, 2414 and **either** 2412 **or** 2413. Individual entries are required for each Unit of Assessment, and for the specification overall (1977) when certification is required.

Unit 2411 assesses the phase 1 modules of the specification (normally studied during Year 10). Units 2412 and 2413 assess phase 2 modules of the specification and one of these two units must be taken at the end of the course. All candidates for Unit 2411 must be entered for a single option under the relevant option code. In each of Units 2412 and 2413, candidates take three question papers – components 01, 02 and 03.

Candidates may re-sit any unit (or option within a unit) once only prior to certification. For each unit, the better score will be used in the aggregation of marks to produce the final overall grade.

Unit Code / Option Code	Title Component No and Name		Duration	Raw Marks	Weighting
	Staged Assessment				
2411 / FA	01	Early June - Foundation	1h 30min	90	25%
2411 / FB	02	Late June - Foundation	1h 30min	90	25%
2411 / HA	03	Early June - Higher	1h 30min	90	25%
2411 / HB	04	Late June - Higher	1h 30min	90	25%
2412	**Terminal Unit – Foundation Tier**				
	01	Paper 1 (Sc2)	1h 10min	66	18.3%
	02	Paper 2 (Sc3)	1h 10min	66	18.3%
	03	Paper 3 (Sc4)	1h 10min	66	18.3%
2413	**Terminal Unit – Higher Tier**				
	01	Paper 1 (Sc2)	1h 10min	66	18.3%
	02	Paper 2 (Sc3)	1h 10min	66	18.3%
	03	Paper 3 (Sc4)	1h 10min	66	18.3%
2414	Coursework (Sc1 investigations)			60	20%

QUESTION PAPERS

In Unit of Assessment 2411, each staged assessment question paper will consist of three sections: section A is Sc2, section B is Sc3 and section C is Sc4.

In Units of Assessment 2412 and 2413, each question paper will cover a specific Attainment Target.

INTERNAL ASSESSMENT

In Unit of Assessment 2414, candidates' performance related to Sc1.2 (Investigative Skills) will be assessed internally through coursework, and teachers' marks will be externally moderated by OCR.

SECTION B: GENERAL INFORMATION

1 Introduction

1.1 RATIONALE

This specification has been designed to fulfil the requirements of the National Curriculum subject orders for Double Science KS4 for England, for Wales and for Northern Ireland. It also meets the requirements of the General Criteria for GCSE and the GCSE Criteria for Science. This specification leads to the award of a double certificate in Science, graded on the eight-point scale from A*A* to GG. It offers the opportunity for Centres to use a co-ordinated teaching approach, by subject specialists in Sc2, Sc3 and Sc4.

This specification allows for staged assessment or for terminal assessment. Students can take the staged assessment question paper at the end of Year 10, or as part of the terminal assessment in Year 11. The specification consists of 19 teaching modules, one focusing on Sc1.1, six on Sc2, six on Sc3 and six on Sc4. The content of each module is written in specific and tightly focussed Learning Outcomes. There is an accompanying Single Award specification that is a complete sub-set of the Double Award specification. This allows transfer of candidates from Double Award to Single, at any stage, with minimum disruption of their progress.

Strong emphasis is placed on the active involvement of candidates in the learning process and the specification encourages a wide range of teaching and learning activities. This variety provides many opportunities to encourage and develop candidates' Key Skills. Skills in interpreting scientific information and in communicating scientific ideas are also strongly encouraged and reflected in the assessment of the specification.

OCR has taken great care in the preparation of this specification and assessment material to avoid bias of any kind.

1.2 CERTIFICATION TITLE

This specification will be shown on a certificate as:

OCR GCSE in Science: Double Award B

1.3 LEVEL OF QUALIFICATION

This qualification is approved by the regulatory authorities (QCA, ACCAC and CCEA) as part of the National Qualifications Framework.

Candidates who gain grades GG to DD will have achieved an award at Foundation Level.

Candidates who gain grades CC to A*A* will have achieved an award at Intermediate Level.

Two GCSEs at grade G to D and two GCSEs at grade C to A* are equivalent to one three-unit GNVQ at Foundation and Intermediate Level respectively.

Four GCSEs at grade G to D and four GCSEs at grade C to A* are equivalent to one six-unit GNVQ at Foundation and Intermediate Level respectively.

1.4 RECOMMENDED PRIOR LEARNING

Candidates who are taking courses leading to this qualification at Key Stage 4 should normally have followed the corresponding Key Stage 3 Programme of Study within the National Curriculum.

Candidates progressing from the OCR Certificate of Achievement course (Science Plus) should normally have achieved a Distinction (interim Gold Award).

Other candidates entering this course should have achieved a general educational level equivalent to National Curriculum Level 3, or a Distinction at Entry Level within the National Qualifications Framework.

1.5 PROGRESSION

GCSE qualifications are general qualifications that enable candidates to progress either directly to employment, or to proceed to further qualifications.

Many candidates who enter employment with one or more GCSEs would undertake training or further part-time study with the support of their employer.

Progression to further study from GCSE will depend upon the number and nature of the grades achieved. Broadly, candidates who are awarded mainly grades G to D at GCSE could either strengthen their base through further study of qualifications at Foundation Level within the National Qualifications Framework or could proceed to Intermediate Level. Candidates who are awarded mainly grades C to A* at GCSE would be well prepared for study at Advanced Level within the National Qualifications Framework.

1.6 OVERLAP WITH OTHER QUALIFICATIONS

This specification covers the core content required for each of Biology, Chemistry and Physics.

OCR GCSE in Science: Single Award B is a subset of this specification.

Some Centres may wish to 'double enter' CoA candidates who respond well during CoA courses for GCSE and so use activities from GCSE specifications to extend the attainment of these students and to provide access to GCSE Foundation Tier assessment. Consequently, this specification represents a progression from the Certificate of Achievement course offered by OCR and it is possible for a co-teaching approach to be used for both courses. In Part 5, the links with CoA are signposted.

The table below shows some areas where there are strong links between this GCSE specification and GNVQ specifications both at Foundation and at Intermediate Levels.

OCR GNVQ Science(Foundation) Specification	GCSE Specification
Unit 1 Measuring and observing in science	Sc1.2 (Scientific Investigations)
Unit 2 Investigating health and safety	Sc1.2 (Scientific Investigations)
Unit 3 Obtaining and making in science (obtaining useful products from rocks and minerals)	Module CD3 (Useful products from metal ores and rocks)
Unit 5 Growing plants (conditions for healthy plant growth)	Modules BD2, BD4 and BD5 (Green plants as organisms and inheritance)
Unit 6 Electrical maintenance	Module PD 2 (Mains electricity)
Unit 7 Investigating health and fitness	Module BD1 and BD6 (Nutrition and Respiration)

.

OCR GNVQ Science (Intermediate) Specification	GCSE Specification
Unit 1 Applying practical skills	Sc1.2 (Scientific Investigations)
Unit 2 Learning knowledge and understanding needed for scientific work	Sc1.2 and Module CD6 (Scientific Investigations, and Periodic Table)
Unit 3 Applying scientific knowledge (changing materials)	Module CD3 and CD5 (Useful products from metal ores and rocks, chemical reactions and reversible reactions)
Unit 4 Forensic science (stages in a forensic investigation and interpreting and presenting evidence)	Sc1.2 (Scientific Investigations)
Unit 6 Biotechnology and genetics	Modules CD1 and BD4 (Reactions involving enzymes, variation and inheritance)
Unit 7 Chemistry of renewable resources (biofuels and foodstuffs)	Modules BD1, BD6 and CD2 (Nutrition, respiration and useful products from organic sources)
Unit 8 Ecology and conservation	Module BD3 (Adaptation and competition, energy and nutrient transfer)
Unit 9 Using electronics	Module PD2 (Circuits)
Unit 10 Optical communication systems	Module PD1 (Characteristics of waves, the electromagnetic spectrum)

Further details of these, and other links between GCSE and GNVQ courses, can be found in the appropriate GNVQ science specifications available from OCR.

1.7 RESTRICTIONS ON CANDIDATE ENTRIES

Candidates who enter for this GCSE specification **may not** also enter for any other GCSE specification with the certification titles Science, Biology, Chemistry or Physics in the same examination series.

Candidates who enter for this GCSE **may**, however, also enter for any GNVQ specification with the certification title Science in the same examination series. They may also enter for any NVQ qualification. They **may** also enter for the Entry Level Certificate in Science.

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 GCSE qualification with the same classification code will have only one grade (the highest) counted for the purpose of the School and College Performance Tables.

The classification code for this specification is 1370.

1.8 CODE OF PRACTICE REQUIREMENTS

These specifications will comply in every respect with the revised Code of Practice requirements for courses starting in September 2001.

1.9 STATUS IN WALES AND NORTHERN IRELAND

This specification has been approved by ACCAC for use by Centres in Wales and by CCEA for use by Centres in Northern Ireland.

There are small differences in the Programmes of Study for each country and these are reflected within the specification content (Part 5) and in Appendices H and I.

By agreement between the Awarding Bodies in England and Wales, the assessment of coursework forms a 'common element' for all specifications in GCSE science and the sciences. For convenience, this is referred to as Sc1.2 throughout this document. Similarly, the 'Ideas and Evidence' aspects are, for convenience, referred to as Sc1.1.

Candidates in Wales and Northern Ireland should not be disadvantaged by terms, legislation or aspects of government that are different from those in England. Where such situations might occur, including in the external assessment, the terms used have been selected as neutral, so that candidates may apply whatever is appropriate to their own situation.

OCR will provide specifications, assessments and supporting documentation only in English.

Further information on the provision of assessment materials in Welsh and Irish may be obtained from the OCR Information Bureau (telephone 01223 553998).

2 Specification Aims

Candidates for assessment under this specification should be provided with opportunities to:

- develop curiosity, interest and enjoyment in science and its methods of enquiry;
- develop abilities and skills that are relevant to the study, practice and application of science, which are useful in everyday life, and which encourage safe practice;
- acquire a systematic body of scientific knowledge, and the skills needed to apply this in new and changing situations in a range of domestic, industrial and environmental contexts;
- acquire an understanding of scientific ideas, how they develop, and the factors which may affect their development and their power and limitations;
- plan and carry out a range of investigations, considering and evaluating critically their own data and that obtained from other sources, and using ICT where appropriate;
- evaluate in terms of their scientific knowledge and understanding, the benefits and drawbacks of scientific and technological developments, including those related to the environment, personal health and quality of life, and considering ethical issues;
- select, organise and present information clearly and logically, using appropriate scientific terms and conventions, and using ICT where appropriate.

3 Assessment Objectives

The Assessment Objectives describe the intellectual and practical skills that candidates should be able to demonstrate, and which will be assessed in the examination.

Assessment Objective AO1: Knowledge and understanding

Candidates must be able to:

- recognise, recall and show understanding of specific scientific facts, terminology, principles, concepts and practical techniques;
- demonstrate understanding of the power and limitations of scientific ideas and factors affecting how these ideas develop;
- draw on existing knowledge to show understanding of the benefits and drawbacks of applications of science;
- select, organise and present relevant information.

Assessment Objective AO2: Application of knowledge and understanding, analysis and evaluation

Candidates must be able to:

- describe, explain and interpret phenomena, effects and ideas in terms of scientific principles and concepts, presenting arguments and ideas clearly and logically;
- interpret and translate, from one form into another, data presented as continuous prose or in tables, diagrams or graphs;
- carry out relevant calculations;
- apply principles and concepts to unfamiliar situations, including those related to applications of science in a range of domestic, industrial and environmental contexts;
- evaluate scientific information and make informed judgements from it.

Assessment Objective AO3: Investigative skills

Candidates must be able to:

- devise and plan investigations, drawing on scientific knowledge and understanding in selecting appropriate strategies;
- demonstrate appropriate investigative methods, including safe and skilful practical techniques, obtaining data which are sufficient and of appropriate precision, and recording these methodically;
- interpret data to draw conclusions which are consistent with the evidence, using scientific knowledge and understanding, wherever possible, in explaining their findings;
- evaluate data and methods.

Weighting of Assessment Objectives

Assessment Objective	Attainment Target (s)	Weighting
AO1: Knowledge and understanding of science (about one third recall)	Sc1.1, Sc2, Sc3, Sc4	50%
AO2: Application of knowledge and understanding, analysis and evaluation	Sc1.1, Sc2, Sc3, Sc4	30%
AO3: Scientific investigation	Sc1.2	20%

Each of the Attainment Targets, Sc1, Sc2, Sc3 and Sc4 will be weighted at 25%.

Assessment of Sc2, Sc3 and Sc4 will be by means of externally set and externally marked question papers to be taken at the end of Year 10 (staged assessment) and/or at the end of the course (terminal assessment).

The assessment of Sc1.1, weighted at 5%, will be distributed equally across all the written terminal question papers.

Assessment of Sc1.2, weighted at 20%, will be internally assessed through coursework activities.

4 Scheme of Assessment

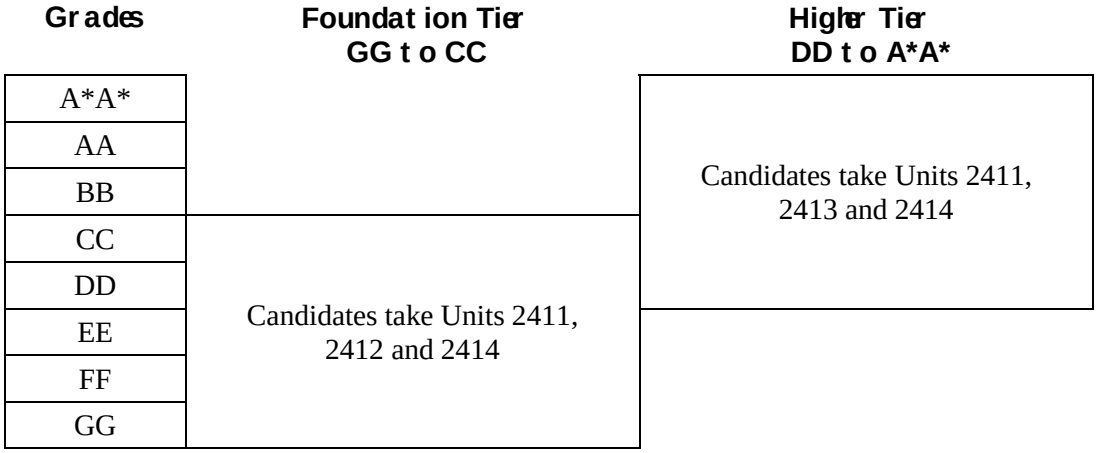
4.1 TIERS

All written papers are set in one of two tiers: Foundation Tier papers assess grades GG to CC and Higher Tier papers assess grades DD to A*A*. In Unit 2411, candidates are entered for an option in either the Foundation Tier or the Higher Tier. Unit 2412 is at Foundation Tier and Unit 2413 is at Higher Tier. Unit 2414 (Coursework) is not tiered.

Candidates entered for final specification certification are entered at Foundation Tier or Higher Tier.

Candidates are not required to be entered for the same tier in Unit 2412 or 2413 as the tier entered in Unit 2411. However, the tier entered for final certification **must** be the same as that entered in Unit 2412 or 2413.

Under no circumstances will a candidate entered for the Foundation Tier be awarded grades higher than CC. For final certification (1977), candidates on the Higher Tier who fail to achieve the minimum mark for the award of grades DD will normally be ungraded. There is, however, provision for those who narrowly fail to achieve this mark to be awarded grades EE.



4.2 UNITS OF ASSESSMENT

The specification provides staged assessment using a modular scheme. Candidates take three Units of Assessment – 2411, 2414 and **either** 2412 **or** 2413. Individual entries are required for each unit of assessment, and for the specification overall (1977) when certification is required.

Unit 2411 assesses the phase 1 modules of the specification (normally studied during Year 10). Units 2412 and 2413 assess phase 2 modules of the specification and one of these two units must be taken at the end of the course.

In each of Units 2412 and 2413, candidates take three question papers – components 01, 02 and 03.

Unit Code	Title Component No and Name		Duration	Raw Marks	Weighting
	Staged Assessment				
2411 / FA	Early June - Foundation		1h 30min	90	25%
2411 / FB	Late June - Foundation		1h 30min	90	25%
2411 / HA	Early June - Higher		1h 30min	90	25%
2411 / HB	Late June - Higher		1h 30min	90	25%
2412	**Terminal Unit – Foundation Tier**				
	01	Paper 1 (Sc2)	1h 10min	66	18.3%
	02	Paper 2 (Sc3)	1h 10min	66	18.3%
	03	Paper 3 (Sc4)	1h 10min	66	18.3%
2413	**Terminal Unit – Higher Tier**				
	01	Paper 1 (Sc2)	1h 10min	66	18.3%
	02	Paper 2 (Sc3)	1h 10min	66	18.3%
	03	Paper 3 (Sc4)	1h 10min	66	18.3%
2414	Coursework (Sc1 investigations)			60	20%

Unit Entry Options

Each candidate for Unit 2411 must be entered for a single option under the relevant option code.

Entry Code	Option Code	Component to be taken	
2411	FA	01	Staged Assessment (early June) – Foundation Tier
	FB	02	Staged Assessment (late June) – Foundation Tier
	HA	03	Staged Assessment (early June) – Higher Tier
	HB	04	Staged Assessment (late June) – Higher Tier

Recommended Entry Policy

Predicted GCSE grade	Recommended Tier of Entry
BB – A*A*	Higher
CC	Higher/Foundation
GG - DD	Foundation

Re-sit Rules

Candidates may re-sit any unit (or any option within a unit) once only prior to certification. For each unit, the better score will be used in the aggregation of marks to produce the final overall grade. Individual unit results have a shelf-life limited only by that of the specification.

4.3 QUESTION PAPERS

All question papers are available in two tiers, Foundation and Higher. Foundation Tier question papers will assess the Learning Outcomes printed in the first and second columns (headed 'Foundation Tier Only' and 'Foundation Tier and Higher Tier') of the teaching modules in Part 5. Higher Tier question papers will assess the Learning Outcomes printed in the second and third columns (headed 'Foundation Tier and Higher Tier', and 'Higher Tier Only') of the teaching modules in Part 5.

The staged assessment question papers in Unit of Assessment 2411 which assess the phase 1 modules of the specification (Year 10) will be available on two alternative dates in June. Candidates can take the staged assessment examination in Year 10 or Year 11. The terminal question papers, which assess the phase 2 modules and the key ideas from phase 1 of the specification, will be available in June of Year 11. Question papers timetabled at the same time (e.g. Unit 2411 components 01 and 03) will contain common questions, or part questions, targeting the overlapping grades CC and DD. No more than two thirds of the marks available in each question paper will be allocated to objective or short answer questions. On all question papers, a significant proportion of the questions will be concerned with the applications and implications of science.

Each staged assessment question paper in Unit of Assessment 2411 will cover all three Attainment Targets, Sc2, Sc3 and Sc4. All the staged assessment papers will carry 90 marks and will consist of three sections, Section A (Sc2), Section B (Sc3) and Section C (Sc4). Each section will carry 30 marks and will consist of structured questions with an incline of difficulty. All questions will be compulsory and candidates will have no choice of questions.

The 'Ideas and Evidence' component of Sc1, (PoS for England - statements 4.1 a-d, PoS for Wales - statements - 1.1 to 1.5) is not assessed in the staged assessment question papers. Candidates' quality of written communication will not be assessed in the staged assessment question papers.

Each terminal question paper in Units of Assessment 2412 and 2413 will cover a specific Attainment Target. Candidates entered for Units 2412 or 2413 take three question papers – 01 (Sc2), 02 (Sc3) and 03 (Sc4). Papers covering the same Attainment Target will be timetabled on the same day, and will commence at the same time. They will contain common questions, or part questions, targeting the overlapping grades CC and DD. All the terminal papers will carry 66 marks and will consist of structured questions with an incline of difficulty. All questions will be compulsory.

The 'Ideas and Evidence' component of Sc1, (PoS for England - statements 1.1 a-d; PoS for Wales - statements - 1.1 to 1.5) for which an overall specification weighting of 5% is required,

will be assessed equally across all terminal question papers (Unit 2412 components 01-03; Unit 2413 components 01-03).

Candidates' quality of written communication will be assessed across all terminal question papers (Unit 2412 components 01-03; Unit 2413 components 01-03). Further details are given in Part 4.10.

A list of formulae which candidates may be required to recall is printed as Appendix C.

The symbols, units and nomenclature used within the question papers will normally conform to the recommendations contained in 'Signs, Symbols and Systematics' [Association for Science Education (1995)]. A list of electrical symbols is provided as Appendix F.

A copy of the Periodic Table of the Elements (Appendix G) will be printed in the question papers for Unit 2412 component 02, Unit 2413 component 02, Unit 2411 components 01-04 and candidates will be expected to use it when necessary.

4.4 INTERNAL ASSESSMENT (COURSEWORK)

All OCR National Curriculum science and separate sciences specifications use a common scheme for the assessment of coursework. This scheme provides continuity from earlier versions of the specification, and will form a 'common element' across all of the National Curriculum science specifications of the GCSE Awarding Bodies.

Examples of appropriate tasks are given in Part 6.2.

Full details of internal assessment can be found in Part 7.

4.5 WEIGHTING OF ASSESSMENT OBJECTIVES

The relationship between the components and the Assessment Objectives of the scheme of assessment is shown in the following grid.

Foundation Tier

	Objective AO1	Objective AO2	Objective AO3	Total
2412	34.4%	20.6%	0%	55%
2414	-	-	20%	20%
Unit 2411 component 01 or 02	15.6%	9.4%	0%	25%
Overall	50%	30%	20%	100%

Higher Tier

	Objective AO1	Objective AO2	Objective AO3	Total
2413	34.4%	20.6%	0%	55%
2414	-	-	20%	20%
Unit 2411 component 03 or 04	15.6%	9.4%	0%	25%
Overall	50%	30%	20%	100%

4.6 CERTIFICATION

Candidates must be entered for certification to claim their overall grades for the specification. Candidates should be entered under the relevant option code:

1977 / F – Foundation Tier

1977 / H – Higher Tier

Rules of Combination

Candidates take 3 Units of Assessment.

Candidates must take the following combination of units:

Entry Code/ Option Code	Tier	Valid Combinations of Units
1977 / F	Foundation	2411, 2412 and 2414
1977 / H	Higher	2411, 2413, and 2414

Candidates are not required to take papers of the same tier in Units 2412 and 2413 as the tier taken in Unit 2411. However, the tier entered for final certification (1977) **must** be the same as that taken for Unit 2412 or 2413 when taken in the terminal session.

Terminal Rules

Candidates must take either Unit 2412 or Unit 2413 in the final examination session.

4.7 UNIT AVAILABILITY

There is one assessment session in June each year. Unit of Assessment 2411 is offered on two occasions in each session: early June and late June

The availability of Units is shown below.

Unit Code	Title	June 2002	June 2003
2411	Staged Assessment	Y	Y
2412	Terminal Unit -Foundation		Y
2413	Terminal Unit - Higher		Y
2414	Coursework (Sc1 investigations)		Y

The availability in subsequent years will be the same as in 2003.

4.8 UNIFORM MARKS

The specification will be graded on a total Uniform Mark Scale (UMS) of 600. The uniform mark thresholds for each of the units are shown below:

Units	2411 FA and FB	2411 HA and HB	2412	2413	2414
Max. uniform mark available	104	150	230	330	120
AA		120		264	96
BB		105		231	84
CC	90	90	198	198	72
DD	75	75	165	165	60
EE	60		132		48
FF	45		99		36
GG	30		66		24

Note: A*A* is not awarded at Unit level.

For final certification (1977), the overall uniform mark grade thresholds are as follows:

Tier	A*A*	AA	BB	CC	DD	EE	FF	GG	UU
Foundation				360	300	240	180	120	0
Higher	540	480	420	360	300				0

4.9 ASSESSMENT OF QUALITY OF WRITTEN COMMUNICATION

Candidates are expected to:

- present relevant information in a form that suits its purpose;
- ensure text is legible and that spelling, punctuation and grammar are accurate, so that meaning is clear.

Where appropriate, they should also use a suitable structure and style of writing.

In the terminal written papers, candidates' quality of written communication will be assessed by means of questions requiring extended responses. In each paper approximately 4 marks, contributing to Assessment Objective AO1, will be allocated to the assessment of written communication. Mark schemes will reflect this provision. Mark schemes will reserve marks for the ability to sequence arguments and present them effectively, and for technical aspects of spelling and grammar.

In coursework, the assessment of quality of written communication is embedded in the level of response mark descriptions for Skill Areas P, A and E.

There is no formal assessment of ICT in Science, but Centres are encouraged, whenever appropriate, to use ICT during the teaching of the specification content. For guidance on the opportunities for the enhancement of candidates' ICT skills see Part 8 of the specification.

4.10 DIFFERENTIATION

In the question papers, differentiation is achieved by the use of two tiers of entry, by setting questions which are designed to assess candidates at their appropriate level of attainment, 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 investigations and tasks which allow them to display positive achievement.

4.11 AWARDING OF GRADES

The written papers have a total weighting of 80% and internal assessment a weighting of 20%.

A candidate’s uniform (UMS) mark for each of the Units of Assessment taken will be aggregated to give the candidate’s total mark for the specification. The candidate’s grade will be determined by this total mark. Thus, 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 assessment may be balanced by better performance in others. Candidates achieving less than the minimum mark for grades GG will be ungraded.

Candidates on the Higher Tier who fail to achieve the minimum mark for the award of grades DD will normally be ungraded. There is, however, provision for those who narrowly fail to achieve this mark to be awarded grades EE.

4.12 GRADE DESCRIPTIONS

Grade descriptions are provided to give a general indication of the standards of achievement likely to have been shown by the candidates awarded particular grades. The descriptions must be interpreted in relation to the content specified in Part 5; they are not designed to define that content.

GradeF

Candidates recall a limited range of information. For example, they state the main functions of organs of the human body, describe some defence mechanisms of the body, state some uses of materials obtained from oil, suggest ways in which insulation is used in domestic contexts.

Candidates use and apply knowledge and understanding in some specific everyday contexts. For example, they describe how a reduction in the population of one organism in a habitat can affect another organism, suggest a way of speeding up a particular chemical reaction, explain that fuels are energy resources and that energy is sometimes `wasted'. Candidates make some use of scientific and technical vocabulary and make simple generalisations from information.

Candidates relate scientific explanations to some experimental evidence and describe simple examples of benefits and drawbacks of scientific development.

Candidates devise fair tests in contexts, which involve only a few factors. They use simple apparatus to make measurements appropriate to the task and record observations and measurements in tables and graphs. Candidates obtain information from simple tables, charts and graphs and identify simple patterns in information and observations. They offer explanations consistent with the evidence obtained.

GradeC

Candidates recall a range of scientific information from all areas of the specification. For example, they describe how some organ systems in living things carry out life processes, recall simple chemical symbols and formulae, recall correct units for quantities. Candidates use and apply scientific knowledge and understanding in some general contexts; for example, they describe how a cell is adapted to its functions, use simple balanced equations, use quantitative relationships between physical quantities to perform calculations. Candidates describe links between related phenomena in different contexts, use diagrams, charts and graphs to support arguments, use appropriate scientific and technical vocabulary in a range of contexts.

Candidates describe how evidence is used to test predictions made from scientific theories, and how different people may have different views on some aspects of science. Candidates use scientific knowledge and understanding to identify an approach to a question, for example, identifying key factors to vary and control. Candidates use a range of apparatus to make careful and precise measurements and systematic observations and recognise when it is necessary to repeat measurements and observations.

They present data systematically, in graphs where appropriate, and use lines of best fit. Candidates identify and explain patterns within data and draw conclusions consistent with the evidence. They explain these conclusions using scientific knowledge and understanding and evaluate how strongly their evidence supports the conclusions.

Grade A

Candidates recall a wide range of knowledge from all areas of the specification.

Candidates use detailed scientific knowledge and understanding in a range of applications relating to scientific systems or phenomena. For example, they explain how temperature or water content is regulated in humans, routinely use a range of balanced chemical equations, use the particle model to explain variations in reaction rates, use a wide range of relationships between physical quantities to carry out calculations effectively. Candidates draw together and communicate knowledge from more than one area, use routinely scientific or mathematical conventions in support of arguments, use a wide range of scientific and technical vocabulary throughout their work.

Candidates explain how scientific theories can be changed by new evidence and identify some areas of uncertainty in science.

Candidates use scientific knowledge and understanding to select an appropriate strategy for a task, identifying the key factors to be considered. They make systematic observations in qualitative work and decide which observations are relevant to the task in hand. When making measurements they decide the level of precision needed and use a range of apparatus with precision and skill to make appropriately precise measurements. They select a method of presenting data appropriate to the task; they use information from a range of sources where it is appropriate to do so. They identify and explain anomalous observations and measurements and the salient features of graphs.

Candidates use scientific knowledge and understanding to identify and explain patterns and draw conclusions from the evidence by combining data of more than one kind or from more than one source. They identify shortcomings in the evidence, use scientific knowledge and understanding to draw conclusions from their evidence and suggest improvements to the methods used that would enable them to collect more reliable evidence.

SECTION C: SPECIFICATION CONTENT

5 Specification Content

5.1 INTRODUCTION

Throughout Key Stage 4, teaching approaches based on this specification should bear in mind the preamble to the Key Stage 4 Programme of Study: Double Award Science.

- Pupils learn about a wider range of scientific ideas and consider them in greater depth, laying the foundations for further study.
- They explore how technological advances relate to the scientific ideas underpinning them.
- They consider the power and limitations of science in addressing industrial, ethical and environmental issues, and how different groups have different views about the role of science.
- When they carry out investigations, they use a range of approaches and select appropriate reference sources, working on their own and with others.
- They do more quantitative work and evaluate critically the evidence collected and conclusions drawn.
- They communicate their ideas clearly and precisely in a variety of ways.
- They see how scientists work together to develop new ideas, how new theories may, at first, give rise to controversy and how social and cultural contexts may affect the extent to which theories are accepted.

5.2 LAYOUT OF TEACHING MODULES

The detailed specification content is displayed on pages 30 to 148. It consists of 19 teaching modules and is displayed in tabular format, each of which contains specific Learning Outcomes linked to the Programme of Study for England and the Programme of Study for Wales for Sc1.1, Sc2, Sc3 and Sc4. Each teaching module includes a short rationale that indicates the links between modules. The format used has been designed to provide a 'teacher-friendly' approach to the content that is a clear development from that used in the former Science B: Double Award (Suffolk Development) syllabus.

The layout uses four columns. The first column gives references to the Programme of Study for England, the Programme of Study for Wales, the Programme of Study for Citizenship, Key Skills, the Certificate of Achievement in Science and opportunities for the development of Sc1.1. The other three columns give learning outcomes targeted for Foundation Tier Only, for Foundation Tier and Higher Tier, and for Higher Tier Only. Some Learning Outcomes in phase 1 modules are highlighted in light grey; these are the key ideas that are tested both in the staged assessment question papers and in the terminal question papers. Some Learning Outcomes are in bold; these are common to the OCR GCSE in Science: Single Award B specification.

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to:		
References to PoS in England, PoS in Wales, PoS in Citizenship, Key Skills signposts, links to CoA and opportunities for the development of Sc1.1	Learning Outcomes that will be assessed only on Foundation Tier question papers Learning Outcomes highlighted in grey are phase 1 key ideas **Learning Outcomes in bold are common with the Single Award specification**	Learning Outcomes that can be assessed on either Foundation Tier or Higher Tier question papers Learning Outcomes highlighted in grey are phase 1 key ideas **Learning Outcomes in bold are common with the Single Award specification**	Learning Outcomes that can be assessed only on Higher Tier question papers Learning Outcomes highlighted in grey are phase 1 key ideas **Learning Outcomes in bold are common with the Single Award specification**

5.3 SIGNPOSTING AND CROSS REFERENCING

The narrow column on the left hand side is provided to give teachers additional information expressed in an abbreviated form, and the table below summarises this information.

Abbreviations used	Explanation and guidance
xx	This is the PoS in England reference. Unless otherwise indicated this will correspond to the Attainment Target referred to in the teaching module.
Wx.x	This is the PoS in Wales reference. This will correspond to the Attainment Target referred to in the teaching module.
CoA x.x	These learning outcomes are linked to the OCR Certificate of Achievement course in science (3970) which has been designed for candidates perceived as unlikely to benefit fully from following a GCSE course in Science. The numbers refer to the Titles of Items from the Certificate of Achievement syllabus.
Key Skills 	This logo appears alongside those Learning Outcomes which are likely to provide opportunities for teachers to develop Key Skills, and further details are provided in Part 9. The Key Skill and Level are coded underneath the logo. The code refers to Application of Number (N), Communication (C), Information Technology (IT), Working with Others (WO), Improving Own Performance (IOP) and Problem Solving (PS), whilst the numbers refer to Levels 1 and 2.
	This logo indicates opportunities to develop aspects of the Programme of Study for Citizenship. Further details are provided in Part 8.2 of the specification.
1.1x	This is the PoS in England reference to Sc1.1 and indicates opportunities for the development of Sc1.1 Ideas and Evidence.

5.4 TEACHING MODULES

The 19 teaching modules are listed in the table below. Phase 1 refers to Year 10 teaching modules and phase 2 refers to Year 11 teaching modules.

Teaching Module Code	Teaching Module Name	Attainment Target	Phase
BD1	Supplying the Cell	Sc2	1
BD2	Control in Animals and Plants	Sc2	1
BD3	Ecology	Sc2	1
BD4	Variation, Inheritance and Evolution	Sc2	2
BD5	The Working Plant	Sc2	2
BD6	Health in the Balance	Sc2	2
CD1	Equations and Rates of Reaction	Sc3	1
CD2	Energy in Chemistry	Sc3	1
CD3	Rocks and Metals	Sc3	1
CD4	Carbon Chemistry	Sc3	2
CD5	Chemical Economics	Sc3	2
CD6	The Periodic Table	Sc3	2
PD1	Waves in Action	Sc4	1
PD2	Energy in the Home	Sc4	1
PD3	Forces and Motion	Sc4	1
PD4	Using Electricity	Sc4	2
PD5	Applications of Physics	Sc4	2
PD6	Earth, Space and Nuclear Radiation	Sc4	2
D7	Ideas and Evidence in Science	Sc1.1	1 and 2

5.5 CONTENT RELATED TO SC1: SCIENTIFIC ENQUIRY

5.5.1 Sc1.1 Ideas and Evidence

This section of the Attainment Target will be assessed in the terminal question papers (Units 2412 and 2413). Candidates should develop the relevant capabilities through the variety of activities used to deliver the content of Sc2, Sc3 and Sc4 throughout the course.

Since it is essential that teachers incorporate this specification content into the teaching and learning requirements of the Programme of Study for Sc2, Sc3 and Sc4, the opportunities have been given in outline only. Teachers need to refer to the PoS and the Learning Outcomes for Sc1.1 in the Teaching Module D7 Ideas and Evidence.

The table below indicates where opportunities exist in the specification for the teaching of Sc1.1.

Sc1 PoS Reference	Possible Opportunity	Teaching Module
1a, 1b, 1c	The development of ideas on blood circulation	BD1
1c, 1d	Illegal drugs in sport	BD2
1.1b	Analysis of ecological surveys	BD3
1c, 1d	The need for conservation of endangered species	BD3
1d	Aspects of the increasing world population	BD3
1d	Biological and chemical methods of increasing crop yield	BD2, BD3 and CD5
1c, 1d	The use of hormones	BD2
1b, 1c, 1d	The importance of genetic and environmental factors on intelligence	BD4
1a	The DNA story	BD4
1a, 1c, 1d	Ethical dilemmas of cloning and genetic modification	BD4
1a, 1b	The contribution of Mendel to the study of genetics	BD4
1a, 1b, 1c	The contribution of Darwin to the development of evolution and the evidence for evolution from the fossil record	BD4
1a, 1b, 1c, 1d	The effects of smoking and drugs	BD6

1b, 1d	Evaluating the use of fuels for different purposes	CD2
1c, 1d	The issues arising from the environmental impact of the oil industry	CD2 and CD4
1a, 1b, 1c	The development of plate tectonics	CD3 and PD1
1b, 1d	Evaluating the use of plastics for different purposes	CD4
1a	The discovery of Buckminster Fullerene	CD4
1b, 1d	Analysis of data with regard to manufacture of chemicals	CD5
1b	The development of the Periodic Table	CD6
1a, 1b, 1c	The development of ideas on atoms and atomic structure	CD6
1a, 1b, 1c	The development of radioactivity	PD1 and PD6
1a, 1c, 1d	Road safety	PD2
1b	Energy saving in a home	PD2
1a, 1b, 1c, 1d	The development of ideas on the origin of the Universe	PD6

5.5.2 Sc1.2 Investigative Skills

Assessment of investigative skills will be by means of internally assessed coursework in Unit of Assessment 2414. Some examples of activities, which might be used as a basis for assessment, are given in Part 6.2. Details of the assessment scheme and the mark descriptions to be used are given in Part 7.

Centres should seek opportunities throughout the course for helping students to develop the necessary skills.

Planning

Programme of Study for England	Programme of Study for Wales
Candidates should be taught to:	**Candidates should be taught to:**
2a use scientific knowledge and understanding to turn ideas into a form that can be investigated, and to plan an appropriate strategy	3.1 prepare and outline a plan for the investigation, making use of their knowledge and understanding of the context in planning their procedure
2b decide whether to use evidence from first-hand experience or secondary sources	3.2 carry out preliminary work, making use of secondary sources when appropriate, where this helps to clarify what they need to do
2c carry out preliminary work and make predictions, where appropriate	
2d consider key factors that need to be taken into account when collecting evidence, and how evidence can be collected in contexts in which variables cannot readily be controlled	3.3 consider the key variables in contexts involving a number of variables
	3.6 recognise factors which cannot readily be controlled and to make judgements about the amount of data needed in these contexts
2e decide the extent and range of data to be collected, and techniques, equipment and materials to use	3.4 plan how to vary or control variables
	3.5 consider the number and range of observations or measurements to be made
	3.7 select apparatus, equipment and techniques, choosing ICT when appropriate to collect and store data
	3.8 take responsibility for recognising hazards in their work

Obtaining Evidence

Programme of Study for England	Programme of Study for Wales
Candidates should be taught to:	**Candidates should be taught to:**
2f use a wide range of equipment and materials appropriately, and manage their working environment to ensure the safety of themselves and others	3.9 use a range of apparatus and equipment safely and with skill taking action to control the risks to themselves and others
2g make observations and measurements, including the use of ICT for datalogging to a degree of precision appropriate to the context	3.10 make observations and measurements to a degree of precision appropriate to the context
2h make sufficient observations and measurements to reduce error and obtain reliable evidence	3.11 make sufficient relevant observations and measurements for reliable data
2i judge the level of uncertainty in observations and measurements	3.12 consider uncertainties in measurements and observations, repeating them when necessary
2j represent and communicate qualitative and quantitative data using diagrams, tables, charts, graphs and ICT	3.13 record findings clearly and appropriately as they carry out the work

Analysing and Considering Evidence

Programme of Study for England	Programme of Study for Wales
Candidates should be taught to:	**Candidates should be taught to:**
2k use diagrams, tables, charts and graphs, and identify and explain patterns or relationships in data	3.14 choose appropriate and effective means of presenting their data
	3.15 identify trends or patterns in data, describing the relationship between the variables
2l present the results of calculations to an appropriate degree of accuracy	
2m use observations, measurements or other data to draw conclusions	3.16 draw conclusions that are consistent with their findings
2n explain to what extent these conclusions support any predictions made, and enable further predictions to be made	
2o use scientific knowledge and understanding to explain and interpret observations, measurements or other data, and conclusions	3.17 use knowledge and understanding of science in commenting on and, if possible, explaining the results of their investigation

Evaluating

Programme of Study for England	Programme of Study for Wales
Candidates should be taught to:	**Candidates should be taught to:**
2p consider anomalous data giving reasons for rejecting or accepting them, and consider the reliability of data in terms of the uncertainty of measurements and observations	3.19 consider whether there are anomalous results and, if so, to consider the reasons for them, rejecting them when appropriate
2q consider whether the evidence collected is sufficient to support any conclusions or interpretations made	3.18 consider whether the information gathered is sufficient to enable firm conclusions to be drawn
2r suggest improvements to the methods used	3.21 propose improvements to the methods that have been used
2s suggest further improvements	3.22 propose further investigations to test their conclusions
	3.20 consider the reliability of results in terms of the uncertainty of measurements and observations

5.6 CONTENT RELATED TO SC1.1: IDEAS AND EVIDENCE IN SCIENCE

D7 Sc1 Scientific Enquiry (Ideas and Evidence in Science)

English National Curriculum		Welsh National Curriculum	
Candidates should be taught:		**Candidates should be taught:**	
		1.1	to apply their knowledge, understanding and skills to solve problems, ask questions, and offer explanations, relating scientific ideas to the information about them
		1.2 (part)	to use and consider (a variety of) sources of information, (both that obtained from their own work and) secondary sources, (including ICT)
		1.3 (part)	to evaluate (a range of sources of) information critically in arriving at conclusions
1a	how scientific ideas are presented, evaluated and disseminated		
1b	how scientific controversies can arise from different ways of interpreting empirical evidence	1.4	to recognise that scientific controversies arise from different interpretations and emphasis placed on information
1c	ways in which scientific work may be affected by the contexts in which it takes place, and how these contexts may affect whether or not ideas are accepted	1.5	to consider ways in which scientific ideas are affected by the social, political, and historical contexts in which they develop, and how these contexts may affect whether or not the ideas are accepted
1d	to consider the power and limitations of science in addressing industrial, social and environmental questions, including the kinds of questions science can and cannot answer, uncertainties in scientific knowledge, and the ethical issues involved		

Learning outcomes in bold are common to the Single Award Specification.

Rationale

This module addresses the Sc1.1 Ideas and Evidence in Science Programme of Study for England. It focuses on the development of scientific ideas and how these scientific ideas are affected by social, historical, political, spiritual, ethical and moral contexts. The module also tackles the controversies that can arise from different interpretations of evidence and considers the kinds of problems scientists can answer and the kinds scientists cannot.

Knowledge and understanding from the phase two modules (BD4, BD5, BD6, CD4, CD5, CD6, PD4, PD5, PD6) and key ideas from phase one modules (BD1, BD2, BD3, CD1, CD2, CD3, PD1, PD2, PD3) will be assumed in the examination questions. All other scientific knowledge will be provided within the examination questions.

The use of case study material will be essential for the study of this module and whenever possible the content of this module should be integrated within the other modules.

The interpretation of evidence will be extended to include examples where there is more than one possible conclusion to show how this can lead to controversy and argument between groups of scientists.

Darwin's theory of evolution and climatic changes due to an increased greenhouse effect could be used to illustrate the controversies that can arise when interpreting evidence. Genetic modification and cloning, food scares, reprocessing of nuclear fuels and use of animals in medical research could provide examples of how scientific work is affected by the contexts in which it takes place. Alternatively, historical contexts could be explored using ideas of Galileo, Darwin or Mendeleev.

Other current day issues such as ozone depletion, use of chlorine containing compounds, BSE, road safety, smoking and drugs could also be used as examples to consider the power and limitations of science.

Module: D7 Module Title: Sc1.1 Scientific Enquiry (Ideas and Evidence in Science)

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
Sc1 1a	**state that scientific ideas are communicated to other people by** • **scientific publications *e.g. Nature, New Scientist and the Lancet*** • **books** • **speeches at conferences** • **internet** • **media *e.g. television and newspapers*** ***e.g. Case Study of the work of a modern scientist.***	**describe why scientific ideas need to be communicated to others** • **provide information to other scientists** • **evaluation by other scientists (checking experimental data or the theory behind the idea)** • **review by other scientists** • **provide information to government agencies** • **provide information to the general public** ***e.g. Case study of the work of a modern scientists***	**explain why scientific ideas need to be communicated to other people so** • **other scientists can be aware of new research that they can use in their own studies** • **other scientists can check and repeat experimental research to check its validity** • **the general public can be aware of new scientific ideas** • **governments can respond with appropriate ethical debate and informed legislation** ***e.g. Case study of the work of a modern scientists***

Module: D7 Module Title: Sc1.1 Scientific Enquiry (Ideas and Evidence in Science)

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
Sc1 1b	**analyse and evaluate simple empirical evidence and information that has only one possible interpretation e.g.** ***identifying trends and patterns Which fuel releases the most energy per gram? The connection between lung cancer and tobacco smoking***	**explain that it is possible to make more than one interpretation from scientific evidence and information** ***e.g. decline in one species in a habitat may lead to an increase or a decrease in other species, choice of insulation material given a variety of data, choice of a fuel for a particular purpose given data*** **analyse and evaluate empirical evidence and information that has only one possible interpretation i.e. processing evidence and then interpreting** **solve problems, ask questions and explain conclusions using knowledge and understanding from the Foundation Tier columns from** • **all phase 2 modules** • **key ideas in phase 1 modules**	**explain that scientific controversies can arise when different scientists interpret data in different** ***ways e.g. causes of cancer and effects of genetically modified crops and foods*** **explain that scientific controversies can only be solved by further research and interpretation of fresh data** ***e.g. analysing more complex data on the effects of drug abuse.*** **analyse and evaluate empirical evidence and information that has more than one possible interpretation** ***e.g. causes of the spread of a disease from statistical data*** **describe the limitations of the interpretation of given empirical evidence and information** ***e.g. causes of acid rain damage in a complex environment*** **solve problems, ask questions and explain conclusions using knowledge and understanding from the Higher Tier columns from** • **all phase 2 modules** • **key ideas in phase 1 modules**

Module D7 Module Title Sc1.1 Scientific Enquiry (Ideas and Evidence in Science)

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
Sc1 1c	**state ways in which scientific work may be affected by the contexts in which it takes place** • **historical** • **social** • **moral or ethical** • **religious or spiritual** • **political** **state some of the contexts that affect whether or not a scientific idea is accepted** • **historical** • **social** • **moral or ethical** • **religious or spiritual** • **political**	**identify ways in which scientific work may be affected by the contexts in which it takes place given information about the scientific work** ***e.g. the impact of humans are the environment and pollution control*** **identify some of the contexts that affect whether or not a given scientific idea is accepted** ***e.g. case study material on evolution versus creationism***	**explain ways in which scientific work may be affected by the contexts in which it takes place given case study information** ***e.g. genetic modification research*** **explain how different contexts can affect whether or not a given scientific idea is accepted** ***e.g. Galilieo and Darwin***
Sc1 1d	**explain that science can answer some industrial, social and environmental questions** ***e.g. How some diseases such as malaria are transmitted? Death rates can be decreased by the provision of clean water***	**explain why it is impossible for science to answer some kinds of questions** ***e.g. are genetic modified foods completely safe?*** **recognise questions that science can and cannot answer from a given case study** ***e.g. Are genetic modified foods completely safe? Are mobile phones safe to use?***	**evaluate the power and limitation of science in addressing social and environmental questions given appropriate case study material** • **questions that can or cannot be answered** • **uncertainties in scientific knowledge** • **ethical issues** ***e.g. long terms effects in drug and medicine trials***

5.7 CONTENT RELATED TO SC2: LIFE PROCESSES AND LIVING THINGS

BD1: Supplying the Cell

Programme of Study

English National Curriculum		Welsh National Curriculum	
Candidates should be taught		**Candidates should be taught**	
1a	about similarities and differences in structure between plant and animal cells	1.1	that plant and animal cells have some similarities in structure
1e	to relate ways in which animals and plants function as organisms to cell structure and activity		
2a	the processes of digestion, including the function of organs and the role of enzymes, stomach acid and bile	2.1	the organs making up the human digestive system and their roles
		2.2	the processes involved in digestion, including the roles of enzymes, stomach acid and bile
2b	the structure of the human circulatory system, including the composition and functions of blood	2.4	the structure of the human circulatory system, including the composition and functions of blood
2c	that there is an exchange of substances between capillaries and tissues	2.5	how substances are exchanged at capillaries
2d	how the structure of the thorax enables ventilation of the lungs	2.6	the structure of the thorax
		2.7	how breathing, including ventilation of the lungs, takes place

Grey highlighting indicates "key ideas" which are to be re-examined in the Terminal examination together with the content from the Phase 2 modules.
Learning outcomes in bold are common to the Single Award Specification.

Rationale

This module reminds candidates of the basics of cell structure which will be implicit to all other Sc2 modules except BD3.
All candidates should develop a sound and useful knowledge of how their bodies work. This knowledge can be extended into the details of how the breathing, circulatory and digestive systems work.
It should introduce candidates to the concept of adaptation in organs and cells of the breathing, circulatory and digestive systems.
The circulatory system is referred to again in module BD6. Enzymes are also covered in module CD1.

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
1a 1e W1.1 CoA 2.1	**identify the parts of cells and their functions** • **nucleus - carries genetic information** • **membrane - controls movement of substances in and out of cell** • **cytoplasm - where many chemical processes happen** • chloroplasts - absorb light energy for photosynthesis • cell wall - provides support • vacuole - contains cell sap and helps provide support	describe the similarities and differences between plant and animal cells • nucleus, membrane, cytoplasm in plant and animal cells • chloroplasts, cell wall, large vacuole in plant cells only **explain how the structure of a cell is related to its functions** • **red blood cell - small size and biconcave disc shape provide a large surface area to take in and release oxygen, haemoglobin to carry oxygen, flexible to pass through small blood vessels** • leaf palisade cell - cells contain many chloroplasts and are positioned on top surface to maximise light absorption • white blood cell - flexible shape to engulf disease organisms	
2a W2.1 W2.2 CoA 2.1, 2.5 Key Skills C1.1, C1.2 and C1.3	**name and locate the main parts of the digestive system:** • **oesophagus, stomach, liver, small intestine, large intestine** **state the functions of the main parts of the digestive system** • **stomach for food storage and digestion** • **small intestine for digestion and absorption of food** • **large intestine for absorption of water**	**name and locate the parts of the digestive system** • **gall bladder, bile duct, pancreas** **describe how the parts of the digestive system work together to bring about digestion** • **peristalsis** • **secretion of digestive juices by liver and pancreas**	**explain how the small intestine is adapted for the absorption of food:** • **large surface area (presence of villi, very long)** • **permeable surface** • **good blood supply**

Module BD1 Module Title Supplying the Cell

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
Key Skills WO1.1, 1.2, 1.3, 2.1, 2.2, 2.3 Key Skills LP1.1, 1.2, 1.3, 2.1, 2.2, 2.3 Key Skills PS1.1, 1.2, 1.3, 2.1, 2.2, 2.3	**state that physical digestion is breaking food into smaller pieces to pass more easily through the digestive system** • **chewing in the mouth** • **squeezing in the stomach**	**describe that small molecules are absorbed into the blood in the small intestine by diffusion** **explain that in chemical digestion the digestive enzymes break down large food molecules into smaller ones** **state that stomach acid aids enzyme function**	**describe how enzyme activity is affected by pH and temperature** • **optimum pH** • **optimum temperature** • **denaturing at extremes pf pH and high temperatures** • **denaturing is an irreversible change inhibiting enzyme function** **explain that bile improves fat digestion by the emulsification of fat droplets providing a larger surface area for enzyme action**

Module BD1 Module Title Supplying the Cell

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
2d W2.6 W2.7 CoA 2.1	name and locate the main parts of the breathing system: • trachea • diaphragm, • rib cage, • lungs	name and locate the main parts of the lungs: • bronchi • bronchioles • alveoli	
Key Skills C1.1, 1.2 1.3	state the functions of the main parts of the breathing system: • lungs for gaseous exchange • the diaphragm and ribs and intercostal muscles move to inhale and exhale	describe how the parts of the respiratory system work together to bring about gaseous exchange • bronchi and bronchioles carry air • exchange within alveoli by diffusion (between air and blood)	explain how the alveoli are adapted for efficient gaseous exchange: • permeable • moist • large surface area • good blood supply
CoA 2.7		describe the changes in position of the ribs and diaphragm that cause inhalation and exhalation	explain the way in which inhalation and exhalation are brought about by pressure changes • changes in lung volume • changes in internal air pressure in lungs • air movement caused by differences between internal and external air pressure explain how the cartilage in bronchioles and bronchi keeps them open when the internal pressure drops

Module BD1 Module Title Supplying the Cell

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
2b 2c W2.4 W2.5 1.1a 1.1b 1.1c CoA 2.4	state that the heart pumps blood state that blood moves around the body in • arteries • veins • capillaries	describe how the parts of the circulatory system work together to bring about the transport of substances around the body • arteries transport blood away from the heart • veins transport blood to the heart • capillaries are involved in exchange of materials with tissues name and locate parts of the heart and describe their functions • left and right ventricles to pump blood • left and right atria to receive blood • semilunar, tricuspid and bicuspid valves to prevent backflow	explain the advantage of the double circulatory system in mammals • higher pressures and therefore greater rate of flow of blood to the tissues explain the adaptations of arteries, veins and capillaries to their functions • presence of valves in veins • thickness of wall in artery • permeability in capillaries
CoA 2.4	**state that blood is a fluid** • **transporting food and oxygen to cells** • **removing waste products** **state that blood is made up of** • **red blood cells** • **white blood cells** • **platelets** • **plasma**	**state the function of plasma in transporting foods, hormones, antibodies, water, waste products around the body**	**explain that haemoglobin in red blood cells reacts with oxygen in the lungs forming oxyhaemaglobin and the reverse of this reaction happens in the tissues** **state the word equation for the reaction of oxygen with haemoglobin to form oxyhaemoglobin**

Module BD1 Module Title Supplying the Cell

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
2b 2c W2.4 W2.5 CoA 2.4	**state the functions of cells in the blood** • **red blood cells transport oxygen** • **white blood cells defence against disease** • **platelets help blood clotting**		
	state that oxygen enters the blood in the lungs and leaves in body tissues	state that oxygen, carbon dioxide and digested food enter and leave the blood by diffusion	explain that diffusion is the net movement of particles from an area of high concentration to an area of low concentration and is a consequence of the random movement of individual particles
	state that carbon dioxide enters the blood in body tissues and leaves in the lungs	describe diffusion as the movement of a substance from a region of high to low concentration	
	state that food enters the blood in the small intestine and leaves in body tissues		

BD2: Control in Animals and Plants

Programme of Study

English National Curriculum		Welsh National Curriculum	
Candidates should be taught		**Candidates should be taught**	
		2.10	that the sense organs are receptors which detect stimuli
2g	the pathway taken by impulses in response to a variety of stimuli	2.11	the pathway taken by impulses in response to a variety of stimuli
2h	how the reflex arc makes rapid response to a stimulus possible	2.12	how the reflex arc, which involves a nerve impulse carried via neurones and across synapses, make possible rapid response to a stimulus
		2.13	the differences between voluntary and reflex responses
2i	how the eye functions in response to light	2.14	the structure of the eye and how its parts function in response to light
2j	the way in which hormonal control occurs, including the effects of insulin and sex hormones	2.15	that chemicals called hormones, produced by glands, control some body functions
		2.16	the effects of insulin and sex hormones
2k	some medical uses of hormones, including the control and promotion of fertility and the treatment of diabetes	2.17	some medical uses of hormones, including the control and promotion of fertility and the treatment of diabetes, and their illegal use, *e.g. in sport*
3e	the hormonal control of plant growth and development, including commercial applications	3.3	the hormonal control of plant growth and development, including commercial applications

Grey highlighting indicates "key ideas" which are to be re-examined in the Terminal examination together with the content from the Phase 2 modules
Learning outcomes in bold are common to the Single Award Specification.

Rationale

The structure and functioning of the nervous system is illustrated by a study of reflexes, neurones and a receptor.

Hormone action is described in detail and the application of this knowledge in the treatment of everyday medical disorders stressed.

Plant growth and its control for commercial purposes is the theme for the study of plant hormones. The nervous system is also studied in module BD6.

Module BD2 Module Title Control in Animals and Plants

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
2g W2.10 W2.11	**state which of the body's receptors gather information about touch, taste, smell, light, sound, balance**	**describe the paths taken by nervous impulses stimulus → receptor → sensory neurone → central nervous system → motor neurone → effector → response**	
2h W2.12 W2.13 CoA 2.1	**name and locate the main parts of the nervous system** • **the brain** • **the spinal cord** • **the peripheral nerves** **state that reflexes** • **are fast** • **automatic** • **protective responses to a stimulus** **state that voluntary responses are under the conscious control of the brain**	**identify the parts of a motor neurone** • **cell body** • **axon** • **sheath** **describe the path taken by spinal reflexes e.g. a hand being withdrawn from a hot object (structure of spinal cord not required)**	**explain how neurones are well adapted to their function** • **length** • **insulating sheath** • **branched endings** **explain that at synapses transmitter substances carry signals between neurones** **describe the pathways that make the brain aware of reflexes and explain the value of these pathways (structure of spinal cord not required)**
2I W2.14 CoA 4.5 Key Skills C1.1, 1.2, 1.3	**name and locate the main parts of the eye** • **cornea** • **iris,** • **pupil** • **lens** • **retina** • **optic nerve**	**describe the functions of the parts of the eye** • **cornea - refract light** • **iris - controls how much light enters pupil** • **lens - focuses light on to retina** • **retina - contains light receptors** • **optic nerve - carries impulses to the brain**	**explain how radial and circular muscles in the iris control pupil size in response to light**

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
2j W2.15 W2.16 CoA 2.2	**name and locate the major human endocrine glands:** • **pituitary** • **thyroid** • **adrenals** • **pancreas** • **ovaries** • **testes** **state the names of the glands that produce** • **growth hormone** • **thyroxine** • **adrenalin** • **insulin** • **the sex hormones, testosterone, oestrogen and progesterone** **explain that hormones travel in the blood to target organs**	**describe the effects of male and female sex hormones on secondary sexual characteristics** • **males: voice breaks, hair grows on face and body, more muscular body, genitals develop, sperm production** • **females: breasts develop, hips widen, periods start, pubic hair and hair under arms grows** **state the functions of** • insulin - control of blood sugar • **adrenalin - prepares the body for** • **'flight or fight': increased heart and breathing rates, pale skin, sweating, hair stands on end, glucose released from liver and muscles**	**state that:** • **oestrogen causes the repair of the uterus wall** • **progesterone maintains the uterus wall** • **oestrogen and progesterone together control ovulation** explain how insulin helps to regulate blood sugar levels by converting excess blood glucose to glycogen in the liver **explain how the effects of adrenalin prepare the body for "flight or fight"**
2k W2.17 1.1c 1.1d CoA 2.6 Key Skills C2.1a	**state that hormone treatments can solve problems of:** • diabetes (insulin) • **lack of growth (growth hormone)** explain that hormones can be used illegally to enhance performance in athletes explain that diabetes is caused by a failure of the pancreas to produce insulin	**State that fertility in humans can be controlled by the artificial use of sex hormones** • **contraceptive pill** • **fertility drugs** explain that people with diabetes suffer excessive fluctuation of blood sugar and that treatment is by insulin injection	**explain how** • **fertility can be reduced by the use of female sex hormones (contraception) which prevent ovulation by mimicking pregnancy** • **infertility due to lack of eggs can be treated by the use of female sex hormones** explain that the dosage of insulin depends upon diet and activity

Module BD2 Module Title: Control in Animals and Plants

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
3e W3.3	state that plant hormones are chemicals that control: • growth of shoots and roots • flowering • ripening of fruits state that shoots grow towards light state that roots grow downwards in response to gravity	state that plant hormones (auxins) • move through the plant in solution • are involved in the response to light (phototropism) • are involved in the response to gravity (geotropism)	interpret data from phototropism experiments in terms of auxin action • auxin made in tip • unequally distributed in response to light explain how auxin brings about shoot curvature in terms of cell elongation
1.1d	state that plant hormones can be used in agriculture to speed up or slow down plant growth	relate the action of plant hormones to their commercial uses. • selective weed killers • rooting powder • fruit ripening (delay or acceleration) • control of dormancy	

BD3: Ecology

Programme of Study

English National Curriculum		Welsh National Curriculum	
Candidates should be taught		**Candidates should be taught**	
5a	how the distribution and relative abundance of organisms in habitats can be explained using ideas of interdependence, adaptation, competition and predation	5.1	how the distribution and relative abundance of organisms in a habitat can be explained in terms of adaptation, competition and predation
5b	how the impact of humans on the environment depends on social and economic factors, including population size, industrial processes and levels of consumption and waste	5.2	the impact of human activity on food chains, *e.g. the effect of pest control by biological or chemical means*
5c	about the importance of sustainable development		
		5.3	how toxic materials may accumulate in food chains
		5.4	about ways of conserving biodiversity in the varied environment of Wales and of protecting endangered species
5d	how to describe food chains quantitatively using pyramids of biomass	5.5	how food chains may be described quantitatively using pyramids of numbers and pyramids of biomass
5e	how energy is transferred through an ecosystem	5.6	how energy is transferred through an ecosystem
5f	the role of microbes and other organisms in the decomposition of organic materials and in the cycling of carbon and nitrogen	5.7	the role of microbes and other organisms in the decomposition of organic materials and in the cycling of carbon
5g	how food production and distribution systems can be managed to improve the efficiency of energy transfers	5.8	how food production can be managed to improve the efficiency of energy transfer

Grey highlighting indicates "key ideas" which are to be re-examined in the Terminal examination together with the content from the Phase 2 modules
Learning outcomes in bold are common to the Single Award Specification.

Rationale

Candidates should have the opportunity to use a counting or collecting method to study an environment close to school. This study should make pupils aware of how organisms are adapted to their environment.

Candidates should be reminded of food chains and the predator-prey relationship. A study of pyramids of numbers and biomass leads to an understanding of how farming involves attempts to improve energy transfer but that some ethical issues are raised.

The nutrient cycling of materials is illustrated by the nitrogen and carbon cycles.

Candidates need to be aware of the impact of the increasing human population upon the world in terms of pollution and consumption of resources, and the need this causes for conservation and sustainable development. The manufacture of fertilsers and eutrophication is studied in module CD5. Ideas about competition and adaptation are referred to again in module BD4 in connection with natural selection.

Module BD3 Module Title Ecology

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
5a W5.1 1.1b Key Skills N2.1, 2.2, 2.3 Key Skills IT1.1, 1.2 Key Skills WO1.1, 1.2, 1.3, 2.1, 2.2, 2.3 CoA 2.8	**describe how to use collecting/counting methods** • **pooters** • **nets** • **pit-fall traps** • **quadrats** **recognise that animals and plants that are adapted to the environment are better able to compete for limited resources**	**use data from collecting/counting methods to make quantitative estimates of population size and distribution** **explain how animals and plants that are adapted to the environment are better able to compete for limited resources**	**explain the limitations of counting and collecting methods** • **sample size affects accuracy of estimate** • **samples may be unrepresentative of population** **explain how the adaptations of animals and plants determine their distribution and abundance**
5a W5.1	**recognise that the distribution and population size of animals or plants can be affected by competition for:** • **food** • **water** • **shelter** • **light** • **minerals**	**explain how competition may influence distribution and population size of animals or plants:** • **availability of food** • **availability of water** • **availability of shelter** • **availability of light** • **availability of minerals**	
5a W5.1	**recognise organisms as predators or prey** • **common/well known organisms** • **when given details of feeding relationships**	**explain how the size of a predator population will affect the numbers of prey and vice versa**	**explain how the populations of predators and their prey regulate one another** • **cyclic fluctuations in numbers**

Module BD3 Module Title Ecology

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
5a	**recognise that the survival of some organisms may depend on the presence of other species** • **parasites**	**explain that some organisms rely on the presence of organisms of a different species in order to exist in a habitat (mutualistic relationships)** • **root nodules in leguminas plants**	**explain how the interdependence of organisms determine their distribution and abundance**
5d W5.5 CoA 2.8	**explain the terms producer and consumer**	construct pyramids of numbers from given information and explain what they show state that pyramids of biomass show the mass of living material at each stage of a food web or chain distinguish between pyramids of numbers and pyramids of biomass	construct pyramids of biomass from given information and explain what they show
5e W5.6	state that energy enters food chains when plants absorb sunlight	explain that energy from the Sun flows through food chains by photosynthesis and feeding explain how some energy is transferred to less useful forms at each stage in the food chain • heat (respiration) • egestion	explain how the efficiency of energy transfers explains the shape of pyramids of biomass

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
5f W5.7 CoA 2.1	state the key factors in the process of decay • presence of micro-organisms • temperature • oxygen • moisture	predict the effects of changing temperature, and the amounts of oxygen and moisture on the rate of decay	explain the effects of changing temperature, and the amounts of oxygen and moisture on the rate of decay • effect on microbial respiration • effect on growth of micro-organism
5f W5.7	recognise materials that can decay and therefore be recycled	explain that materials are recycled in a biological community: • carbon cycle (to include photosynthesis, respiration and decay)	describe that the cycling of carbon and nitrogen is made possible by the activity of microbes and other living things • carbon cycle(to include the role of soil organisms) • nitrogen cycle(to include: nitrates in soil, plant growth, animal growth, decay, the roles of nitrifying, denitrifying and nitrogen fixing bacteria, plus lightning)
5b 1.1d 1i, 1j Key Skills C2.1a, 2.2, 2.3 Key Skills IT 2.1, 2.3	**state that the human population is increasing** **state that the human population uses finite resources** • **fossil fuels** • **minerals** **explain that an increasing population will increase use of resources which will lead to an increase in pollution:** • **household waste** • **sewage** • **sulphur dioxide** • **carbon dioxide**	**explain that as the human population increases exponentially, there is a related increase in use of resources and the production of pollution** **explain the effects of increasing amounts of pollution:** • **global warming from increasing levels of carbon dioxide** • **ozone depletion from CFCs in upper atmosphere** • **acid rain from sulphur dioxide**	**explain that the developed countries of the world, with a small proportion of the world's population, have the greatest impact on the use of resources and production of pollution**

Module BD3 Module Title Ecology

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
5b 5g W5.2 W5.3 W5.8 1.1d 1i, 1j Key Skills C2.1a, 2.1b, 2.2,	**explain that farmers can produce more food if they use herbicides, and pesticides and other intensive practices, but that these practices can cause harm to the environment and to health** **describe how pests can also be controlled biologically by introducing predators**	**explain how intensive farming produces more food but:** • **pesticides may enter and accumulate in food chains** • **pesticides may harm organisms which are not pests** • **intensive farming raises ethical dilemmas** **explain the advantages and disadvantages of biological control** **explain how removing one organism from a food chain or web may affect other organisms**	explain how intensive food production improves the efficiency of energy transfer by reducing energy transfer: • to competing plants • to pests • as heat from farm animals by keeping them penned indoors **explain why pesticides may accumulate in food chains**
5c	**explain the term sustainable resource** **explain that some resources can be maintained** • **fish stocks** • **woodland**	**explain the term sustainable development** **explain how fish stocks and woodland can be sustained and yet exploited** • **education** • **quotas on fishing** • **re-plantation of woodland**	**discuss the importance of population size, waste products and food and energy demands to sustainable development**
W5.4 1.1c 1.1d CoA 2.8 1c, 1i, 1j	describe why some species in Britain are endangered and need protection • red kite • red squirrel • osprey	describe how endangered species are protected • education • protected sites • legal protection	**describe how sustainable development may protect endangered species**

BD4: Variation, Inheritance and Evolution

Programme of Study

English National Curriculum		Welsh National Curriculum	
Candidates should be taught		**Candidates should be taught**	
1c	that the nucleus contains chromosomes that carry the genes	1.3	that the nucleus contains chromosomes that carry the genes
1d	how cells divide by mitosis during growth, and by meiosis to produce gametes	1.4	how cells divide by mitosis so that growth takes place, and by meiosis to produce gametes
4a	how variation may arise from genetic causes, environmental causes, and a combination of both		
4b	that sexual reproduction is a source of genetic variation, while asexual reproduction produces clones	4.1	that sexual reproduction is a source of genetic variation, while asexual reproduction produces clones
4c	that mutation is a source of genetic variation and has a number of causes	4.2	that mutation, which may be beneficial or harmful, is a source of genetic variation and has a number of causes
4d	how sex is determined in humans	4.3	how gender is determined in humans
4e	the mechanism of monohybrid inheritance where there are dominant and recessive alleles	4.4	the mechanism of monohybrid inheritance where there are dominant and recessive alleles
4f	about mechanisms by which some diseases are inherited	4.5	that some diseases are inherited
4g	that the gene is a section of DNA	4.6	that the gene is a section of DNA
4h	the basic principles of cloning, selective breeding and genetic engineering	4.7	the basic principles of cloning, selective breeding and genetic engineering
		4.8	the potential benefits and ethical dilemmas posed by advances in cloning and genetic engineering
4i	that the fossil record is evidence for evolution	4.9	the fossil record as evidence for evolution
4j	how variation and selection may lead to evolution or to extinction	4.10	how variation and selection may lead to evolution or to extinction

Learning outcomes in bold are common to the Single Award Specification.

Rationale

Candidates' awareness of variation is explained in terms of chromosomes and genes and the study of cell division provides access to an understanding of inheritance, including inherited diseases, gender determination and selective breeding.

Consideration of evolutionary change and natural selection is illustrated by a balanced examination of the fossil record.
Knowledge of cell structure from module BD1 is developed and adaptation and competition from module BD3 are linked with natural selection.

Module BD4 Module Title: Variation, Inheritance and Evolution

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
4a 4c W4.2 1.1b 1.1c 1.1d Key Skills C2.1a	**identify variations within a population**	**explain that variation can be caused by genetic and environmental factors** **explain that genetic variation can be caused by:** • **mutations (as caused by radiation, chemicals, spontaneous)** • **fertilisation** **explain that mutations are usually harmful but may be beneficial**	**recognise that there is a debate over the relative importance of genetic and environmental factors in determining some human attributes** • **intelligence** • **sporting ability** • **health**
1c 4g W1.3 W4.6 1.1a	**state that chromosomes are held in the nucleus and that they carry information in the form of genes**	**state that chromosomes are strings of genes which instruct each cell** **state that most body cells have the same number of chromosomes** **state that gametes have half the number of chromosomes of body cells**	state that genes are made of a chemical called DNA which carries the genetic code describe mutations as changes to the genetic code **explain that only some of the full set of genes are used in any one cell**
1d W1.4	**explain that organisms grow by cells dividing**		**explain that in mitosis the chromosomes** • **are copied to produce genetically identical cells** • **divide to opposite poles of the cell** **explain that in meiosis the** • **chromosome number is halved and each cell is different** • **pairs of chromosomes separate to opposite poles of the cell**

Module BD4 Module Title: Variation, Inheritance and Evolution

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
4b (part) W4.1 (part)	**state that sexual reproduction is the joining of a sperm and egg to produce a new individual**	**state that, at fertilisation, genetic material from both parents combine to produce the unique individual**	**explain how the random events of fertilisation produce unique individuals**
4b (part) 4h (part) W4.1 (part) W4.7 (part) W4.8 (part) 2a, 2b, 2c Key Skills C2.2, 2.3 Key Skills IT2.1, 2.3	**describe how, in asexual reproduction, cell division produces new individuals** • **describe how spider plants, potatoes and strawberries reproduce asexually** • **describe how to take a cutting**	**explain that asexual reproduction produces clones which are genetically identical to their parent** **describe the advantages and disadvantages associated with commercial use of cloned plants** • **advantage can be sure of the characteristics of the plant since all plants will be genetically identical** • **advantage it is possible to mass produce plants that may be difficult to grow from seed** • **disadvantage if plants become susceptible to disease or to change in environmental conditions then all plants will be affected** • **disadvantage lack of genetic variation**	**describe cloning by tissue culture** • **selection for characteristics** • **large numbers of small pieces of tissue** • **aseptic technique** • **use of suitable growth medium and conditions** **explain that cloning may pose ethical dilemmas**

Module BD4 Module Title: Variation, Inheritance and Evolution

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates will be able to		
4e W4.4 1.1a 1.1b	**explain that features can be passed from one generation to the next**		**recognise dominant and recessive characteristics and explain that these depend on dominant and recessive alleles** • **dominant alleles are those expressed in heterozygous individuals** **state that alleles are different versions of the same gene** **explain a monohybrid cross involving dominant and recessive alleles** • **genetic diagrams using letters to represent alleles** **use and explain genetic terms** • **homozygous** • **heterozygous**
4d W4.3	**state that gender is inherited**	**explain that it is the Y chromosome's presence or absence that determines gender** • **XX = female** • **XY = male**	**explain sex inheritance using genetic diagrams** • **production of equal numbers of male and female offspring**
4f W4.5	**state that diseases can be inherited or caused by infection** • **sickle cell anaemia - inherited** • **cystic fibrosis – inherited** • **AIDS - infected**	**state that inherited diseases are caused by faulty genes**	**explain that inherited diseases are caused by faulty alleles, most of which are recessive** **use genetic diagrams to predict the probabilities of inherited diseases passing to the next generation**

Module BD4 Module Title: Variation, Inheritance and Evolution

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
4h (part) W4.7 (part) W4.8 (part) 1.1a 1.1c 1.1d 1e, 2a, 2b 2c Key Skills C 2.1a Key Skills IT 2.1	**recognise features of plants and animals that might be selected for enhancement in a breeding programme**	**describe the process of selective breeding involving the** • **selection of characteristics** • **cross breeding** • **selection of suitable offspring over many generations** **explain how selective breeding can contribute to improved agricultural yields**	**explain that a selective breeding programme may reduce the gene pool leading to problems of inbreeding** • **accumulation of harmful recessive characteristics** • **reduction in variation** **describe the principles of genetic engineering** • **selection of characteristics** • **isolation of genes,** • **replication** • **insertion** **explain some potential advantages and risks of genetic engineering and selective breeding** • **advantage – production of organisms with new features** • **disadvantage – inserted genes may have unexpected harmful effects** • **ethical dilemmas**

Module BD4 Module Title: Variation, Inheritance and Evolution

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
4i W4.9 1.1b 1.1c	**explain that animals and plants can change over long periods of time and that fossils provide evidence for this**	**explain that the fossil record is incomplete** • **some body parts, particularly soft tissue, may not be fossilised** • **fossilisation rarely occurred** • **fossils not yet discovered** **explain how the fossil record has been interpreted differently over time** • **social and historical context**	
4j W4.10 1.1a 1.1b 1.1c CoA 2.3	**explain that animals and plants that are better adapted to their environment are more likely to survive**	**explain that adaptations are controlled by genes and that these can be passed on to the next generation** **explain that when environments change some animal and plant species evolve and survive but many become extinct**	**explain the main steps in Darwin's theory of natural selection leading to the evolution or extinction of organisms** • **presence of natural variation** • **'survival of the fittest'** • **inheritance of 'successful' adaptations** • **extinction of species unable to compete** **explain the reasons why the theory of evolution by natural selection met with an initially hostile response** • **social and historical context**

BD5: The Working Plant

Programme of Study

English National Curriculum		Welsh National Curriculum	
Candidates should be taught		**Candidates should be taught**	
1b	how substances enter and leave cells by diffusion, osmosis and active transport	1.2	how substances enter and leave cells by diffusion, osmosis and active transport
3a	the reactants in, and products of, photosynthesis		
3b	that the rate of photosynthesis may be limited by light intensity, carbon dioxide concentration or temperature	3.1	that the rate of photosynthesis may be limited by light intensity, carbon dioxide concentration or temperature
3c	how the products of photosynthesis are utilised by the plant	3.2	how the products of photosynthesis are transported within and utilised by the plant for growth
3d	the importance to healthy plant growth of the uptake and utilisation of mineral salts		
3f	how plants take up water and transpire	3.4	how plants take up water and transpire
3g	the importance of water in the support of plant tissues	3.5	the importance of water in the support of plant tissues
3h	that substances required for growth and reproduction are transported within plants		

Learning outcomes in bold are common to the Single Award Specification.

Rationale

This unit concentrates on the processes of photosynthesis and water relations in plants.
The study of plant structure leads to a consideration of the adaptations for effective photosynthesis.
The uptake and loss of water is described and linked to the processes of osmosis and diffusion.

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
3a 3c W3.2 (part) CoA 2.8 Key Skills C 1.1, 1.2, 1.3	state that plants make glucose and starch by a process called photosynthesis state that plants need carbon dioxide, water, light and chlorophyll to carry out photosynthesis explain glucose is converted and stored as starch explain that substances in plants are used for: providing energy, growth and storage products • glucose, starch, cellulose, proteins, fats and oils state that photosynthesis occurs mainly in the leaves	state the equation to describe photosynthesis carbon dioxide + water (+light energy) (+chlorophyll) → glucose + oxygen explain that the glucose made in photosynthesis is transported as soluble sugars but is stored as insoluble starch explain how leaves are adapted for efficient photosynthesis • broad • thin • contain chlorophyll • have a network of veins	state the balanced symbol equation for photosynthesis $6CO_2 + 6H_2O$ (+light energy) (+chlorophyll) → $C_6H_{12}O_6 + 6O_2$ explain how the cellular structure of a leaf is well adapted for efficient photosynthesis • transparent epidermis • palisade layer at the top containing most of the chloroplasts • air spaces in the mesophyll connected to the stomata • internal surface area : volume ratio very large
3b W3.1 Key Skills WO1.1, 1.2, 1.3, 2.1, 2.2, 2.3 Key Skills PS1.1, 1.2, 1.3, 2.1, 2.2, 2.3	state that plants grow faster in the summer because of more • light • warmth	describe how photosynthesis can be increased by providing more • CO_2 • light • higher temperature	explain the effects of limiting factors on the rate of photosynthesis: • CO_2 • light • temperature

Module: BD5 Module Title: The Working Plant

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
3g 3h W3.2 (part) W3.5 CoA 2.10 Key Skills C 1.1, 1.2, 1.3	state the functions of: • stem - support, transport • leaf - photosynthesis • flower - reproduction • root - water uptake and anchorage explain that healthy plants must balance water loss with water uptake describe that roots take in water which is transported through the plant to the leaves where it is lost to the atmosphere	describe the arrangement of xylem and phloem in a dicotyledonous stem and leaf state the function of xylem and phloem: • xylem - transpiration - movement of water and minerals from the roots to the shoot • phloem - translocation - movement of food substances around the plant explain that the inelastic cell wall is essential for the support of plants state that transpiration provides water for • cooling, • photosynthesis • support • movement of minerals	explain how plants are supported by the turgor pressure within cells • wilting explain that water loss from leaves and subsequent transpiration are a consequence of the way in which the leaf is adapted for efficient photosynthesis

Module: BD5 Module Title: The Working Plant

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
1b (part) 3f 1.2 (part) W3.4	state that water is taken into a plant through its root hairs and that most is lost by evaporation from the leaves	explain that by increasing surface area root hairs increase the ability of roots to take up water describe how molecules enter and leave cells by diffusion through the cell membrane • movement from high to low concentration describe osmosis as the movement of water across a partially-permeable membrane explain how the structure of a leaf is adapted to reduce water loss • waxy cuticle • small number of stomata on upper surface explain the loss of water from leaves in terms of the diffusion of water molecules	explain that osmosis occurs due to differences in concentration across a partially-permeable cell membrane predict the direction of water movement in osmosis explain how the cellular structure of the leaf is adapted to reduce water loss: • changes in guard cell turgidity regulate stomatal apertures • number, distribution, position and size of stomata explain how stomatal apertures will depend upon light intensity and availability of water • photosynthesis in guard cells • supply of water to guard cells
1b(part) 3d W1.2 (part) Key Skills IT1.1	state that fertilisers in solution are absorbed by the roots state that fertilisers contain minerals such as nitrates, phosphate, potassium and magnesium and that these are needed for plant growth	state that plants require • nitrates for proteins which are needed for cell growth • magnesium for chlorophyll	state that minerals are taken up into roots by active transport explain that active transport can move substances from low concentrations to high concentrations using energy from respiration

BD6: Health in the Balance

Programme of Study

English National Curriculum		Welsh National Curriculum	
Candidates should be taught		**Candidates should be taught**	
2e	that respiration may be either aerobic or anaerobic, depending on the availability of oxygen	2.8	that respiration may be either aerobic or anaerobic, depending on the availability of oxygen
2f	that an "oxygen debt" may occur in muscle during vigorous exercise	2.9	that an "oxygen debt" may occur in muscles during vigorous exercise
2l	the importance of maintaining a constant internal environment	2.18	the importance of maintaining a constant internal environment
2m	how waste products of body functions are removed by the lungs and kidneys	2.19	how waste products of body functions are removed by the lungs and kidneys
2n	how the kidneys regulate the water content of the body	2.20	that the kidneys regulate the water content of the body
2o	how humans maintain a constant body temperature	2.21	how humans maintain a constant body temperature
2p	the defence mechanisms of the body, including the role of the skin, blood and mucous membranes of the respiratory tract	2.22	the defence mechanisms of the body, including the role of the skin, blood and mucous membranes of the respiratory tract
2q	the effects of solvents, alcohol, tobacco and other drugs on body functions		

Learning outcomes in bold are common to the Single Award Specification.

Rationale

Candidates should be able to explain some everyday changes in their bodies in terms of excretion and homeostasis.

The means by which the body defends itself against infection by natural and medical means is contrasted to the damage done by tobacco, alcohol and certain drugs.

There are links with module BD1 in particular the study of the circulatory system.

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
2e W2.8	state that exhaled air • contains less oxygen than inhaled air • contains more carbon dioxide than inhaled air • more moisture than inhaled air • is warmer than inhaled air	state the approximate percentages of oxygen and carbon dioxide in inhaled air • oxygen 21% • carbon dioxide 0.03% state the approximate percentages of oxygen and carbon dioxide in exhaled air • oxygen 16% • carbon dioxide 4%	
CoA 2.7	state that sugar reacts with oxygen in the cells to release energy and that the process is called respiration	state the word equation for aerobic respiration glucose + oxygen → carbon dioxide + water (+ energy)	state the symbol equation for aerobic respiration $C_6H_{12}O_6 + 6O_2$ → $6CO_2 + 6H_2O$ (+ energy)
2f W2.9 CoA 2.4 Key Skills N1.1, 1.3 Key Skills WO1.1, 1.2, 1.3, 2.1, 2.2, 2.3 Key Skills LP1.1, 1.2, 1.3 2.1, 2.2, 2.3	explain that during exercise, breathing and pulse rates increase to deliver oxygen and glucose to muscles more quickly	explain that during hard exercise the oxygen supply is insufficient to meet energy demands so anaerobic respiration then takes place in addition to aerobic respiration state the word equation for anaerobic respiration glucose → lactic acid + energy state that anaerobic respiration releases much less energy than aerobic	explain fatigue in terms of lactic acid build up and how this is removed during recovery (oxygen debt)
2m (part) W2.19 (part) CoA 2.6	state that carbon dioxide from respiration is removed from the body by the lungs	explain that high levels of CO_2 in the blood are toxic and must be removed from the body	explain that when increased CO_2 levels in the blood are detected the brain then brings about an increase in breathing rate

Module BD6: Module Title: Health in the Balance

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
2o W2.21 CoA 2.6	**state that the temperature of the human body is approximately 37°C** **state that the heat released by respiration is used to maintain body temperature** **state that when we shiver the muscles make heat by respiration to keep us warm**	**explain how sweating increases heat transfer to the environment by evaporation** • **evaporation of sweat** • **evaporation requires and removes heat from the skin**	**explain how vasodilation increases heat transfer to the environment** **explain how vasoconstriction reduces heat transfer to the environment** **explain that blood temperature is monitored by the brain which will bring about temperature control mechanisms**
2m (part) 2n W2.19 (part) W2.20 CoA 2.6	**state that we gain water from food and drink and lose it in urine, faeces, sweat and breath** **name and locate the** • **kidney** • **bladder**	**name and locate** • **ureter** • **urethra** **describe that the kidneys filter blood removing excess water and salt and the waste product urea**	**explain that the water content of the blood is monitored by the brain which causes the kidney to adjust the concentration and volume of urine produced**
2l W2.18 CoA 2.6	**state that the body works to maintain steady levels of temperature, water, oxygen and CO_2 and that this is essential to life**	**explain that maintaining a constant internal environment involves balancing bodily inputs and outputs and is called homeostasis**	**explain how homeostasis is achieved by negative feedback mechanisms**

Module: BD6 Module Title: Health in the Balance

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
2p W2.22	**explain that the body is defended against disease organisms by** • **the skin** • mucous membranes (breathing system) • **stomach acid**	**explain how the ciliated cells and mucous in the breathing system combine to trap air-borne particles and prevent infection**	
Key Skills C2.3	**describe that disease organisms that do enter the body can be destroyed by white blood cells which engulf them or produce antibodies**	**describe that antibodies lock on to antigens causing the death of the disease organisms**	**explain that each disease organism has its own antigens and that specific antibodies are needed**
Key Skills IT2.1, 2.3		**describe how immunity to disease organisms arises from prior infection**	**explain the process of immunisation** • **harmless form of disease organism given** • **harmless form still carries antigens** • **antigens trigger immune response – antibody production** • **immunity remains**
2q 1.1a, 1.1b 1.1c, 1.1d CoA 2.7	**state that tobacco smoking can cause** • **emphysema** • **bronchitis** • **cancer** • **heart disease**	**describe how cigarette smoke effects ciliated epithelial cells and how this is linked to 'smokers cough'**	
Key Skills C2.1b	**state that alcohol has short term effects on the brain and nervous system (impaired judgement) and long term effects causing liver damage, brain damage**	**explain that the liver can become damaged as it removes toxic alcohol**	
	state that solvents slow down brain activity and caffeine and nicotine speed it up	**state that alcohol and solvents are depressants** **state that caffeine and nicotine are stimulants**	**explain the action of depressants and stimulants upon the synapses of the nervous system**
2a, 2b, 2c	**explain the terms 'addiction' and 'withdrawal symptoms'**	**explain that as addicts become used to drugs they need larger doses (tolerance)**	

5.8 CONTENT RELATED TO SC3: MATERIALS AND THEIR PROPERTIES

Module CD1: Equations and Rates of Reaction

Programme of Study

English National Curriculum		Welsh National Curriculum	
Candidates should be taught		**Candidates should be taught**	
		2.18	to represent chemical reactions by word equations
2n (part)	to represent chemical reactions by balanced symbol equations (and to use these to predict reacting quantities)	2.19 (part)	to represent reactions, (including electrolytic reactions), by balanced equations using chemical symbols
3m	about ways in which knowledge about chemical reactions is applied when new substances are made		
3n	about the great variation in the rates at which different reactions take place	3.10	that there is a great variation in the rates at which different reactions take place
3o	how the rates of reactions can be altered by varying temperature or concentration, or by changing the surface area of a solid reactant, or by adding a catalyst	3.11	how the rates of reactions can be altered by varying temperature or concentration, or by changing the surface area of a solid reactant, or by adding a catalyst
		3.12	that reactions may occur when particles collide
3p	how the rates of many reactions depend on the frequency and energy of collisions between particles	3.13	that the rates of many reactions can be increased by increasing the frequency or energy of collisions between particles
3q	about the effect of temperature on the rates of enzyme-catalysed reactions and their dependence on pH	3.14	how the rates of enzyme-catalysed reactions vary with temperature
3r	how enzymes may be used in biotechnology	3.15	the use of enzymes in the baking, brewing and dairy industries

Grey highlighting indicates "key ideas" which are to be re-examined in the Terminal examination together with the content from the Phase 2 modules.

Learning outcomes in bold are common to the Single Award Specification.

Rationale

The module concentrates on the factors which affect the rate of a chemical reaction. These include temperature, concentration, surface area and the influence of catalysts and enzymes. A simple collision theory is used to explain observable changes in rate. The reactions used to develop understanding can be chosen from: magnesium and dilute acid; marble and acid; hydrogen peroxide decomposition, sodium thiosulphate and acid and fermentation. Other reactions can be used as appropriate, and contexts such as the corrosion of marble statues can be chosen to aid relevance. The importance of rate of reaction is further explored in module CD5.

This module focuses on reactions involving enzymes and how changes in temperature and pH affect the rate of enzyme catalysed reactions. Digestive enzymes are studied in module BD1.

This module also allows an early opportunity to introduce equations, both word and symbolic. These ideas will need to be developed throughout the course and so teachers will need to consider what depth of treatment to aim for in this unit.

The ideas of word and symbolic equations are a feature of all the chemistry modules.

Module CD1 Module Title Equations and Rates of Reaction

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
W2.18 CoA 3.2	**recognise a chemical change from given data** • **temperature change** • **change in appearance** • **change in mass e.g. during decomposition** **describe a chemical change as a process which involves** • **the formation of new substances** • **a change which cannot be easily reversed** • **a large energy (temperature) change** **describe that in a chemical reaction reactants are changed into products** **recognise the reactants and the products in a word equation**	**construct word equations given the reactants and the products**	
2n (part) W2.19	**state the number of elements in a compound given its formula** **state the number of atoms in a formula (no brackets)** **state the number of each different type of atom in a formula (no brackets)** **recognise an element or a compound from its formula** **recognise the reactants and the products in a symbol equation**	**state the number of atoms in a formula (with brackets)** **state the number of each different type of atom in a formula (with brackets)** **construct balanced symbol equations given the formulae (no brackets) of the reactants and of the products**	**recall the formulae of the following substances** • **carbon dioxide, water, hydrogen, oxygen, hydrochloric acid, nitric acid, sulphuric acid and ammonia** • **chlorides, nitrates, sulphates, carbonates, hydroxides, and oxides of the metals sodium, potassium, calcium, magnesium, copper(II), iron(II) and zinc** **construct balanced symbol equations given the** • **formulae (with brackets) of the reactants and of the products** • **formulae not given**

Programme of study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
3n W3.10 3o W3.11 3p W3.13 W3.12 CoA 3.9 Key Skills C1.1, 1.2, 1.3 Key Skills N2.1, 2.2, 2.3 Key Skills IT 1.1, 1.2, 2.1, 2.2, 2.3 Key Skills WO1.1, 1.2, 1.3, 2.1, 2.2, 2.3 Key Skills LP1.1, 1.2, 1.3 2.1, 2.2, 2.3	**describe rusting as a slow reaction** **describe burning and explosions as fast reactions** **explain that reactions stop when one of the starting materials is used up** **describe ways of increasing or decreasing the rate of a reaction** **describe how the rate of a chemical reaction can be changed by:** • **changing the temperature** • **changing the concentration** • **using a powder or a lump** • **using a catalyst**	**describe that a chemical reaction takes place when particles collide** **explain that the more collisions between particles the faster the reaction** **explain ways of increasing or decreasing the rate of reaction in terms of the number of collisions** **explain that increasing the concentration increases the rate of a reaction because the particles are more crowded (and vice-versa)** **explain that a temperature increase makes particles move faster so they have more energy, and that this gives an increased rate of reaction (and vice versa)** **explain that a powder has a larger surface area than a lump and so reacts faster because there are more collisions** **define a catalyst as a substance that increases the rate of reaction but remains unchanged at the end of the reaction**	**explain ways of increasing or decreasing the rate of reaction in terms of collision frequency and collisions with sufficient energy (successful or effective collisions)** **explain that increasing the concentration increases the rate of a reaction by increasing the frequency of collisions between particles (and vice versa)** **explain that an increase in temperature results in more effective, successful or energetic collisions (and vice versa)** **explain that an increase in surface area increases the frequency of collisions** **describe that a catalyst is specific to a particular reaction and that only a small amount of catalyst can catalyse a large amount of reactants**

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
Key Skills N1.1, 1.2, 1.3	**interpret graphical data involving rates of reaction e.g.** • **reading off values from a graph** • **recognising the fastest reaction by comparing gradients of graphs**	**interpret data from graphs e.g.** • **deciding when a reaction has finished** • **comparing the rate of reaction during a reaction** • **deciding when the rate of reaction is the greatest** **explain that the amount of product formed depends on the amount of reactant used** **draw sketch graphs to show the effect of changing temperature, concentration or the addition of a catalyst on the** • **rate of reaction** • **amount of product formed in a reaction**	**interpret data from graphs e.g.** • **calculating the rate of reaction from the slope of a graph** • **extrapolation** • **interpolation**
3r W3.15 CoA 2.11, 3.2, 3.3 and 3.9	**describe fermentation as a process that converts sugar and water into alcohol and that it is catalysed by enzymes found in yeast** **state that fermentation is used in the brewing, baking and dairy industries**	**state the word equation for the fermentation of glucose i.e.** **glucose → ethanol (alcohol) + carbon dioxide** **state the conditions needed for fermentation as** • **25-55 °C** • **presence of water** • **enzymes found in yeast** • **absence of air** **describe the use of enzymes in the brewing, baking and dairy industries, sweet-making and washing powders genetic engineering and penicillin production**	**state the balanced symbol equation for the fermentation of glucose** **explain the conditions used in fermentation** • **water is needed for the yeast as it is a living organism** • **at low temperature the rate is too slow** • **at high temperature the yeast dies and the enzymes are denatured** • **if air is present ethanoic acid (vinegar) is formed**

Module CD1 Module Title Equations and Rates of Reaction

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
3q 3r W 3.14 Key Skills C2.2 Key Skills N 1.1, 1.2, 1.3 Key Skills WO1.1, 1.2, 1.3, 2.1, 2.2, 2.3 Key Skills LP1.1, 1.2, 1.3 2.1, 2.2, 2.3 Key Skills PS1.1, 1.2, 1.3, 2.1, 2.2, 2.3	**describe an enzyme as a biological catalyst will increase the rate of a reaction** state that changes in temperature and changes in pH affect the rate of an enzyme catalysed reaction. interpret graphs showing the effect of temperature or pH on the rate of an enzyme catalysed reaction • reading off the graph • comparing the rate of reaction of several enzymes	describe how changes of temperature affect the rate of an enzyme catalysed reaction • initial increase • optimum temperature • rate rapidly decreases at higher temperatures until there is no reaction describe how the pH changes the rate of an enzyme catalysed reaction and that there is an optimum pH interpret graphs showing the effect of temperature or pH on the rate of an enzyme catalysed reaction • identifying the optimum temperature • identifying the optimum pH • describing the changes in the rate of reaction	**describe an enzyme as a protein which is a biological catalyst with high specificity** explain how temperature affects the rate of an enzyme catalysed reaction • initially more energetic particles increases rate of reaction • at higher temperatures reaction the enzyme is denatured, so the reaction stops explain how pH affects the rate of an enzyme catalysed reaction by denaturing • change in pH may affect the shape of the enzyme • shape of active site changes

Module CD2: Energy in Chemistry

Programme of Study

English National Curriculum		Welsh National Curriculum	
Candidates should be taught		**Candidates should be taught**	
2a	how a mixture of substances in crude oil, most of which are hydrocarbons, can be separated by fractional distillation	2.2	that crude oil is a mixture of substances, most of which are hydrocarbons, which can be separated by fractional distillation
2b	the use of some of the products from crude oil distillation as fuels	2.3	the use as fuels of some of the products from crude oil distillation
2c	the products of burning hydrocarbons	2.4	the products of burning hydrocarbons
		2.5 (part)	that there are different groups of hydrocarbons
2d (part)	that alkanes are saturated hydrocarbons, (and alkenes are unsaturated hydrocarbons	2.6 (part)	that alkanes are saturated hydrocarbons, (and alkenes are unsaturated hydrocarbons containing one double covalent bond between carbon atoms)
2p	how the Earth's atmosphere and oceans have changed over time	2.22	how the atmosphere and oceans evolved to their present composition
2q	how the carbon cycle helps to maintain atmospheric composition	2.23	how the carbon cycle helps to maintain atmospheric composition and how human influence may affect it
3k (part)	about different types of chemical reaction, including neutralisation, oxidation, reduction and thermal decomposition, and examples of how these are used to make new material		
3t	that changes of temperature often accompany reactions	3.19	that changes of temperature often accompany reactions
3u	that reactions can be exothermic or endothermic	3.20	that reactions can be exothermic or endothermic
3v	how making and breaking chemical bonds in chemical reactions involves energy transfers	3.21	that energy transfers are involved in making and breaking chemical bonds in chemical reactions

Grey highlighting indicates "key ideas" which are to be re-examined in the Terminal examination together with the content from the Phase 2 modules.

Learning outcomes in bold are common to the Single Award Specification.

Rationale

Crude oil is introduced as a mixture of hydrocarbons many of which are presently used as fuels. These important fuels can be separated from the crude oil by fractional distillation. Hydrocarbon fuels whilst having a high 'energy value' are non-renewable and on burning produce waste products which can have a detrimental effect on the environment. The carbon cycle is introduced and this provides an opportunity to describe how the composition of the atmosphere remains fairly constant.

The chemistry of the combustion of a hydrocarbon fuel can then be studied using word and symbolic equations to summarise reactions. Simple bonding can be introduced by talking about bonds existing between the carbon atoms and between carbon and hydrogen atoms. A more detailed study, involving the concept of electron sharing, and developing the idea of covalent bonding, will be encountered in Module CD4. Students can also be introduced to displayed formulae which will are used to explain the energy transfers that take place during reactions in terms of the making and breaking of chemical bonds. Fuels provide an obvious context for introducing the concept of an exothermic reaction. Simple calorimetric methods can be used to measure the energy transferred in simple reactions. Comparison between the energy transferred by different fuels can then be used as a basis for discussion of bond breaking and making. Endothermic reactions can be introduced as a contrast to the more common exothermic reactions.

The ideas of word and symbolic equations are a feature of all chemistry units. The concept of covalent bonding will be extended in Module CD4.

The cracking of hydrocarbon fractions is covered in Module CD4. The economical use of energy is studied in Module PD2 and PD5. The carbon cycle is also studied in module BD3 and BD5.

Module: CD2 Module Title: Energy in Chemistry

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
2b W2.2 1.1b 1.1d CoA 3.10 1i,1j	**state that crude oil is separated by fractional distillation** **describe fractional fraction as a process that separates liquids because they have different boiling temperatures** **state that petrol, diesel, paraffin, propane and butane are made from crude oil**	**describe the process of fractional distillation of crude oil** • **crude oil is heated in a fractionating column** • **'fractions' contain mixtures of hydrocarbons with similar boiling temperatures** • **fractions with low boiling temperatures 'exit' at the top of the fractionating column whereas fractions with high boiling temperatures 'exit' from the bottom.** • **liquefied petroleum gases (LPG), petrol, diesel and kerosene are 'fractions'**	**explain why crude oil can be separated by fractional distillation** • **bonds between carbon and hydrogen atoms within a hydrocarbon molecule are stronger than the intermolecular forces between hydrocarbon molecules** • **during boiling intermolecular forces are broken** • **intermolecular forces between large hydrocarbon molecules are stronger than those between smaller hydrocarbon molecules** • **hydrocarbons with large molecules have a higher boiling temperature than those with smaller molecules** **explain the connection between the strength of the intermolecular force and the boiling temperature**

Programme of study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
2d (part) W2.5 (part) W2.6 (part)	**state the two elements chemically combined in a hydrocarbon** **recognise a hydrocarbon from a molecular or a displayed formula** **identify the elements in a compound given its molecular or displayed formula** **describe a molecule as two or more atoms bonded together** **state the number of atoms in a molecule given its molecular or displayed formula** **state the number of each different type of atom in a molecular or displayed formula**	**describe a hydrocarbon as a compound between carbon and hydrogen only** **explain why a compound is a hydrocarbon using its molecular or displayed formula** state that the alkanes are a series of hydrocarbons describe alkanes as hydrocarbons which only contain single bonds recognise an alkane given its displayed formula **state the molecular formula of a compound given its displayed formula** **balance symbol equations given the displayed formulae of the reactants and of the products**	**interpret equations using displayed molecular formulae** • **identify the bonds broken** • **identify the bonds formed** • **write the balanced symbol equation**

Module: CD2 Module Title: Energy in Chemistry

Programme of study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
2b W2.3 1.1b 1.1d Key Skills C2.1a, 2.2	**state that fuels from crude oil can be used for heating, cooking and transport** • **petrol is used as a fuel for cars** • **diesel is used as a fuel for cars and lorries** • **propane and butane are used as fuels in portable cooking stoves** • **one use for paraffin is as a fuel in heaters**	**list factors that need to be considered in the use of a fossil fuel** • **energy value** • **availability** • **storage** • **cost** • **toxicity** • **pollution e.g. acid rain, greenhouse effect** • **ease of use**	**evaluate the use of different fossil fuels given data on** • **energy value** • **availability** • **storage** • **cost** • **toxicity** • **pollution e.g. acid rain, greenhouse effect** • **ease of use**
2c W2.4	**describe combustion or burning as a reaction between a fuel and oxygen which releases lots of heat** **state that complete combustion needs a plentiful supply of oxygen (air)** **state that complete combustion of a hydrocarbon fuel gives carbon dioxide and water** **state that incomplete combustion takes place when there is a shortage of oxygen (air)** **state that incomplete combustion of a hydrocarbon fuel gives water and either carbon or carbon monoxide**	**construct the word equation to show the complete or incomplete combustion of a hydrocarbon fuel** **construct the symbol equation to show the complete or incomplete combustion of a hydrocarbon fuel given the formulae** **describe the advantages of complete combustion over incomplete combustion of hydrocarbon fuels** • **less soot made** • **more heat released** • **poisonous carbon monoxide not produced** **describe oxidation as the reaction of a substance with oxygen to make an oxide**	**construct the symbol equation to show the complete or incomplete combustion of a hydrocarbon fuel given only the formula of the fuel** **identify oxidation reactions from word or symbol equations**

Module: CD2 Module Title: Energy in Chemistry

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
2q 3k (part) 3u W2.23 W3.20 1.1b 1.1d Cit 1i Cit 1j	state that air contains nitrogen, oxygen, water vapour and carbon dioxide state that oxygen and carbon dioxide levels in the atmosphere are approximately constant recognise that photosynthesis decreases the level of carbon dioxide and increases the level of oxygen in the air recognise that respiration and combustion increase the level of carbon dioxide and decrease the level of oxygen in the air	state that clean air contains 78% nitrogen, 21% oxygen and 0.035% carbon dioxide describe photosynthesis as an endothermic process that takes place in green plants and converts carbon dioxide and water into oxygen and sugar (glucose) describe respiration as an exothermic process that takes place in living organisms by which sugar (glucose) and oxygen are converted into carbon dioxide and water write a word equation to describe respiration or photosynthesis	describe a simple carbon cycle involving photosynthesis, respiration and combustion and use the cycle to explain why the composition of clean air hardly changes write a symbol equation to describe photosynthesis or respiration given the formula of glucose evaluate the effects of human influences on the composition of air • deforestation • increased energy consumption (burning of fossil fuels) • population • pollution limited to increase in sulphur dioxide and unburnt hydrocarbons

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
2p W2.22		state that the earliest atmosphere of the Earth contained ammonia and carbon dioxide and that these gases came from the inside of the Earth describe how oxygen appeared in the atmosphere as a result of photosynthesis	describe one possible theory for how the atmosphere evolved • degassing from the Earth's crust • initial atmosphere of ammonia and carbon dioxide • formation of water • development of photosynthetic organisms • increase in oxygen and nitrogen levels • lack of reactivity of nitrogen
	state that oceans contain dissolved substances (salts) that were once in rocks	describe how the oceans have evolved water has dissolved salt from rocks these salts do not evaporate so the oceans have become more concentrated in salts	interpret and evaluate possible theories for how the atmosphere and oceans evolved given appropriate data
3t W3.19	**recognise that chemical reactions can be used to heat things, to make light, sound and electricity**		
3u W3.20	**describe combustion as an exothermic reaction**	**describe an exothermic reaction as one in which energy is transferred into the surroundings (releases energy)**	**describe bond making as an exothermic process**
3v W3.21	**state that energy can be given out or taken in during a chemical reaction**	**describe an endothermic reaction as one in which energy is taken from the surroundings (absorbs energy)**	**describe bond breaking as an endothermic process** **state that ΔH = -ve shows an exothermic reaction and ΔH = +ve shows an endothermic reaction**
	recognise that an energy change has taken place by using temperature changes	**recognise exothermic and endothermic reactions using temperature changes**	**explain why a reaction is exothermic or endothermic using the energy changes that occur during bond breaking and bond making**

Module: CD2 Module Title: Energy in Chemistry

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
Key Skills N2.1, 2.2, 2.3 Key Skills IT2.1, 2.2, 2.3 Key Skills WO1.1, 1.2, 1.3, 2.1, 2.2, 2.3	**interpret and use data from simple calorimetric experiments related to the combustion of fuels comparing the energy transferred in different reactions** • **use of temperature changes to compare the size of the energy change** **state that energy is measured in J or kJ**	**describe a simple calorimetric method for comparing the energy transferred in combustion reactions** • **use of spirit burner** • **heating water in a copper calorimeter** • **measuring the temperature change** • **fair tests**	**describe a simple calorimetric method for comparing the energy transferred per gram of fuel combusted** **calculate energy changes in J** • **recall and use the formula energy supplied to raise temperature = mass x specific heat capacity x temperature change** • **by comparing temperature changes** **calculate the energy output of a fuel in J/g by recalling and using the formula** $$\text{energy per gram} = \frac{\text{energy supplied}}{\text{mass of fuel burnt}}$$

Module CD3: Rocks and Metals

Programme of Study

English National Curriculum		Welsh National Curriculum	
Candidates should be taught		**Candidates should be taught**	
1a	that atoms consist of nuclei and electrons	1.1	that atoms consist of nuclei and electrons
1b (part)	the charges (and relative masses) of protons, neutrons and electrons	1.2 (part)	the charges (and relative masses) of protons, neutrons and electrons
1h (part)	how ions are formed when atoms gain or lose electrons (and how giant ionic lattices are held together by the attraction between oppositively charged ions)	1.8	how ions are formed when atoms gain or lose electrons
		2.10	that metal ores are found in the Earth
2g	about the variety of useful substances that can be made from rocks and minerals	2.15	that a variety of useful substances can be made from rocks and mineral e.g. rock salt
2h	how the reactivity of a metal affects how it is extracted from its naturally occurring ores	2.11	that the way in which a particular metal is extracted from its ores is related to its reactivity
2i	an example of how a less reactive metal can be extracted by reduction with carbon or carbon monoxide	2.13	how a less reactive metal e.g. iron, can be extracted by reduction with carbon or carbon monoxide
2j	an example of how a metal can be purified or recycled by electrolysis	2.14	how a metal e.g. copper, can be purified by electrolysis
2k	an example of how a reactive metal can be extracted by electrolysis	2.12	how a reactive metal e.g. aluminium, can be extracted by electrolysis
2n(part)	to represent reactions by balanced symbol equations (and use these to predict reacting quantities)	2.19	to represent reactions, including electrolytic reactions, by balanced equations using symbols
Sc4 3n	that the Earth's outermost layer, the lithosphere, is composed of plates in relative motion, and that plate tectonic processes result in the formation, deformation and recycling of rocks	2.24	how plate tectonic processes are involved in the formation, deformation and recycling of rocks
2r	how the sequence of, and evidence for, rock formation and deformation is obtained from the rock record	2.25	how the sequence of, and evidence for, these processes is obtained from the rock record
3k (part)	about different types of chemical reactions, including (neutralisation), oxidation, reduction and thermal decomposition, and examples of how these are used to make new materials		
3l	to recognise patterns in chemical reactions and use these to make predictions		
3m	about ways in which knowledge about chemical reactions is applied when new substances are made		

Grey highlighting indicates "key ideas" which are to be re-examined in the Terminal examination together with the content from the Phase 2 modules
Learning outcomes in bold are common to the Single Award Specification.

Rationale

In this module, rocks are classified as igneous, sedimentary and metamorphic groups as a result of the way they are formed. The concept of plate tectonics is introduced to provide an explanation of the recycling of rocks. Rocks are then considered as the raw material from which many useful metals can be extracted. The terms 'ore' and mineral' are introduced and the method of extraction of common metals is then related to their position in the reactivity series. Extraction by reduction with carbon or carbon monoxide is contrasted with that achieved by electrolysis.

The differences between elements, mixtures and compounds are discussed and basic ideas on atomic structure are introduced so that the differences between atoms, molecules and ions, and those between mixtures and compounds, can be more readily understood. The formation of ions is discussed so that the electrolytic extraction of reactive metals such as aluminium can be better understood. Ionic bonding will be covered in Module CD6.

There are good opportunities in this unit for developing the understanding of word and symbolic equations.

The ideas of word and symbolic equations are a feature of all chemistry units. In Module PD1 how the structure of the Earth has been investigated using seismic waves is described.

Module CD3 Module Title Rocks and Metals

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
2r W2.25 CoA 2.3 and 3.8 Key Skills C2.2, 2.3 Key Skills IT2.2, 2.3	state that the three types of rock are igneous, metamorphic and sedimentary describe that sedimentary rocks are found in layers and that the bottom layer is most likely to the oldest layer describe that sedimentary rocks are found in layers and that the bottom layer is most likely to the oldest layer	explain how the size of crystals in an igneous rock is related to the rate of cooling of molten rock explain why an igneous intrusion contains younger rock than the surrounding sedimentary rock recognise from a diagram that any rock or fracture that cuts any other rock will be younger than the rock that it cuts explain why sedimentary rocks may contain fossils and how the ages of the fossils found can indicate the age of the rock (the younger the fossils the younger the rock) explain how fossils can be distorted or destroyed during formation of metamorphic rock from sedimentary rock describe how folding and faulting of rock can occur	interpret evidence of modes of formation • igneous: interlocking crystals, glassy, ash deposits, intrusion into another rock, from lava • sedimentary: presence of fossils, layering, grain size reflecting energy during deposition, sedimentary structures (e.g. ripples, cross bedding) • metamorphic: recystallisation of grains, distortion or destruction of fossils, baking by intrusions, high or low grade regional metamorphism interpret evidence for rock deformation • folding • faulting

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
Sc4 3n W2.24 1.1a 1.1b 1.1c 1i, 1j	describe the structure of the Earth as a sphere with a thin rocky crust, mantle and core state that the Earth's core contains iron	describe the outer layer of the Earth as oceanic plates under oceans and continental plates forming continents describe the mantle as a layer of rock that • has a higher density than rock in the crust • has a different composition from the rock in the crust describe the lithosphere as the (relatively) cold rigid outer part of the Earth that includes the crust and the outer part of the mantle describe the lithosphere as formed of a number of large interlocking tectonic plates that can move slowly relative to each other state that the movement of tectonic plates results in volcanic activity and earthquakes at plate boundaries explain that tectonic plates are found on top of the mantle because they are less dense than the mantle	describe the mantle as the zone between the crust and the core that is • relatively cold and rigid just below the crust • hot and non-rigid that so able to flow at greater depths describe the theory of plate tectonics and the contribution this process makes to the recycling of rocks • energy transfer involving convection currents in the largely solid mantle causing the plates to move slowly • oceanic plates are more dense than continental plates • collision between oceanic and continental plate leads to subduction and partial re-melting (oceanic goes underneath continental) • collision between two continental plates leads to folding, compressional faulting, regional metamorphism and to mountain building • movement apart (splitting) of plates leads to a weakness in the crust and the formation of new igneous rock at mid-ocean ridges or rift valleys • movement of plates leads to the deformation of rocks and the formation of metamorphic rock

Module CD3 Module Title: Rocks and Metals

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
2g W2.10 CoA 3.2 and 3.8	state that an ore is a mixture of a mineral and surrounding rock describe that metals are extracted from ores state that a mixtures contains two or more substances that are not chemically combined describe a compound as a pure substance that contains two or more elements chemically combined describe an element as a substance that contains only one type of atom identify whether a mineral is an element or a compound from its formula	describe an ore as a mixture containing a metal or metal compound that is found in the Earth's crust state the useful substances that can be made from the following rocks and minerals • clay to pottery • limestone (calcium carbonate) to cement • rock salt (sodium chloride) to chlorine and sodium hydroxide • sand (silicon oxide) to glass • bauxite (aluminium oxide) to aluminium • haematite (iron (III) oxide) to iron	
2h W2.11 3l CoA 3.4	describe that reactive metals are extracted by electrolysis describe that less reactive metals are extracted by heating the ore with carbon state that very unreactive metals are found uncombined in the ground e.g. silver and gold	predict the method of extraction of a metal given a reactivity series and relevant data State the following reactivity series, Na, Ca, Mg, Al, Zn, Fe, Cu, Au	predict the method of extraction of a metal from a recalled reactivity series and relevant data

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
2i 3k (part) W2.13	state that iron can be extracted from its ore (haematite) by heating with carbon in a blast furnace	describe the extraction of iron in the blast furnace • raw materials needed are haematite (iron ore), coke and limestone • heated above 1000°C • use of a blast of hot air write the word equation for the reduction of iron (III) oxide by carbon and by carbon monoxide construct the symbol equations for the reactions that take place in the blast furnace given the formulae of the appropriate substances describe reduction as the loss of oxygen from an oxide	construct symbol equations for reactions that occur in the blast furnace (formulae not given) identify reduction reactions from word or symbol equations
2k W2.12 W2.19	state that aluminium is extracted from its mineral using electricity define electrolysis as the decomposition of a liquid using electricity	describe the key features of the electrolytic decomposition involved in the production of aluminium • use of molten aluminium oxide • oxygen is formed at the graphite anode • aluminium is formed at the graphite cathode • process requires a high electrical energy requirement write the word equation for the decomposition of aluminium oxide construct the symbol equation for the decomposition of aluminium oxide given the formulae	state the electrode reactions in the electrolytic extraction of aluminium • cathode $Al^{3+} + 3e^- \rightarrow Al$ • anode $2O^{2-} \rightarrow O_2 + 4e^-$ write the symbol equation for the decomposition of aluminium oxide

Module CD3 Module Title Rocks and Metals

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
2j W2.14 CoA 3.4	state that copper can be purified by electrolysis describe that recycling copper is cheaper than making copper and that it saves resources	describe the use of electrolysis in the purification of copper • boulder (impure) copper as anode • pure copper as cathode • copper(II) sulphate solution as electrolyte	state the electrode reactions in the purification of copper cathode $Cu^{2+} + 2e^- \rightarrow Cu$ anode $Cu \rightarrow Cu^{2+} + 2e^-$
1a W1.1 1b (part) W1.2 (part)	describe an atom as a nucleus surrounded by electrons state that a nucleus is positively charged, an electron is negatively charged, and an atom is neutral	state the relative charges of electrons, protons and neutrons. • proton +1 • electron –1 • neutron 0 explain that that an atom is neutral since it contains the same number of protons as electrons	describe that atoms of the noble gases (helium, neon, argon) have a stable number of electrons and that other atoms want to gain or lose electrons to achieve this number of electrons
1h (part) W1.8	state that an ion is a charged atom or group of atoms recognise that a particle is an ion from its formula	state that positive ions are called cations and negative ions are called anions recognise cations and anions from their formulae state that positive ions are formed by loss of electrons from an atom state that negative ions are formed by the gain of electrons from an atom	construct a half equations showing the formation of ions from atoms given the formulae of the ion explain why positive ions are formed when atoms lose electrons and why negative ions are formed when atoms gain electrons describe reduction as the gain of electrons describe oxidation as the loss of electrons identify oxidation or reduction reactions from half equations

Module: CD3 Module Title: Rocks and Metals

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
W2.19 (part)	state that liquids that conduct electricity contain ions	state that the negative electrode is called the cathode and that the positive electrode is called the anode explain that conduction in some solutions is due to the movement of ions positive ions move to the negative electrode (cathode) negative ions move to the positive electrode (anode)	explain that during electrolysis positive ions gain electrons at the cathode to form neutral atoms and negative ions lose electrons at the anode construct equations for electrode reactions given negative ion formula and positive ion formula

Module CD4: Carbon Chemistry

Programme of Study

English National Curriculum		Welsh National Curriculum	
Candidates should be taught		**Candidates should be taught**	
1d	about a model of a way electrons are arranged in atoms	1.4	about a model of the way electrons are arranged in atoms for elements 1 to 20
1f	that new substances are formed when atoms combine	1.6	that new substances are formed when atoms combine
1g (part)	that chemical bonding can be explained in terms of the transfer or sharing of electrons	1.7 (part)	that chemical bonding can be explained in terms of the transfer or sharing of electrons
1i	how covalent bonds are formed when atoms share electrons	1.10	that covalent bonds are formed when atoms share electrons
1j	that substances with covalent bonds may form simple molecular structures or giant structures	1.11	that substances with covalent bonds may form simple molecular structures or giant structures
1k	ways in which the physical properties of some substances with giant structures differ from those with simple molecular structures	1.12 (part)	the physical properties of some substances with simple molecular structures e.g. carbon dioxide, water, some with giant molecular structures, e.g. graphite, diamond, (and some with giant ionic structures, e.g. sodium chloride, magnesium oxide)
		2.5	that there are different groups of hydrocarbons
2d	that alkanes are saturated hydrocarbons, and alkenes are unsaturated hydrocarbons	2.6	that alkanes are saturated hydrocarbons, and alkenes are unsaturated hydrocarbons containing one double covalent bond between carbon atoms
2e	how addition polymers can be formed from the products of crude oil by cracking and polymerisation	2.7	that hydrocarbon molecules can be cracked to form smaller molecules, including alkenes
		2.8	that addition polymers can be made from alkenes formed during cracking
2f	some uses of addition polymers	2.9	some uses of addition polymers
3l (part)	to recognise patterns in chemical reactions and use these to make predictions		
3m (part)	about ways in which knowledge about chemical reactions is applied when new substances are made		

Learning outcomes in bold are common to the Single Award Specification.

Rationale

In this module the structure and bonding of covalent compounds is studied. The difference between simple molecular and giant molecular structures are illustrated by carbon and carbon compounds. Displayed formula are used to represent molecules and the 'dot and cross' module is developed in relation to covalent bonding.

The names and structures of three forms of carbon, diamond, graphite and Buckminster Fullerene are described and the properties of diamond and graphite are related to their structure and bonding. Hydrocarbons are then reintroduced (studied in Module CD2) in the context of the alkanes and alkenes series. Cracking is seen as a process which produces alkenes. Addition reactions are introduced as the characteristic reactions of alkenes with polymerisation an important example of an addition reaction. Ideas on bonding and the forces that exist between molecules are used to explain the properties of plastics and of simple and giant molecular compounds.

The ideas of word and symbolic equations are a feature of all chemistry modules.

Simple ideas about atomic structure and bonding have been introduced in modules CD2 and CD3.

Module: CD4 Module Title: Carbon Chemistry

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
2d W2.5 W2.6	**state that in a hydrocarbon the two elements carbon and hydrogen are chemically combined** **recognise a hydrocarbon from a molecular or a displayed formula** **state that alkanes are hydrocarbons and recognise from their names that methane, ethane, propane and butane are alkanes** **state that alkenes are hydrocarbons and recognise from their names that ethene, propene and butene are alkenes**	**define a hydrocarbon as a compound between carbon and hydrogen only** **state the molecular formula of a compound from its displayed formula** **explain why a compound is a hydrocarbon given its molecular or displayed formula** **describe alkanes as hydrocarbons which contain single covalent bonds only** **describe alkenes as hydrocarbons which contain one double covalent bond between carbon atoms** **recognise an alkane or an alkene from a displayed formula** describe how bromine water can be used to distinguish between an alkane and an alkene • an alkene will change bromine water from orange /brown to colourless • an alkane has no effect on bromine water (remains orange/brown) balance symbol equations given the displayed formulae **draw the displayed formula of ethane, propane, ethene and propene given their molecular formula**	**define a saturated compound as one which only contains single covalent bonds between carbon atoms** **define an unsaturated compound as one which contains one double covalent bond between carbon atoms** **state that the general formula of an** • **alkane is C_nH_{2n+2}** • **alkene is C_nH_{2n}** **recognise from its displayed or molecular formula** • **a saturated hydrocarbon** • **an unsaturated hydrocarbon** **describe an addition reaction as one in which an unsaturated substance is converted into a saturated substance** • hydrogenation using hydrogen under high pressure to change an alkene into an alkane using a nickel catalyst • an alkene reacts with bromine water to produce a saturated dibromo compound write a balanced symbol equation using displayed formulae which are not given • hydrogenation of ethene and propene • bromination of ethene or propene

Module CD4 Module Title: Carbon Chemistry

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
2e (part) W2.7 1.1c 1.1d Key Skills IT1.1	**describe cracking as a process for making smaller hydrocarbon molecules from larger ones** **state that cracking needs a catalyst and a high temperature**	**describe that cracking enables more useful hydrocarbon molecules to be made from less useful molecules** • **fractional distillation produces some fractions in which supply exceeds demand e.g. fuel oil, naphtha and bitumen** • **fractional distillation produces some fractions in which demand exceeds supply e.g. petrol and diesel** • **cracking converts fractions such as naphtha into petrol** • **cracking converts large alkane molecules into smaller hydrocarbon molecules**	**explain that cracking converts saturated hydrocarbons into smaller saturated and unsaturated hydrocarbons** • **cracking involves the breaking of single covalent bonds between carbon atoms** • **cracking produces a mixture of products since any single covalent bond between carbon atoms can break** • **cracking produces alkanes and alkenes** **construct equations to show cracking given the formula of the alkane being cracked**
2e (part) W2.8 3l (part) 3m (part)	**describe polymerisation as a process for making very large molecules from many small molecules** **state that the very large molecules in plastics are called polymer molecules**	**state that the small molecules used to make polymers are called monomers** **describe addition polymerisation as a process** • **in which many monomer molecules react together to give a polymer** • **which requires high pressure and a catalyst** **state the name of an addition polymer given the name of the monomer** • **ethene makes poly(ethene)** • **propene makes poly(propene)** • **chloroethene makes poly(chloroethene)** • **styrene makes polystyrene**	**explain that addition polymerisation involves the reaction of many unsaturated monomer molecules (alkenes) to form a saturated polymer.** **construct the displayed formula of a polymer given the displayed formula of a monomer** **construct the displayed formula of a monomer given the displayed formula of a polymer**

Module: CD4 Module Title: Carbon Chemistry

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
2i W2.9 1.1b 1.1d CoA 3.11 1f 1i, 1j Key Skills C2.1a, 2.2	**state some uses for polymers (plastics)** • **polythene or poly(ethene) is used for plastic bags** • **polystyrene is used for packaging and insulation** • **epoxy glue is used as an adhesive** **describe addition polymers as non-biodegradable, so they will not decay or decompose by bacterial action**	**suggest the properties a polymer (plastic) should have to be used for a particular use** **explain why a polymer (plastic) is suitable for a particular use given the properties of the polymer** **describe some of the environmental and economic issues related to the use of plastics** • **difficult to dispose in land fill sites** • **difficult to dispose by burning because toxic gases are produced** • **disposal by burning or land-fill sites wastes a valuable resource** • **problems of recycling**	**describe that the atoms in plastics are held together by strong covalent (intramolecular) bonds** **relate the properties of plastics to simple models of their structure** • **plastics that have weak intermolecular forces between polymer molecules have low melting points and can be stretched easily as the polymer molecules can slide over one another** • **plastics that have strong forces between the polymer molecules (covalent bonds or cross-linking bridges) have high melting points, cannot be stretched and are rigid**

Module: CD4 Module Title: Carbon Chemistry

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
2i W2.9 1f W1.6 1g (part) W 1.7 (part) 1l W1.10 1j (part) W1.11 (part)	describe a molecule as two or more atoms bonded together state the number of atoms in a molecule given its molecular formula or displayed formula state the number of each different type of atom in a molecule or displayed formula	state or draw the electron arrangements for hydrogen, carbon and oxygen state that non-metals combine together by sharing electrons and this is called covalent bonding	describe the formation of simple molecules containing single and double covalent bonds by the "dot and cross" model limited to the molecules • H_2 • Cl_2 • CH_4 • C_2H_4 • CO_2 • H_2O •
1k (part)	describe carbon dioxide as a gas with a low melting point describe water as a liquid with a low melting point	state that carbon dioxide and water do not conduct electricity	describe carbon dioxide and water as simple molecules with weak intermolecular forces between molecules relate the properties of carbon dioxide and water to their structure • weak intermolecular forces so low melting points • no free electrons so do not conduct electricity

Module: CD4 Module Title: Carbon Chemistry

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
1.1a	state that there are three forms of carbon • diamond • graphite • Buckminster Fullerene	recognise the structures of diamond, graphite and Buckminster Fullerene	describe diamond as a giant molecule in which every carbon atom is bonded to four other carbon atoms by strong covalent bonds describe graphite as a giant molecule which • exists in layers within which each carbon atom is bonded to three other carbon atoms by strong covalent bonds • has layers that are held together by weak intermolecular forces • has delocalised electrons
1j (part) 1k (part)		state that diamond • is very hard • does not conduct electricity • has a very high melting point state that graphite • is soft • does conduct electricity • has a very high melting point	relate the properties of diamond and graphite to their structures • strong covalent bonds in diamond and graphite result in high melting points • weak intermolecular bonds between the layers of carbon in graphite allow each layer to slide easily so it is used as a lubricant • because it does not exist in layers and because of the strong covalent bonds between carbon atoms diamond is very hard • presence of "free" delocalised electrons in graphite explain the electrical conductivity of graphite • diamond does not have free electrons so it does not conduct electricity

Module CD5: Chemical Economics

Programme of Study

English National Curriculum		Welsh National Curriculum	
Candidates should be taught		**Candidates should be taught**	
2l	the importance for agriculture of converting nitrogen to ammonia	2.16	how nitrogen can be converted to ammonia in industry
2m	how nitrogenous fertilisers are manufactured, their effect on plant growth, and the environmental consequences of over-use	2.17	how nitrogenous fertilisers are manufactured, and their effects on plant growth and the environment
		2.18	to represent chemical reactions by word equations
2n	to represent chemical reactions by balanced symbol equations and to use these to predict reacting quantities	2.19 (part)	to represent reactions, (including electrolytic reactions), by balanced equations using chemical symbols
		2.20	to use chemical equations to predict reacting quantities
2o	to determine the formulae of simple compounds from reacting masses	2.21	to determine the formulae of simple compounds from reacting masses
3k (part)	about different types of chemical reaction, including neutralisation, (oxidation, reduction and thermal decomposition) and examples of how these are used to make new materials		
3l (part)	to recognise patterns in chemical reactions and use these to make predictions		
3m	about ways in which knowledge about chemical reactions is applied when new substances are made		
		3.16	that some reactions are reversible
		3.17	how the yield of products from reversible reactions depends on the conditions
3s	about manufacturing processes based upon reversible reactions, and how the yield of these depends on the conditions	3.18	that some manufacturing processes are based on reversible reactions

Learning outcomes in bold are common to the Single Award Specification.

Rationale

This module chooses as its central focus the industrial preparation of ammonia and its link with the fertiliser industry. The concept of reversible reactions is introduced with reference being made to the production of ammonia. In reversible reactions the fact that a balance that has to be struck between rate and percentage conversion is explored.

Quantitative aspects of chemistry are introduced. Ideas can be extended and applied to industrial context. The use of relative atomic masses to calculate formula masses is developed and chemical equations are used quantitatively in 'reacting masses' calculations.

The idea of percentage yield is used in relation to 'loss' of product during a reaction and in terms of the difficulty of getting a reversible reaction to go to completion. Wider social and economic considerations of an industrial process are studied.

This unit provides the major opportunity in the course for developing an understanding of quantitative chemistry. It also enables much of the work done previously on word and symbolic equations to be consolidated and extended.

The ideas of word and symbolic equations are a feature of all chemistry units.

The factors which affect the rate of a reaction are covered in Module CD1.

The use of nitrogenous fertilisers in intensive farming and the nitrogen cycle are covered in module BD3

Module: CD5 Module Title: Chemical Economics

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
W2.18 W 2.19 2n (part)	recognise, in a word or symbol equation, the reactants and the products describe that, in a chemical reaction reactants, are made into products	construct word equations given the reactants and the products construct balanced symbol equations given the formulae (no brackets) of the reactants and products	construct balanced symbol equations given the formulae (with brackets) of the reactants and products construct balanced symbol equations (formulae not given)
2n (part) W2.20 Key Skills N1.2	state the number and the identity of the elements in a formula calculate the relative formula mass of a substance from its formula (no brackets)	calculate the relative formula mass of a substance from its formula (with brackets)	calculate the relative formula mass of a substance such as a hydrate e.g. $CuSO_4.5H_2O$
2n (part)			calculate the mass of one mole of a substance given its formula interpret chemical equations quantitatively • write and to balance straightforward equations • use molar masses • calculate masses of products or reactants from equations
2o W2.21			determine the empirical formula of a compound from given data • percentage by mass composition • the mass of each element in a sample of a compound

Module CD5 Module Title: Chemical Economics

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
Key Skills WO1.1, 1.2, 1.3, 2.1, 2.2, 2.3 Key skills LP1.1, 1.2, 1.3 2.1, 2.2, 2.3 Key Skills PS1.1, 1.2, 1.3 2.1, 2.2, 2.3	recognise that the greater the amount of starting materials (reactants) used, the greater the amount of new substances (products) formed describe percentage yield as a way of comparing amount of product made (actual yield) to amount expected (predicted yield) • 100% yield means that no product has been lost • 0% yield means that no product has been made recognise possible reasons (given experimental details) why the percentage yield of a product is less than 100% e.g. • loss in filtration • loss in evaporation • loss in transferring liquids • loss in heating	state the formula $percentage\ yield = \frac{actual\ yield}{predicted\ yield} \times 100$ calculate percentage yield given 'actual yield' and' predicted yield'	

Module CD5 Module Title: Chemical Economics

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
2l 3s W2.16 W3.17 W3.18 W3.16	state that ammonia is made from nitrogen and hydrogen state that the nitrogen needed for the manufacture of ammonia is obtained from air state that ammonia is used to make fertilisers	describe how ammonia is made in the Haber process • nitrogen + hydrogen ⇌ ammonia • iron catalyst • high pressure • temperature in the region of 450°C • unreacted nitrogen and hydrogen are recycled	explain the use of the conditions used in the Haber process • high pressure increases the percentage yield of ammonia • high temperature decreases the percentage yield of ammonia • high temperature gives a high rate of reaction • 450°C is an optimum temperature to give a fast reaction with a sufficiently high percentage yield • catalyst increases the rate of reaction but does not change the percentage yield state the balanced equation for the manufacture of ammonia in the Haber process
1.1b Key Skills N1.1 Key Skills IT1.1	recognise that ⇌ is used to represent a reversible reaction	state that a reversible reaction can proceed in both directions interpret data in tabular and graphical form relating to percentage yield in reversible reactions and changes in conditions	

Module CD5 Module Title: Chemical Economics

Programme of Study	Foundation Tier Only	Foundation and Higher Tier	Higher Tier Only
	Candidates should be able to		
W3.17 1.1d 1e 1h Key Skills N2.1, 2.2, 2.3 Key Skills IT1.1, 1..2	state that the cost of making a new substance depends on: • price of energy (gas and electricity) • cost of starting material • wages (labour costs) • equipment (plant) • how quickly the new substance can be made (cost of catalyst)	describe how different factors affect the cost of making a new substance • the higher the pressure the higher the plant cost • the higher temperature the higher the energy cost • catalysts reduce costs by increasing the rate of reaction • when unreacted starting materials are recycled costs are reduced • automation reduces the wages bill	explain that economic considerations determine the conditions used in the manufacture of chemicals • rate must be high enough to give a sufficient daily yield of product • percentage yield must be high enough to give a sufficient daily yield of product • a low percentage yield can be accepted if the reaction can be repeated many times with recycled started materials • optimum conditions used that give the lowest cost rather than the fastest reaction or highest percentage yield
2m W2.17 CoA 3.1 Key Skills IT1.1	state that many fertilisers are made in neutralisation reactions **state that a base neutralises an acid and vice versa** state that • ammonia is an alkali so has a pH of greater than 7. • nitric acid is an acid so has a pH of less than 7 describe the change in pH when an acid is neutralised by an acid or vice versa	describe an alkali as a soluble base **state that in neutralisation** **acid + base → salt + water** describe that ammonium sulphate is manufactured by neutralising sulphuric acid with ammonia describe that ammonium nitrate is manufactured by neutralising nitric acid with ammonia explain the change in pH when an acid is neutralised by an acid or vice versa	**predict the names of salts produced when bases are neutralised by laboratory acids** • **sulphuric acid** • **nitric acid** • **hydrochloric acid** construct word equations to show the neutralisation of acids by base (without given the names of the products) construct symbol equations for the neutralisation of acids by bases limited to • sulphuric acid, nitric acid, and hydrochloric acid • ammonia, potassium hydroxide sodium hydroxide and copper oxide state that acids in solution contain hydrogen ions and alkalis in solution contain hydroxide ions and describe neutralisation using the ionic equation $H^+ + OH^- \rightarrow H_2O$

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
1.1c 1.1d CoA 2.8 1j Key Skills IT2.1	state that nitrogen, phosphorus and potassium are the three main essential elements found in fertilisers describe that fertilisers provide plants with essential elements for growth	state the name of two nitrogenous fertilisers manufactured from ammonia e.g. • ammonium nitrate • ammonium phosphate • ammonium sulphate • urea explain that fertilisers must dissolve in water to be taken in by roots in solution state that the use of fertilisers increase crop yield	describe the process of eutrophication • run-off of fertiliser • increase of nitrate or phosphate in river water • algal bloom • blocks off sunlight to other plants which die • aerobic bacteria use up oxygen • most living organisms die explain how the use of fertilisers increase crop yield • replaces essential elements used by a previous crop or provides extra essential elements • more nitrogen gets incorporated into plant protein so increased growth

CD6: The Periodic Table

Programme of Study

English National Curriculum		Welsh National Curriculum	
Candidates should be taught		**Candidates should be taught**	
1a	that atoms consist of nuclei and electrons	1.1	that atoms consist of nuclei and electrons
1b	the charges and relative masses of protons, neutrons and electrons	1.2	the charges and relative masses of protons, neutrons and electrons
1c	about mass number, atomic number and isotopes	1.3	about mass number, atomic number and isotopes
1d	about a model of the way electrons are arranged in atoms	1.4	about a model of the way electrons are arranged in atoms for elements 1 to 20
1e	how the reactions of elements depend on the arrangement of electrons in their atoms	1.5	that the reactions of elements depend upon the arrangement of electrons in their atoms
1f	that new substances are formed when atoms combine	1.6	that new substances are formed when atoms combine
1g	that chemical bonding can be explained in terms of the transfer or sharing of electrons	1.7	that chemical bonding can be explained in terms of the transfer or sharing of electrons
1h	how ions are formed when atoms gain or lose electrons and how giant ionic lattices are held together by the attraction between oppositively charged ions	1.8	how ions are formed when atoms gain or lose electrons
		1.9	that ionic lattices are held together by the attraction between oppositively charged ions
1k (part)	ways in which the physical properties of some substances with giant structures (differ from those with simple molecular structures)	1.12 (part)	the physical properties of (some substances with simple molecular structures, e.g. carbon dioxide, water, some with giant molecular structures e.g. graphite and diamond), and some with giant ionic structures e.g. sodium chloride, magnesium oxide
3a	that there are approximately 100 elements and that all materials are composed of one or more of these		
3b	that the periodic table shows all the elements, arranged in order of ascending atomic number	3.1	that the periodic table shows all elements, arranged in order of ascending atomic number
3c	the connection between the arrangement of outer electrons and the position of an element in the periodic table	3.2	the connection between the arrangement of outer electrons and the position of an element in the periodic table
3d	that elements in the same group of the periodic table have similar properties	3.3	that elements in the same group of the periodic table have similar properties
3e	how the properties of elements change gradually from the top to the bottom of a group	3.4	that there is a gradual change in the properties of elements from the top to the bottom of a group

English National Curriculum		Welsh National Curriculum	
Candidates should be taught		**Candidates should be taught**	
3f	the properties and uses of the noble gases	3.5	the properties and uses of the noble gases
3g	the properties and reactions of the alkali metals	3.6	the properties and reactions of the alkali metals
3h	the properties, reactions and uses of the halogens	3.7	the properties, reactions and uses of the halogens
3i	about similarities between transition metals and about the characteristic properties of their compounds	3.8	similarities between transition metals and characteristic properties of their compounds
3j	some uses of transition metals	3.9	some uses of transition metals
3k (part)	about different types of chemical reaction, including neutralisation, oxidation, reduction and thermal decomposition, and examples of how these are used to make new materials		
3l (part)	to recognise patterns in chemical reactions and use these to make predictions		
3m	about ways in which knowledge about chemical reactions is applied when new substances are made		

Learning outcomes in bold are common to the Single Award Specification.

Rationale

This module allows for a detailed study of the periodic table.

A number of Groups are chosen for a more systematic study. These are the noble gases, the alkali metals and the halogens.

Ideas on atomic structure first described in module CD3 are developed. The existence of isotopes is related to the arrangement of protons and neutrons within the nucleus. The link between Group number and electron arrangement is identified and the similarity of the chemical properties of element within a Group is explained in terms of electron arrangement. The variation in chemical properties as you descend some groups is identified and explained.

Consideration of Group I and Group VII elements allows ideas on ions to be revised and extended to include ionic bonding. The 'dot and cross' model first described in module CD4 is extended to include ionic bonding. The properties of giant ionic compounds are studied and these properties are explained in terms of structure and bonding.

The transition elements are also studied. Reference is made to their characteristic physical properties. Transition metal carbonates are studied. The identification of metal ions in solution with sodium hydroxide solution and flame tests on solid s are used as analytical processes.

The ideas of word and symbolic equations are a feature of all units.

Atomic structure and the nature of ions is introduced in Module CD3. The relationship between structure and bonding and the property of a substance is also described in module CD4.

Module CD6 Module Title: The Periodic Table

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
1a W1.1 1b W1.2 1.1c	**describe an atom as a nucleus surrounded by electrons** **state that a nucleus is positively charged, an electron is negatively charged and an atom is neutral**	**state that the nucleus is made up of protons and neutrons** **state the relative charge and relative mass of an electron, a proton and a neutron** • **electron charge -1 and mass 0.0005 (zero)** • **proton charge +1 and mass 1** • **neutron charge 0 and mass 1** **explain that an atom is neutral because it has the same number of electrons as protons**	
1c W1.3 1.1a 1.1b 1.1c	**identify the atomic number of an element by using a periodic table** **identify the name or symbol of an element given its atomic number using a periodic table**	**describe atomic (proton) number as the number of protons in an atom** **describe mass (nucleon) number as the total number of protons and neutrons in an atom** describe isotopes as varieties of an element that have the same atomic number but different mass numbers	**deduce the number of protons, electrons and neutrons in a particle given its atomic number, mass number and the charge on the particle** • **using data in a table** • **using the conventional symbolism e.g. carbon-12 or $^{12}_{6}C$.** identify isotopes from data about the number of electrons, protons and neutrons in particles
3a 3b W3.1	**state that there are just over 100 elements** **describe an element as a substance which** • **cannot be broken down chemically** • **contains the same type of atom** **identify the elements in a compound from its formula, using a periodic table** **describe a compound as a substance that contains at least two elements chemically combined**	**state that the elements in the periodic table are arranged in ascending atomic number**	

Module: CD6 Module Title: The Periodic Table

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
1d W1.4		**describe that electrons occupy the space around the nucleus** **state that electrons occupy shells**	**deduce the electronic structure of the first 20 elements in the periodic table e.g. calcium is 2.8.8.2**
3c W3.2 3d W3.3	**recognise, using a periodic table, elements from a list that are in the same group (family)** **recognise, using a periodic table, elements from a list that are in the same period** **describe a group of elements as all the elements in a vertical column of the periodic table and that the elements have similar chemical properties** **describe a period of elements as all the elements in a horizontal row of the periodic table**	**explain that the group number is the same as the number of electrons in the outer shell** • **Group 1 elements have 1 electron in the outer shell** • **Group 7 electrons have 7 electrons in the outer shell** • **Group 8 electrons have 8 electrons in the outer shell** **explain that the period to which the element belongs corresponds to the number of shells in the electronic structure**	**deduce the group to which an element belongs from its electronic structure (limited to the first 20 elements)** **deduce the period to which the element belongs**
3f W3.5 3d W3.3 Key Skills C1.1, 1.2	**describe Group 8 elements as the noble gases because they are unreactive** **recognise helium, argon, neon and krypton as noble gases** **state that helium is used in balloons** **state that argon, neon and krypton are used in lighting**	**state that atoms of argon, neon and krypton have eight electrons in their outer shell** **state that the density of the noble gases increases down the group** **explain that helium is used in balloons since it is less dense than air** **explain that argon, neon and krypton are used in lighting because they are unreactive**	**explain that noble gases are unreactive because they have atoms with a complete outer electron shell (stable octet)**

Module: CD6 Module Title: The Periodic Table

Programme of Study	Foundation Tier Only	Foundation and Higher Tier	Higher Tier Only
	Candidates should be able to		
3g W3.6 3d W3.3 3e W3.4 3l	**state that Group 1 metals are known as the alkali metals** **recognise sodium, lithium and potassium as Group 1 metals** **state that alkali metals react vigorously with water** **explain that alkali metals are stored under oil because they react with air and water** **recall the order of reactivity with water of the alkali metals** • **potassium is more reactive than sodium** • **sodium is more reactive than lithium**	**describe the reaction of lithium, sodium and potassium with water** • **hydrogen is formed** • **an alkali is formed which is the hydroxide of the metal** • **the reactivity with water increases down Group 1** • **potassium gives a lilac flame**	**construct the balanced symbol equation for the reaction of an alkali metal with water** **predict the properties of alkali metal e.g.** • **reactivity of rubidium with water,** • **the physical properties of caesium given information about the other alkali metals**
1e W1.5 3d W3.3 3e W3.4		**state that the Group 1 metals have one electron in the outer shell** **explain that Group 1 metals have similar properties because they have one electron in their outer shell**	**explain that alkali metals have similar properties because when they react an atom loses one electron to form a positive ion with a stable electronic structure** **describe the loss of electrons as oxidation** **explain that the more reactive the alkali metal the easier it for an atom to lose one electron**
		describe how to carry out a flame test to test for the presence of lithium, sodium and potassium compounds **state the flame test colours for lithium, sodium and potassium compounds**	

Module: CD6 Module Title: The Periodic Table

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
3h W 3.7	**state that Group 7 elements are known as the halogens** **recognise fluorine, chlorine, bromine and iodine as halogens**	**describe the halogens at room temperature** • **chlorine as a green gas** • **bromine as an orange liquid** • **iodine as a grey solid**	
3h W3.7	**state that uses of some halogens** • **chlorine to sterilise water** • **chlorine to make pesticides and plastics** • **iodine is used to sterilise wounds**		

Module CD6 Module Title: The Periodic Table

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
3h W 3.7 3d W3.3 3e W3.4 3l	**state that halogens react vigorously with alkali metals** **recall the order of reactivity of the halogens** • **fluorine is more reactive than chlorine** • **chlorine is more reactive than bromine** • **bromine is more reactive than iodine**	**describe the reaction between alkali metals and halogens to give metal halides** **identify the metal halide formed when a halogen reacts with an alkali metal** **construct the word equation for the reaction between an alkali metal and a halogen** **state that the reactivity of the halogens decreases down the group** **describe the displacement reactions of halogens with solutions of metal halides** • **chlorine displaces bromides and iodides** • **bromine displaces iodides** **construct the word equation for the reaction between a halogen and a metal halide**	**construct the balanced symbol equation for the reaction of an alkali metal with a halogen** **predict the properties of fluorine or astatine given the properties of the other halogens e.g.** • **physical properties,** • **displacement reactions** **construct the balanced symbol equation for the reaction between halogens and metal halides**
1e W1.5 3d W3.3 3e W3.4		**explain that Group 7 elements have similar properties because they have seven electrons in their outer shell**	**explain that halogens have similar properties because when they react an atom gains one electron to form a negative ion with a stable electronic structure** **describe the gain of electrons as reduction** **explain that the more reactive the halogen the easier it for an atom to gain one electron**

Module CD6 Module Title: The Periodic Table

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
1g 1h W1.7 W1.8	**state that an ion is a charged atom or group of atoms** **recognise an ion, an atom and a molecule from given formulae**	**describe the formation of positive ions by the loss of electrons** **describe the formation of a negative ion by the gain of electrons** **explain that a metal and non-metal combine by transferring electrons to form positive ions and negative ions which then attract one another**	describe, using the "dot and cross" model, the ionic bonding in the following • sodium chloride • magnesium oxide • sodium oxide • magnesium chloride **explain that atoms gain or lose electrons to get a complete outer shell (a stable octet)** **deduce the formula of an ionic compound from the formula of the positive and negative ion**
1f W1.6 1g (part) W1.7 (part) 1h W1.8 W1.9 W1.12 (part)	state that sodium chloride • has a high melting points • dissolves in water • when solid does not conduct electricity state that magnesium oxide • has a very high melting point • when solid does not conduct electricity	recognise the structure of sodium chloride or magnesium oxide state that sodium chloride solution conducts electricity state that magnesium oxide and sodium chloride conduct electricity when molten	describe the structure of sodium chloride or magnesium oxide as a giant ionic lattice in which positive ions are electrostatically attracted to negative ions explain some of the physical properties of sodium chloride and magnesium oxide • strong attraction between positive and negative ions so have a high melting points • ions cannot move in solid so does not conduct electricity • ions can move in solution or in a molten liquid so conducts electricity
3j W3.9 CoA 3.7	state that iron is used to make steel and to make cars and bridges because it is strong state that copper is used to make brass and to make electrical wiring because it is a good electrical conductor		

Module CD6 Module Title: The Periodic Table

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
3i W3.8 3m (part) Key Skills N1.1, N1.2, N1.3 Key Skills IT1.1,1.2, 1.3, 2.1, 2.2,2.3	**identify whether an element is a transition metal from its position in the periodic table** **state the name or symbol of a transition element using the periodic table** **describe the physical properties of transition elements** • **lustrous, hard and high density** • **high tensile strength** • **high melting and boiling points** **describe thermal decomposition as a reaction in which a substance is broken down into at two other substances by heat**	**state that compounds of transition metals are often coloured** • **copper compounds are blue** • **iron(II) compounds are light green** • **iron(III) compounds are orange/brown** state that transition metals and their compounds are often catalysts • iron in the Haber process • nickel in the hydrogenation of alkenes **describe the thermal decomposition of transition metal carbonates illustrated by $FeCO_3$, $CuCO_3$, $MnCO_3$ and $ZnCO_3$** • **metal oxide and carbon dioxide formed** • **word equations** • **colour change occurs (colours not needed)** **describe that the test for carbon dioxide is that it turns limewater milky**	**construct the balanced symbol equation for the thermal decomposition of** • **$FeCO_3$** • **$CuCO_3$** • **$MnCO_3$** • **$ZnCO_3$**
		describe the use of sodium hydroxide solution to identify the presence of transition metal ions in solution • Cu^{2+} give a blue solid • Fe^{2+}, gives a grey/green solid • Fe^{3+}gives an orange/solid solid • the solids are called precipitates	construct the symbol equation for the reaction between Cu^{2+}, Fe^{2+} and Fe^{3+} and OH^- (without state symbols) given the formulae of the ions describe the reaction between the transition metal ions and sodium hydroxide solution as precipitation

5.9 CONTENT RELATED TO SC4: PHYSICAL PROCESSES

PD1: Waves in Action

Programme of Study

English National Curriculum		Welsh National Curriculum	
Candidates should be taught		**Candidates should be taught**	
3a	about the reflection, refraction and diffraction of waves including light and sound as examples of transverse and longitudinal waves.	3.1	that waves can be reflected, refracted and diffracted
		3.2	about longitudinal and transverse waves in ropes, springs and water
3b	the meaning of frequency, wavelength and amplitude of a wave	3.3	the meaning of frequency, wavelength and amplitude of a wave
3c	the quantitative relationship between the speed, frequency and wavelength of a wave	3.4	the quantitative relationship between speed, frequency and wavelength of a wave
3d	that waves transfer energy without transferring matter	3.5	that waves transfer energy without transferring matter
3e	that the electromagnetic spectrum includes radio waves, microwaves, infra-red, ultraviolet waves, X-rays and gamma rays		
3f	some uses and dangers of microwaves, infra-red and ultraviolet waves in domestic situations		
3g	some uses of X-rays, and gamma rays in medicine	3.11	the benefits and potential dangers associated with the use of X-rays and gamma rays in medicine
		3.10	that the energy associated with electromagnetic waves and thus its potential danger varies with its frequency
3h	how information can be transmitted along optical fibres	3.7	the principles involved in the transmission of waves along optical fibres
3i	that radio waves, microwaves, infrared and visible light carry information over large and small distances	3.8	that electromagnetic waves can be used to carry large amounts of information
3l	about sound and ultrasound waves and some medical uses of ultrasound		
3m	that longitudinal and transverse waves are transmitted through the Earth producing wave records that provide evidence for the Earth's layered structure	3.12	that longitudinal and transverse waves are transmitted through the Earth producing wave records that provide evidence for the Earth's layered structure

Grey highlighting indicates "key ideas" which are to be re-examined in the Terminal examination together with the content from the Phase 2 modules

Learning outcomes in bold are common to the Single Award Specification.

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Rationale

This module explores the ways in which waves affect our lives in domestic situations, communications and medicine. The wave concept encompasses not only the sound and light of everyday experience but also the full electromagnetic spectrum and ultrasound.

The nature and properties of waves are covered. The measurable quantities of speed, frequency and wavelength are linked by the wave equation, and the effects on waves of reflection, refraction and diffraction are explored. Work in the module also includes the main features and uses of sound, ultrasound and the electromagnetic spectrum. A key idea encountered in this module is that of the electromagnetic spectrum (including the use of X-rays in medicine). This idea underpins later work and will be tested in the terminal question papers.

There is a link with module PD6 where ideas about waves are developed in connection with the layered structure of the Earth and radioactivity. There is also a link with module CD3 where the theory of plate tectonics is explored. There are links with the speed of sound in module PD3 where pupils learn to calculate speed from distance and time.

Module PD1 Module Title Waves in Action

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
3a W3.1	**state and recognise that sound and light are waves** **state and recognise that waves can be reflected**	**state and recognise that water ripples and light travel as transverse waves** **state and recognise that waves can be refracted**	**state and recognise that waves can be diffracted**
3b W3.3 Key Skills C1.1, 1.2, 1.3	**identify the main features of transverse waves** • **crest** • **trough** • **amplitude** • **wavelength** • **frequency**	**describe the main features of transverse waves** • **crest** • **trough** • **amplitude** • **wavelength** • **frequency**	**identify and describe features of transverse and longitudinal waves** • **crest** • **trough** • **amplitude** • **wavelength** • **frequency** • **compression** • **expansion (rarefaction)**
3d W3.2 W3.5	recognise longitudinal waves in springs	state and recognise that sound travels as a longitudinal wave	state and explain that waves transfer energy without transferring matter describe the motion of particles in longitudinal and transverse waves
3c W3.4		state and use the qualitative relationship between frequency and wavelength for waves of the same speed: • the frequency of the waves increases as their wavelength decreases for waves at constant speed and vice versa state and use the qualitative relationship between wave speed and wavelength for waves of constant frequency • the wavelength increases as the wave speed increases and vice versa	state and use the quantitative relationship between wave speed, frequency and wavelength • v = fL (change of subject required)

Module PD1 Module Title Waves in Action

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
3a W3.7 Key Skills C1.1, 1.2, 1.3	**recognise that and describe how light travels along an optical fibre from one end to another by reflection**	**state that and describe how light can be internally reflected for example in** • **optical fibres** • **binoculars** • **periscopes** • **bicycle reflectors** • **endoscopes** **draw simple ray diagrams to illustrate refraction or reflection (including the normal line)**	**explain total internal reflection in the following contexts:** • **binoculars** • **periscopes** • **bicycle reflectors** • **endoscopes** **by drawing or interpreting simple ray diagrams** **describe the application of total internal reflection in fibre optics**

Module PD1 Module Title Waves in Action

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
3l Key Skills C2.2, 2.3 Key Skills IT2.1, 2.3	**state and recognise examples of the use of ultrasound** • **body scans** • **sonar** • **cleaning**	**state and recognise that the frequency of ultrasound is higher than the upper threshold of human hearing** **describe applications of ultrasound** • **body scans** • **breaking down kidney and other stones** • **sonar** • **cleaning**	**explain how ultrasound is used in:** • **body scans (reflection from different layers)** • **breaking down accumulations in the body such as kidney stones** • **sonar and echo sounding** • **cleaning**
3m W3.12 1.1b 1i, 1j	state and recognise that the Earth is made up of layers that are either liquid or solid describe the structure of the Earth as a sphere with • A thin rocky crust • mantle • core	describe the physical state of each layer of the Earth • crust is a solid • mantle contains solid and liquid rock • outer core is a liquid • inner core is a solid state that waves can be transmitted through the Earth and that this provides evidence for the structure describe longitudinal p waves and transverse s waves.	describe how waves transmitted through the Earth can be used to provide evidence for its structure • longitudinal p waves travel through solid and liquid • transverse s waves cannot travel through liquid • longitudinal p waves can travel through all layers of the Earth • transverse waves cannot travel through the outer core

Module PD1 Module Title Waves in Action

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
3e	**identify the following as part of the electromagnetic spectrum** • **gamma-rays** • **X-rays** • **infra-red** • **visible light** • **ultraviolet** • **microwaves** • **radio waves** **state that different parts of the electromagnetic spectrum have different wavelengths.**	**describe the order of the electromagnetic spectrum is in terms of wavelength** **state that all electromagnetic waves travel at the same speed in space**	**be able to relate the physical properties of the main areas of the electromagnetic spectrum to their uses and effects**
3f 3I W3.8 W3.10	**state some uses and effects of electromagnetic radiation** • **infra-red radiation is used for cooking and in remote controls** • **ultraviolet causes sunburn** • **microwaves are used for cooking and in radar** **state that parts of the electromagnetic spectrum have different frequencies**	**state some of the uses and dangers of electromagnetic waves** • **light, radio and microwaves are used to carry information** • **microwaves and infra-red can heat materials** • **ultraviolet and X-rays can damage living cells** **describe the order of the electromagnetic spectrum in terms of frequency**	**explain how microwaves and infra-red transfer energy to materials** • **microwaves absorbed by water, penetrate only a few centimetre then energy transferred to central parts by conduction** • **infra-red radiation absorbed by the surface then energy transferred by conduction to central parts of the material** **state that the energy associated with an electromagnetic wave depends on its frequency and relate this to its potential danger**

Module: PD1 Module Title: Waves in Action

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
3g W3.11 1.1d	**state that X-rays can be used to look inside the human body**	**describe how gamma rays can be used to treat cancer** • **gamma source outside the body** • **focussed on the tumour** • **rotated round the outside with the tumour at the centre** • **minimises effects on the rest of the body** **describe the risks and benefits of using gamma rays or X rays in medicine** • **benefits - destroys cancer cells and avoids surgery** • **risks - may damage other cells or may cause sickness**	**describe how tracers are used in medicine** • **radioactive material administered to patient** • **given time to spread in the patient** • **progress tracked with a detector outside the body** • **only beta and gamma sources suitable**

PD2: Energy in the Home

Programme of Study

English National Curriculum		Welsh National Curriculum	
Candidates should be taught		**Candidates should be taught**	
1a	that resistors are heated when a charge flows through them	1.1	that resistors are heated when a charge flows through them
1h	the functions of the live, neutral and earth wires in the domestic mains supply and the use of insulation, earthing, fuses and circuit breakers to protect users of electrical equipment	1.9	the functions of the live, neutral and earth wires in the domestic mains supply and the use of insulation, earthing, fuses and circuit breakers to protect users of electrical equipment
1i	that electrical heating is used in a variety of ways in domestic contexts	1.10	that electrical heating is used in a variety of ways in domestic contexts
1j	how measurements of energy transferred are used to calculate the costs of using common domestic appliances	1.11	how measurements of energy transferred are used to calculate the costs of using common domestic appliances
		5.1	that differences in temperature can lead to transfer of energy
		5.2	how energy is transferred by the movement of particles in conduction, convection
		5.3	how energy is transferred by electromagnetic radiation
5a	how insulation is used to reduce transfer of energy from hotter to colder objects	5.4	that insulation can reduce transfer of energy from hotter to colder objects and how insulation is used in domestic contexts

Grey highlighting indicates "key ideas" which are to be re-examined in the Terminal examination together with the content from the Phase 2 modules

Learning outcomes in bold are common to the Single Award Specification.

Rationale

Energy is used to keep our homes warm, to provide light and hot water and to cook our food. This module looks at the way we manage the energy and avoid wasting it. Much of the energy used in the home is supplied by electricity. The safe use of electricity is also covered.

The process of conduction, convection and radiation are studied briefly leading to a consideration of energy-saving strategies. The use of electric appliances provides the background for cost calculations in terms of the kilowatt-hour. The use of earthing and fuses is also dealt with.

A number of key ideas in this module underpin later work and will be tested in the Sc4 terminal question paper. They are: energy transfer in electrical devices, the heating effect of a current, the features and functions of the domestic electricity supply, the connection between temperature and energy transfer and the use of insulation.

Electrical circuit theory and current flow is developed more fully in module PD4.

Sources of energy (fossil fuels) are dealt with in module CD2.

Module PD2 Module Title Energy in the Home

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
W5.1 W5.2 W5.3 CoA 4.7 Key Skills WO1.1, 1.2, 1.3, 2.1, 2.2, 2.3	**recognise that hot objects have high temperatures and tend to cool down** **recognise that cold objects have low temperatures and tend to warm up**	**state that energy is transferred from a high temperature region to a low temperature region** **describe how energy is transferred by:** • **conduction: - transfer of kinetic energy between particles** • **convection: - change of density causes bulk fluid flow** • **radiation: - infra-red radiation needs no medium** **describe the effect of dull, black surfaces and shiny, silver surfaces on radiation** • **absorbtion** • **emission**	
5a W5.4 1.1b CoA 4.7 and 4.10 Key Skills C2.1a, 2.1b, 2.2, 2.3 Key Skills IT1.1, 1.2	**recognise everyday examples of energy saving methods in the home** • **recognise good and bad conductors** • **recognise that curtains reduce energy loss through windows** • **recognise that many insulating materials contain air** • **state that air is a good insulator**	**calculate costs and interpret data to do with saving energy in the home** • **to include pay-back time**	**explain, in the context of the home, the concepts of conduction convection and radiation (absorption and emission) in terms of:** • **the design features of the home** • **the design and use of everyday objects in the home** • **energy saving strategies**

Module PD2 Module Title Energy in the Home

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
1j W1.11 CoA 4.1 and 4.2 Key Skills N1.1, 1.2 Key Skills IT1.1, 1.2	**explain why electricity is an important way of supplying energy to the home** • **most domestic appliances use electricity** • **can be used for a variety of tasks** **recognise that power rating (in watts and kilowatts) determines how expensive electrical appliances are to use**	**explain the advantages and disadvantages of electricity compared with other methods of supplying energy to the home** **Advantages** • **no pollution at point of use** • **easy to use** • **can be used to operate a large variety of domestic appliances** • **no storage problems** **Disadvantages** • **cannot be stored so risk of power cut** • **risk of shock** • **needs cables to the house- problem for remote properties** **state that the unit of consumption is the kilowatt-hour (kWh)** **calculate the number of kWh units given the power in kW and the time in hours** • **cost calculations**	**use the kilowatt-hour as a measure of the energy supplied** **calculate the energy supplied in kilowatt-hours given the power in kW or W and the time in hours and/or minutes (including change of subject)**

Module PD2 Module Title: Energy in the Home

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
1i W1.10 CoA 4.2 Key Skills N1.1, N1.2	**describe how electricity is used for heating in the home** • **heaters** • **cookers** • **other domestic appliances e.g. kettles, toasters, washing machines**	**explain the meaning of electrical power (in watts and kilowatts) in the context of everyday electrical appliances**	**describe the use of off-peak electricity (economy-7) in the home** • **in space heating and water heating** • **in electrical appliances such as washing machines and dishwashers** **describe the advantages and disadvantages of using off-peak electricity (economy-7) in the home** • **advantage for producer in terms of the economics of electricity generation** • **advantages and disadvantages for the consumer in terms of costs, convenience and cleanliness/pollution** **calculate costs from an electricity bill**
1a W1.1 CoA 4.2	**state the reasons for the use of:** • **fuse/circuit breakers (as a re-settable fuse)**	**describe how a wire fuse works** • **if the current becomes too large** • **wire fuse melts** • **breaking the circuit**	**explain how a wire fuse protects an appliance** • **if the appliance develops a fault** • **too large a current causes fuse to melt** • **preventing flow of current** • **prevents flex overheating and causing fire** • **prevents further damage to appliance** **explain the reasons for the use of fuses/circuit breakers (as a re-settable fuse - structure and mode of operation not required)**

Module PD2 Module Title Energy in the Home

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
1h W1.9	**state that an earthed conductor cannot become live**		**explain how a wire fuse and earthing protects people**
CoA 4.2	**state and recognise that "double insulated" appliances do not need earthing**		**explain why "double insulated" appliances do not need earthing** • **case of appliance is a non-conductor and cannot become live**
	state the colour coding for live, neutral and earth wires • **live – brown** • **neutral – blue** • **earth - green and yellow**	**state and explain the functions of the live, neutral and earth wires:** • **live- carries a high voltage** • **neutral - the second wire to complete the circuit** • **earth - a safety wire to stop the appliance becoming live**	

PD3: Forces and Motion

Programme of Study

English National Curriculum		Welsh National Curriculum	
Candidates should be taught		**Candidates should be taught**	
2a	how distance, time and speed can be determined and represented graphically	2.1	how distance, time and speed can be determined and represented graphically
2b	about factors affecting vehicle stopping distances	2.2	about factors affecting vehicle stopping distances
2d	that acceleration as change in velocity per unit time	2.4	about acceleration as change in velocity per unit time
2f	the quantitative relationship between force, mass and acceleration	2.6	the quantitative relationship between force, mass and acceleration
		2.10	the quantitative relationship between the turning moment, the magnitude of the force and its distance from the pivot.
		2.11	the principle of moments and its application to situations involving one pivot

Grey highlighting indicates "key ideas" which are to be re-examined in the Terminal examination together with the content from the Phase 2 modules

Learning outcomes in bold are common to the Single Award Specification.

Rationale

Road transport and safety provide the context for this module. The abilities to describe and measure motion are used in the treatment of issues involving everyday motoring, including potentially hazardous situations. The safe design and operation of cars (including braking) are also covered. The relationship between distance, time, velocity and acceleration are explored and lead to a qualitative treatment of F=ma. Graphical representation is limited to motion with constant acceleration. The principle of moments is explored and applied to everyday situations.

The relationships between distance, time, velocity and acceleration are explored and lead to a qualitative treatment of F=ma. Graphical representation is limited to motion with constant acceleration.

A number of key ideas in this unit underpin later work and will be tested in the Sc4 terminal question paper. They are: The graphical representation of distance, time and speed, acceleration as the rate of change of velocity and the relationship between force, mass and acceleration.

There are links to module PD6 where speed is re-introduced and developed into velocity and force, mass and acceleration is dealt with more formally.

There are links with the speed of sound in module PD1.

There are links with the effects of forces dealt with in module PD5.

Module PD3 Module Title Forces and Motion

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
2a W2.1 Key Skills N2.1, 2.2, 2.3	**state that the measurements needed to determine speed are distance and time** **describe appropriate means of measuring distance and time in everyday situations** • **stop watch/clock** • **ticker-tape** • **measuring tape** • **trundle wheel**	**interpret the relationship between speed, distance and time** • **faster the speed, the greater the distance travelled in the same time** • **faster the speed the shorter the time to cover the same distance** **state and use the quantitative relationship v = s/t** • **calculate speed (change of subject not required)**	**interpret the relationship between speed, distance and time** • **effect of changing any one or two of the quantities** state and use the quantitative relationship v = s/t • calculate speed (to include change of subject)
2a W2.1 Key Skills N1.1, 1.2, 1.3 Key Skills IT2.1, 2.2, 2.3	**interpret simple graphs of distance against time** and speed against time	**draw and interpret qualitatively simple graphs of distance against time** and speed against time for uniform acceleration **interpret the gradient (steepness) of distance-time graph as speed** interpret the gradient (steepness) of a speed-time graph as acceleration interpret the area under the line of a speed-time graph as distance travelled	**draw and interpret simple graphs of distance against time** and speed against time • quantitatively for uniform acceleration • qualitatively for non uniform acceleration • **calculate speed from the gradient of a distance-time graph** • calculate distance travelled and acceleration from a speed-time graph for uniform acceleration

Module: PD3 Module Title: Forces and Motion

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
2d (part) W2.4 Key Skills N1.1, 1.2, 1.3 Key Skills WO1.1, 1.2, 1.3, 2.1, 2.2, 2.3	recognise that acceleration involves a change in speed (limited to a straight line)	define acceleration as change in velocity per unit time recall and use the quantitative relationship acceleration = change in velocity/ time taken (no change of subject)	use the formula acceleration = change in velocity/ time taken (change of subject required) interpret the relationship between acceleration, change of velocity and time • effect of changing any one or two of the quantities
2f (part) W2.6	describe situations in which forces cause things to speed up or slow down	interpret the relationship between force, mass and acceleration in everyday examples • larger masses have lower acceleration for the same force • larger masses require greater forces for the same acceleration	use the quantitative relationship between force, mass and acceleration F = ma (including change of subject)

Module: PD3 Module Title: Forces and Motion

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
2b W2.2 1.1a 1.1b 1.1d 1a 1i Key Skills C2.1a, 2.2, 2.3 Key Skills N2.1, 2.2, 2.3 LP1.1, 1.2, 1.3 2.1, 2.2, 2.3	**describe thinking distance as the distance travelled between the need for braking occurring and the brakes starting to act** **describe braking distance as the distance taken to stop once the brakes have been applied** **describe stopping distance as the sum of thinking distance and stopping distance** **explain the significance of thinking distance, braking distance and stopping distance in road safety**	**describe the factors which might affect thinking distance:** • **driver tiredness** • **influence of alcohol or other drugs** • **illness** • **speed** **describe the factors which might affect braking distance:** • **road conditions** • **condition and level of inflation of tyres** • **condition of brakes** • **speed** **interpret charts of thinking distances and braking distances** **calculate stopping distances from thinking distances and braking distances.**	**explain qualitatively everyday situations where braking distance is changed** • **friction** • **mass** • **speed** • **braking force**

Module PD3 Module Title Forces and Motion

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
W2.10 W2.11	State that a force can make things turn State examples of where forces cause an object to turn • Water tap • Screwdriver • Spanner • Steering wheel • Door handle	State that a turning force is called a moment State the quantitative relationship Moment = Force x perpendicular distance between the line of action of the force and the pivot State that a moment can be increased by either increasing the applied force or increasing the perpendicular distance between the line of action of the force and the pivot	Use the quantitative relationship Moment = Force x perpendicular distance between the line of action of the force and the pivot. Limited to cases where the force and the distance are clearly perpendicular to each other. State the principle of moments that at balance, the total clockwise moment equals the total anticlockwise moment Apply the principle of moments to everyday situations involving one pivot to calculate forces and distances

PD4: Using Electricity

Programme of Study

English National Curriculum		Welsh National Curriculum	
Candidates should be taught		**Candidates should be taught**	
1b	the qualitative effect of changing resistance on the current in a circuit	1.2	the qualitative effect of changing resistance on the current in a circuit
1c	the quantitative relationship between resistance voltage and current	1.4	the quantitative relationship between resistance voltage and current
		1.3	how to make simple measurements of voltage
1d	how current varies with voltage in a range of devices, including resistors, filament bulbs, diodes, light dependent resistors (LDRs) and thermistors	1.5	how current varies with voltage in a range of devices, including resistors, filament bulbs, diodes
		1.6	the variation of resistance with ambient conditions for light dependant resistors (LDRs) and thermistors
1e	that voltage is the energy transferred per unit charge		
1f	the quantitative relationship between power, voltage and current	1.7	the quantitative relationship between power, voltage and current
1g	the difference between direct current (dc) and alternating current (ac)	1.8	the difference between direct current (dc) and alternating current (ac)
1k	how an insulating material can be charged by friction		
1l	about the forces of attraction between positive and negative charges, and the forces of repulsion between like charges		
1m	about common electrostatic phenomena in terms of movement of electrons		
1n	the dangers and uses of electrostatic charges generated in everyday situations	1.12	the dangers and uses of electrostatic charges generated in everyday and industrial situations
1o	the quantitative relationship between steady current, charge and time	1.13	the quantitative relationship between steady current, charge and time
1p	about electric current as the flow of free electrons in metals or ions during electrolysis	1.14	about electric current as the flow of free electrons in metals or ions during electrolysis

Learning outcomes in bold are common to the Single Award Specification.

Rationale

This module looks in detail at electricity in dc circuits and the behaviour of some common electrical components. This leads to a comparison of dc with ac and its use in the mains electricity supply. Detailed understanding of electrical behaviour depends on the notion of electric charge which is also covered.

The concept of positive and negative charge is explained in terms of electrons and illustrated by electrostatic phenomena. The meanings of current, pd, resistance and electric power are used in the context of simple series and parallel circuits. The use of ammeters and voltmeters is covered and the voltage/current characteristics of a number of devices are determined. Work on alternating current is limited to qualitative description.

This unit builds on the work done in module PD2 by looking at circuits, current and voltage.

There is a link to module PD5 through electromagnetism.

Module PD4 Module Title Using Electricity

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
1p W1.14	recognise that a complete loop is required for a circuit to work	explain the behaviour of simple circuits in terms of the flow of electric charge recognise that current involves a flow of electric charge	state that the charge carriers in a circuit are • free electrons in metals • ions during electrolysis
1e 1o W1.13 W1.3 CoA 4.1	**state and recognise that an ammeter measures the current in a circuit** **state that current is measured in ampere (A)**	**state and recognise that ammeters are connected in series** **state that a voltmeter measures the potential difference (pd) in a circuit in volt (V)** **state and recognise that voltmeters are connected in parallel**	state and explain that current is the rate of flow of charge state and use the quantitative relationship I=Q/t (to include change of subject) state and explain that pd is the energy transferred per unit charge flowing
1f W1.7		state and use the quantitative relationship between power, voltage and current • P = IV (no change of subject)	state and use the quantitative relationship between power, voltage and current • P = IV (to include change of subject)

Module PD4 Module Title Using Electricity

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
1b W1.2 CoA 4.1	**state and recognise how resistors can be used to change the current in a circuit**	**describe how variable resistors can be used change the current in a circuit** • **variable resistor configured as a rheostat only**	
1c W1.4 1d W1.5 W1.6 Key Skills N1.1, 1.2, 1.3 Key Skills IT1.1, 1.2		**describe the relationships between current , potential difference (pd) and resistance** • **for a given resistor, current increases as pd increases and vice versa** • **for a fixed pd, current decreases as resistance increases and vice versa** **recall and use the quantitative relationship R = V/I to calculate resistance (change of subject not required)**	**explain how current varies with pd:** • **in an ohmic resistor** • **in a filament bulb** • **in a diode** **use the quantitative relationships between current, potential difference (pd) and resistance** • **be able to recall the quantitative relationship R = V/I** • **be able to use the quantitative relationship R = V/I (including change of subject)** describe how semiconductor diodes, light dependent resistors (LDRs) and thermistors may be used to control electric currents **describe qualitatively how light and temperature affect the resistance of LDRs and thermistors** • **increase in brightness reduces resistance of LDR and vice versa** • **increases in temperature reduces resistance of thermistor**

Module PD4 Module Title Using Electricity

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
1g W1.8	**state and recognise that batteries produce direct current (dc)** **state and recognise that mains electricity is supplied as alternating current (ac)**	**describe the difference between dc and ac** • **in terms of current flow** • **as shown by displays on a cathode ray oscilloscope (C.R.O.) (not to include rectification)**	
1k 1l 1m	state and recognise that insulating materials can become charged when rubbed with another insulating material state and recognise that when some materials are rubbed they attract other objects • small pieces of paper or cork to a rubbed comb or strip of plastic	state that there are two kinds of charge: • positive • negative state and recognise that like charges repel and unlike charges attract state and recognise that electrostatic phenomena are caused by the transfer of electrons	interpret static electricity in terms of the movement of electrons • a positive charge due to lack of electrons • a negative charge due to an excess of electrons
1n W1.12 Key Skills C1.1, 1.2, 1.3	recognise and describe how you can get an electrostatic shock from charged objects • synthetic clothing recognise and describe how you can get an electrostatic shock if you become charged and then become earthed • stepping out of a car after it has been driven • touching water pipes after walking on a carpet recognise and describe how static electricity can be useful • paint spraying • photocopiers/laser printers (detailed structural knowledge not required)	explain how static electricity can be dangerous when: • fuelling aircraft • in atmospheres where explosions could occur explain how static electricity can be useful • paint spraying • photocopiers/laser printers (detailed structural knowledge not required)	

PD5: Applications of Physics

Programme of Study

English National Curriculum		Welsh National Curriculum	
Candidates should be taught		**Candidates should be taught**	
5b	about the efficient use of energy, the need for economical use of energy resources and the environmental implications of generating energy	5.5	the meaning of energy efficiency and the need for economical use of energy resources
5c	the quantitative relationship between force and work	5.6	the quantitative relationship between force and work
5d	to calculate power in terms of working or of transferring energy	5.7	to calculate power in terms of working or of transferring energy
5e	to calculate kinetic energy and potential energy	5.8	the quantitative links between kinetic energy, potential energy and work
5f	that force is exerted on a current carrying wire in a magnetic field and the application of this effect on simple electric motors	1.15	that force is exerted on a current carrying wire in a magnetic field and the application of this effect on simple electric motors
5g	that a voltage is induced when a conductor cuts magnetic field lines and when the magnetic field through the coil changes	1.16	that a voltage is induced when a conductor cuts magnetic field lines and when the magnetic field through the coil changes
5h	how simple a.c. generators and transformers work	1.17	how simple a.c. generators and transformers work
5i	the quantitative relationship between the voltage across the coils in a transformer and the number of turns in them	1.18	the quantitative relationship between the voltage across the coils in a transformer and the number of turns in them
5j	how electricity is generated and transmitted	1.19	how electricity is generated and transmitted
3h	how information can be transmitted along optical fibres	3.7	the principles involved in the transmission of waves along optical fibres
		3.6	that all electromagnetic waves travel at the same speed in space
3i	that radio waves, microwaves, infrared and visible light carry information over large and small distances, including global transmission via satellites	3.8	that electromagnetic waves can be used to carry large amounts of information
		3.9	that radio waves can carry information over large distances and how satellites aid global communication
3j	about ways in which reflection, refraction and diffraction affect communication		
3k	the difference between analogue and digital signals and how more information can be transmitted		

Learning outcomes in bold are common to the Single Award Specification.

Rationale

The concept of energy runs through this module and links together kinematics, electricity and electromagnetism. Material encountered previously is developed, using a quantitative approach, including the measurement of energy, power and efficiency. The generation of domestic electricity is covered.

A study of simple magnetism paves the way for a qualitative treatment of the ac generator. The use of the transformer and the application of the transformer equation are included in a section on power stations and the national grid. Quantitative relationships for work, power, kinetic energy, gravitational potential energy and efficiency arise during the module.

This unit builds on the work done in module PD2 by looking at how electricity is produced and transmitted.

There are links with module PD2 also in the development of ideas about power and energy.

The section dealing with the electric motor, generator and transformers links with voltage and current in module PD4.

Module PD5 Module Title Applications of Physics

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
5f W1.15 CoA 4.3	recognise that electric motors use magnets and are found in a variety of everyday applications e.g. vacuum cleaners, washing machines, tumble dryers, mixers, electric drills , electric lawnmowers	state and recognise that a force is exerted on a current carrying wire in a magnetic field	interpret diagrams showing the operation of a simple dc electric motor explain the functions of parts of a simple dc electric motor • permanent magnets • coil • brushes • split-ring commutator
5c W5.6 5d W5.7 Key Skills N1.1, 1.2 Key Skills IT1.1, 1.2	recognise everyday examples in which work is done and power is developed • work is the energy transferred when a force moves an object • power is the work done per second	calculate work done • state the quantitative relationship W = Fs • use the quantitative relationship = Fs (work = force x distance moved in direction of force). Change of subject not required calculate power • state the quantitative relationship P = W/t • use the quantitative relationship P = W/t (power = work done / time taken). Change of subject not required	calculate work done • use the quantitative relationship W = Fs (work = force x distance moved in direction of force). To include change of subject calculate power • use the quantitative relationship P = W/t (power = work done / time taken). To include change of subject

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
5e, W5.8 CoA 4.4 Key Skills N2.1, 2.2, 2.3 Key Skills IT 2.1, 2.2, 2.3 Key Skills WO1.1, 1.2, 1.3, 2.1, 2.2, 2.3 Key Skills LP1.1, 1.2, 1.3 2.1, 2.2, 2.3 Key Skills PS1.1, 1.2, 1.3, 2.1, 2.2, 2.3	recognise everyday examples in which objects have kinetic and/or gravitational potential energy • moving objects have kinetic energy • objects have gravitational potential energy because of their position in Earth's gravitational field	describe everyday examples in which objects have kinetic and/or gravitational potential energy • kinetic energy is greater for objects with greater speed or greater mass • gravitational potential energy is greater for objects with greater height or greater mass recognise and interpret examples of energy transfer between gravitational potential energy and kinetic energy	state and use the quantitative relationships between potential energy, kinetic energy and work • state the quantitative relationship kinetic energy = ½mv^2 • use the quantitative relationship kinetic energy = ½mv^2 (change of subject not required) • state the quantitative relationship: increase in gravitational potential energy = mgh • use the quantitative relationship: increase in gravitational potential energy = mgh (change of subject required) • interpret the link between work done and gravitational potential energy
5g W1.16 5I W1.18 5h W1.17	**state and recognise the dynamo effect** • **electricity can be generated by moving a wire near a magnet** • **electricity can be generated by moving a magnet near a wire**	**describe how simple ac generators work** • **coil of wire** • **magnetic field** • **coil and field close to each other** • **relative motion between coil and field** **describe how transformers work** • **alternating current in primary coil (assuming it is part of a circuit)** • **electromagnetic effect in primary coil** • **alternating magnetic field in soft iron core** • **dynamo effect in secondary coil** • **alternating current in secondary coil (assuming it is part of a circuit)**	**state the dynamo effect** • **a voltage is induced when a wire (or wire coil) and a magnetic field move relative to each other** state and use the transformer formula turns ratio = voltage ratio

Module PD5 Module Title Applications of Physics

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
5j W1.19 Key Skills C2.2, 2.3	**describe the main stages in the production and distribution of electricity** • **source of energy** • **power station produces electricity** • **National grid of power lines connecting power stations and consumers** • **consumers e.g. homes, factories, offices, farms**	**describe how domestic electricity is generated at a conventional power station:** • **burning fuel** • **producing steam** • **turning a turbine** • **turbine turns a generator** **state and recognise that there is a significant energy wasted in the production of electricity in a conventional power station** **explain how transformers are used in the National Grid** • **that electricity is transmitted at high voltage to reduce energy waste and therefore reduce costs**	**explain how transformers are used in the National Grid** • **how, for a given power transmission, increase of voltage reduces current so reduces energy waste by heating of cables**
5b W5.5		**state and use the quantitative relationship for either energy or power** • $\textbf{\% efficiency} = \frac{\textbf{useful output}}{\textbf{imput}} \times \textbf{100}\,\%$ **(change of subject not required)**	
3h W3.7	**state and recognise that light and infra-red can pass along optical fibres**	**explain in terms of total internal reflection how light and infra-red can pass along optical fibres**	**explain how optical fibres can be used to carry information** • **using light e.g. endoscopes** • **using infra-red e.g. pulses in digital code**

Module PD5 Module Title Applications of Physics

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
W3.6 3l W3.8 Key Skills C2.2, 2.3	**state that all electromagnetic waves travel at the same speed in space** **state and recognise that radio, microwaves, infra-red and light can carry information**	**describe examples of electromagnetic waves carrying information** • **infra-red remote controls and fibre optic cables for telecommunications or computer links** • **microwave communications and radar** • **light optical information** • **radio global and satellite communication**	**explain how satellites can be used for global communication** • **ground station transmitter dish** • **satellite receiver dish** • **satellite transmitter** • **ground receiver dish**
3j	state and recognise that radiation used for communication can be reflected	state and recognise that radiation used for communication can be refracted	state and recognise that radiation used for communication can be diffracted explain how long-distance communication depends on the reflection of waves from the ionosphere or by being received and re-transmitted from satellites explain how the refraction and diffraction of radiation can affect communications • refraction at the interfaces of different layers of Earth's atmosphere • diffraction at the edge of transmission dishes results in signal loss
3k	**state and recognise one example of an analogue device and one example of a digital device** • **analogue devices - dimmer switch, thermometer, meters including a pointer, speedometer** • **digital devices - off/on switch, digital meters, digital clock**	**describe the difference between analogue signals and digital signals** • **the parts of an analogue signal can have any value within a fixed range of values** • **the parts of a digital signal can have one of only two values**	**explain how the use of digital signals in telecommunications allows more information to be transmitted than using analogue signals** • **analogue to digital conversion** • **multiplexing (interleaving of many digital signals on the same data line)** • **digital to analogue conversion**

PD6: Earth, Space and Nuclear Radiation

Programme of Study

English National Curriculum		Welsh National Curriculum	
Candidates should be taught		**Candidates should be taught**	
2c	the difference between speed and velocity	2.3	the difference between speed and velocity
2d	that acceleration is change in velocity per unit time	2.4	about acceleration as change in velocity per unit time
2e	that balanced forces do not alter the velocity of a moving object	2.5	that balanced forces do not alter the velocity of a moving object
2f	the quantitative relationship between force, mass and acceleration	2.6	the quantitative relationship between force, mass and acceleration
2g are	that when two bodies interact, the forces they exert on each other equal and opposite	2.7	that when two bodies interact, the forces they exert on each other are equal and opposite
2h	how the forces acting on falling objects change with velocity	2.8	the forces acting on familiar moving objects e.g. cars and falling objects
2i	why falling objects reach a terminal velocity	2.9	why falling objects may reach a terminal velocity
4a	the relative positions of the Earth, Moon, Sun, planets and other bodies in the Universe	4.1	the relative positions of the Earth, Moon, Sun, planets and other bodies in the Universe
4b	that gravitational forces determine the movements of the planets, moons, comets and satellites	4.2	that gravitational forces determine the movements of the planets, moons, comets and satellites
4c	how stars evolve over a long time-scale	4.3	how stars evolve over a long time-scale
4d	about some ideas used to explain the evolution of the Universe into its present state	4.4	about some ideas used to explain the evolution of the Universe into its present state
4e	about the search for evidence of life elsewhere in the universe		
6a	that radioactivity arises from the breakdown of an unstable nucleus	6.1	that radioactivity arises because of unstable nuclei
6b	about some of the sources of ionising radiation found in all environments	6.2	that there is background radiation
6c	the characteristics of alpha and beta particles and of gamma radiation	6.4	the nature of alpha and beta particles and of gamma radiation
6d	the meaning of the term “half – life”	6.5	the meaning of the term “half – life”
6e	the beneficial and harmful effects of radiation on matter and living organisms	6.6	the beneficial and harmful effects of radiation on matter and living organisms
6f	some uses of radioactivity including the radioactive dating of rocks	6.7	some uses of radioactivity including the radioactive dating of rocks

Learning outcomes in bold are common to the Single Award Specification.

Rationale

From microscopic atoms to the vast universe - this module spans the range. The significance of radiations produced by changes in the nucleus is highlighted and the theories of the evolution of the universe are detailed. The module includes the motion of the planets in the solar system. The nature, properties and effects of alpha, beta and gamma radiations are the basis of work on radioactivity (which includes the concept of half-life). The relationship between force, mass and acceleration, previously encountered in module PD3, is made quantitative. Understanding of the vector nature of acceleration leads to the concept of centripetal acceleration and circular motion. The gravitational force is linked with terminal speed, orbital motion and the structure and origin of the Universe.

The use of waves to study the layered structure of the Earth was studied in module PD1. Here the rocks in the Earth's crust are a source of radioactivity. There are links with module PD1 also because it introduced the electromagnetic spectrum. Gamma (γ) radiation is an important part of that spectrum. In module PD3 the idea of acceleration was introduced.

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
2c W2.3 2e W2.5 CoA 4.4	 state and recognise that objects fall to the centre of the Earth state and recognise that the force pulling objects to Earth is the force of gravity	state and explain the difference between speed and velocity • both have size • only velocity has direction state that an object keeps still or moves with a constant velocity (constant speed in a straight line) when either: • no force acts on it • the forces that act on it are balanced (restricted to two equal and opposite forces acting through the same point	
2d W2.4 Key Skills N1.1, 1.2		recall acceleration as change in velocity per unit time state and use the quantitative relationship $\text{acceleration} = \frac{\text{change in velocity}}{\text{time taken}}$ (no change of subject) state and recognise that the acceleration of free fall (g) is constant	explain that acceleration could involve either a change • in speed • in direction • state and use the quantitative relationship $\text{acceleration} = \frac{\text{change in velocity}}{\text{time taken}}$ (change of subject required)
2f W2.6 2g W2.7			state and use the quantitative relationship between force, mass and acceleration • F=ma (including change of subject) • gravitational force, weight = mg recognise that when body A exerts a force on body B, body B exerts an equal but opposite force on body A. these constitute two different views of the same interaction and are not balanced forces.

Module PD6 Module Title Earth, Space and Nuclear Radiation

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
2h W2.8 2i W2.9	**state and recognise that falling objects go faster and faster as they fall**	**state and recognise that objects falling through Earth's atmosphere reach a terminal speed** **explain in terms of balance of forces why objects accelerate**	**explain, in terms of balance of forces, why objects falling through Earth's atmosphere reach a terminal speed**
4a W4.1 4b W4.2 CoA 4.6	**state and recognise that Earth is one of a number of planets which orbit the Sun** **state and recognise that the Moon orbits Earth** **state and recognise that Earth orbits the Sun**	**state and recognise the relative positions of Earth, Moon, Sun and planets (includes the order of the planets)** **state that gravitational forces determine the motion of planets, comets and satellites**	**state the relative positions of planets, stars, comets, meteors, galaxies and black holes** **state and recognise that circular motion requires a centripetal force** **state and recognise that gravity provides the centripetal force for orbital motion**
4d W4.4 1.1a 1.1b 1.1c 1.1d Key Skills IT2.1, 2.3	**state and recognise that the universe consists of** • **stars** • **planets** • **comets** • **meteors** • **black holes** • **large groups of stars called galaxies**	**state and recognise the relative sizes of stars, planets and galaxies** **state and recognise the relative distances from the Earth of stars, planets and galaxies** **describe some ideas used to explain the evolution of the universe into its present state** • **big bang** • **expansion of the universe**	**state and recognise the relative sizes of planets, stars, comets, meteors, galaxies and black holes** **explain some ideas used to explain the evolution of the universe into its present state** • **big bang** • **evidence of big bang from microwave background radiation** • **expansion of the universe** • **evidence for expansion from red shift of spectrums of stars**

Module PD6 Module Title Earth, Space and Nuclear Radiation

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
4c W4.3 1.1b Key Skills C2.1a, 2.2, 2.3	**state and recognise that stars can be seen even though they are far away because they are very hot and give off light**	**state that stars have a finite life** **describe the end of a medium-weight star like our Sun** • **red giant** • **planetary nebula** • **white dwarf** **describe the end of a heavy-weight star** • **red giant** • **supernova** • **neutron star or black hole**	**describe the life history of a star** • **interstellar gas clouds** • **gravitational collapse producing proto-star** • **thermonuclear fusion** • **long period of normal life (main sequence)** • **end depending on mass of star** **explain that there are different ways of interpreting the same evidence and this can lead to different ideas of how the universe developed.** • **the expanding universe might continue expanding** • **the expanding universe might stop expanding** • **the expanding universe might start to collapse**
4e 1.1b 1.1d	**recognise that there is the possibility of life elsewhere in the universe** **state that space craft are used for the search for life elsewhere in the universe** **state that radio telescopes are used to detect radio messages from distance object in space**	**describe the conditions necessary for life to exist on other planets** • **the need for liquid water** • **suitable temperatures** • **suitable pressures** • **suitable atmosphere**	**describe and explain some of the ways in which scientists are searching for life elsewhere in the universe.** • **microscopic analysis of meteorites landing on Earth** • **SETI – looking for radio messages** • **surveys of planets and moons within our solar system** • **searching for other stars with planets**

Module PD6 Module Title Earth, Space and Nuclear Radiation

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
6e W6.6 6c W6.3 W6.4 1.1c 1.1d Key Skills C1.1, 1.2, 1.3	**state and recognise that nuclear radiation can be either beneficial or harmful** • **state one example of a beneficial use** • **harmful effect: damages living cells** **state and recognise the names of the three types of nuclear radiation** • **alpha (α),** • **beta (β)** • **gamma(γ))**	**state examples of a beneficial use of radiation** • **alpha – smoke detectors** • **beta – tracers and paper thickness gauges** • **gamma – treating cancer, non-destructive testing and sterilising equipment** **describe the relative penetrating power of alpha (α), beta (β) and gamma(γ)** **explain the nature of nuclear radiation** • **alpha (α) particle - a massive, positively charged particle (He nucleus)** • **beta (β) particle - a small negatively charged particle (electron) from the nucleus** • **gamma(γ) ray - uncharged electromagnetic wave**	**describe how alpha, beta and gamma can be identified by their penetrating power**
6b W6.2	**state and recognise that there is background radiation in the environment which is always present**	**state that radioactive substances give out nuclear radiation** **state that nuclear radiation is ionising radiation and explain the meaning of ionising** **describe background radiation and state that it is caused by radioactive substances in rocks and soil and by cosmic rays**	**explain ionisation in terms of** • **removal of electrons from particles** • **gain of electrons by particles**

Module PD6 Module Title Earth, Space and Nuclear Radiation

Programme of Study	Foundation Tier Only	Foundation Tier and Higher Tier	Higher Tier Only
	Candidates should be able to		
6d W6.5 6f W6.7 Key Skills IT2.2	**state and recognise that the radioactivity of an object is measured by the number of nuclear rays emitted per second** **state and recognise that radioactivity decreases with time**	**state some uses of radioactivity** • **radioactive dating of rocks** • **treatment of cancer** • **tracers**	**explain and use the concept of half-life** • **interpret graphical or numerical data of radioactive decay** explain how the radioactive dating of rocks depends on the calculation of the uranium / lead ratio
6a W6.1	**state that an atom contains a small, massive, central nucleus** **state that radiation comes from the nucleus**	**state that radioactivity comes from the nucleus an atom that is breaking up**	

SECTION D: COURSEWORK

6 Coursework Tasks

6.1 NATURE OF COURSEWORK

All OCR National Curriculum science and separate sciences specifications use a common scheme for the assessment of coursework. This scheme forms a 'common element' across all of the National Curriculum science specifications of the GCSE Awarding Bodies.

Coursework represents 20% of the total assessment.

The common scheme of assessment is designed to award credit for performance under four headings:

Skill Area P - Planning

Skill Area O - Obtaining Evidence

Skill Area A - Analysing and Considering Evidence

Skill Area E - Evaluating

The Programme of Study for Sc1 [for England - statements 2a - 2s, for Wales - statements 3.1 to 3.22] indicates the variety of activities which may be used both to help candidates develop these skills and to assess their achievement. Mark descriptions (Part 7.3) indicate the levels of performance expected and are based on the Programme of Study and the criteria for grades F, C and A (Part 4.12).

The mark descriptions are designed to allow credit for a wide variety of activities including laboratory work, field work and investigations based on the use of secondary sources of information.

The scheme of internal assessment is designed to encourage a wide variety of activities. These include those based on the collection of first-hand evidence and those which depend on secondary evidence. The term 'evidence' has been used consistently throughout the assessment scheme to mean observations, measurements or other data. Through the teaching of investigative skills, candidates should be given opportunities to apply and develop their ICT capability. In particular, candidates could:

- use data-handling software to analyse data from fieldwork;
- use data-handling software to create, analyse and evaluate charts and graphs;
- use data loggers in investigations;
- use spreadsheets for data analysis;
- use the Internet or CD-ROM software as sources of secondary evidence.

Coursework may be assessed at any time during the course, using suitable activities related to the content of Sc2, Sc3 and Sc4. It is expected that candidates will have had opportunities to acquire experience and develop the relevant skills before assessment takes place.

6.2 EXEMPLAR COURSEWORK TASKS

The specification offers many opportunities for the assessment of practically based coursework and activities based on secondary sources, including ICT. The following examples have been shown to offer opportunities for effective assessment in all four Skill Areas.

- Investigating the effect of changing the solution concentration on osmosis in potatoes.
- Investigating the kinetics of an enzyme-catalysed reaction.
- Investigating the effect of changing the temperature on the rate of the reaction between limestone and dilute acid.
- Investigating enthalpy changes of chemical reactions (e.g. combustion of liquid fuels) – this could provide an opportunity to design spreadsheets to analyse results.
- Investigating the change in electrical resistance with wires of different diameters.
- Investigating the movement of trolleys on slopes – this could provide an opportunity to use light–gates and data-capture.
- Investigation of the frequency and severity of earthquakes in a particular region – based on searches of WWW sites which report earthquake data, and using ideas of plate tectonics to explain the patterns.
- Investigating enthalpy changes of chemical reactions (e.g. neutralisation) – this could provide an opportunity to monitor the reaction using a temperature sensor connected to a datalogger.

Other examples of suitable coursework tasks are provided in coursework guidance material published separately.

7 Regulations for Internal Assessment

7.1 SUPERVISION AND AUTHENTICATION OF INTERNALLY ASSESSED WORK

OCR expects teachers to supervise and guide candidates who are undertaking work which is internally assessed. The degree of teacher guidance will vary according to the kind of work being undertaken. It should be remembered, however, that candidates are required to reach their own judgements and conclusions.

When supervising internally assessed tasks, teachers are expected to:

- offer candidates advice about how best to approach such tasks;
- exercise supervision of work in order to monitor progress and to prevent plagiarism;
- ensure that the work is completed in accordance with the specification requirements and can be assessed in accordance with the specified mark descriptions and procedures.

Investigative work which is assessed for Sc1 should, wherever possible, be carried out under supervision. However, it is accepted that some investigations may require candidates to undertake some coursework outside the Centre. Where this is the case, the Centre must ensure that sufficient supervised work takes place to allow the teachers concerned to authenticate each candidate's work with confidence.

7.2 PRODUCTION AND PRESENTATION OF INTERNALLY ASSESSED WORK

Candidates must observe certain procedures in the production of internally assessed work:

- any copied material must be suitably acknowledged;
- where work is based on the use of secondary data, the original sources must be clearly identified;
- each candidate's assessed work submitted for moderation should be stapled together at the top left hand corner and have a completed Coursework Cover Sheet as the first page.

7.2.1 Arrival at Skill Area Marks

Mark descriptions, comprising a number of statements, are provided in each Skill Area. Activities chosen for assessment should, wherever possible, provide opportunities for all the statements in a mark description to be addressed. It should be noted that some of the statements in a mark description contain a phrase such as `where appropriate' and may therefore not apply to a particular activity.

Descriptions are provided for 2, 4, 6 and 8 marks in Skill Areas P, O and A, and for 2, 4 and 6 marks in Skill Area E. The performance needed to gain 6 marks in Skill Area E is commensurate with that required for 8 marks in the other Skill Areas.

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

Adjacent descriptions should be considered when making judgements and use made of the intermediate marks (i.e. 3, 5 and 7) where performance exceeds one description but only partially satisfies the next.

In the mark descriptions (for the assessment of Sc1.2), the use of terms such as *'plan', 'communicate', 'record', 'identify', 'explain', 'comment', 'consider'* and 'describe' ensures that the quality of written communication forms part of the assessment of Sc1.2.

The term 'evidence' has been used throughout this assessment scheme to mean observations, measurements and other data.

A candidate who fails to meet the requirements for 2 marks in a Skill Area but who has made a creditworthy attempt should be given 1 mark. In some activities, a candidate may not attempt all four Skill Areas. A mark of zero should only be awarded where it is clear that the candidate has attempted a skill but has failed to show any positive achievement.

Teachers are required to use their professional judgement in making these decisions.

7.2.2 Annotation of Candidates' Work

Each piece of assessed coursework should be annotated to show how the marks have been awarded in relation to the mark descriptions.

The writing of comments on candidates' work provides a means of dialogue and feedback between teacher and candidate and a means of communication between teachers during internal standardisation of coursework.

However, the main purpose of annotating candidates' coursework is to provide a means of communication between teacher and moderator, showing where marks have been awarded and why they have been awarded.

Annotations should be made at appropriate points in the margins of the script of all work submitted for moderation. The annotations should indicate where achievement for a particular skill has been recognised.

It is suggested that the minimum which is necessary is that the 'shorthand' mark descriptions (for example, P.6a) should be written at the point on the script where it is judged that the work has met the mark description.

7.2.3 The Demand of an Activity

The demand of an activity is an important feature of the assessment. Increasing marks in a Skill Area should relate to increasing demands of associated scientific knowledge and understanding, manipulation, precision and accuracy, and complexity.

Candidates are required to apply knowledge and understanding from the specification in planning investigative work, in analysing and considering the evidence obtained and in the evaluation of their data and procedures. Teachers should appreciate that the choice of an activity that is comparatively undemanding in terms of the level of the scientific knowledge and understanding that can be linked to the activity, or 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 determines 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.

Teachers are reminded that there is a 'loose-coupling' between the descriptions for the highest marks in each Skill Area and the performance likely to be achieved by a candidate working confidently at or around the GCSE Grade A standard.

Details of the way in which tasks can be differentiated, and further guidance on setting appropriate tasks, is given in guidance material published separately.

7.2.4 Arrival at the Final Mark Submitted

Centres may assess the performance of candidates on any occasion when investigative work or experimental activities are taking place throughout the course. Marks will be awarded under four Skill Area headings, using the mark descriptions given.

Thus a candidate may accumulate an unlimited number of marks throughout the course. The final total submitted for each candidate is made up from this body of evidence according to the following aggregation rules:

- **Two** marks are required for each Skill Area.
- These marks should be drawn from **not more than four** pieces of work.
- **At least one mark** must be from a **practically based whole investigation.**
- **At least two** of the attainment targets Sc2, Sc3 and Sc4 must be represented.
- A total of **eight** marks is therefore required, and this yields a maximum mark of **60**.

The marks selected should reflect a candidate's best performance during the course.

A **'whole investigation'** is defined as a single activity in which a candidate has engaged in each of the four Skill Areas.

A **'practically based investigation'** is one in which a candidate has obtained evidence through his/her own practical laboratory work or fieldwork.

7.2.5 Recording Marks

Coursework Assessment Forms will be provided for Centres to record marks submitted at the end of the course.

All assessed work which has contributed to candidates' final totals must be available for moderation.

7.3 MARKING CRITERIA FOR INTERNALLY ASSESSED WORK

Skill Area P: Planning

Programme of Study requirements

Candidates should be taught to:

a use scientific knowledge and understanding to turn ideas into a form that can be investigated, and to plan an appropriate strategy;

b decide whether to use evidence from first-hand experience or secondary sources;

c carry out preliminary work and make predictions, where appropriate;

d consider key factors that need to be taken into account when collecting evidence, and how evidence can be collected in contexts in which the variables cannot readily be controlled;

e decide the extent and range of data to be collected, and the techniques, equipment and materials to use.

Mark descriptions			
		The mark descriptions are designed to be hierarchical. All work should be assessed in the context of the specification.	Increasing demand of activity
		Candidates	
2 marks	P.2a	outline a simple procedure	↓
4 marks	P.4a	plan to collect evidence which will be valid	
	P.4b	plan the use of suitable equipment or sources of evidence	
6 marks	P.6a	use scientific knowledge and understanding to plan and communicate a procedure, to identify key factors to vary, control or take into account, and to make a prediction where appropriate	
	P.6b	decide a suitable extent and range of evidence to be collected	
8 marks	P.8a	use detailed scientific knowledge and understanding to plan and communicate an appropriate strategy, taking into account the need to produce precise and reliable evidence, and to justify a prediction when one has been made	
	P.8b	use relevant information from preliminary work, where appropriate, to inform the plan	

Skill Area O: Obtaining evidence

Programme of Study requirements

Candidates should be taught to:

f use a wide range of equipment and materials appropriately, and manage their working environment to ensure the safety of themselves and others;

g make observations and measurements, including the use of ICT for datalogging, to a degree of precision appropriate to the context;

h make sufficient observations and measurements to reduce error and obtain reliable evidence;

i judge the level of uncertainty in measurements and observations;

j represent and communicate qualitative and quantitative data using diagrams, tables, charts, graphs and ICT.

<table>
<tr><th colspan="4">Mark descriptions</th></tr>
<tr><td colspan="2" rowspan="2"></td><td>The mark descriptions are designed to be hierarchical.
All work should be assessed in the context of the specification.</td><td rowspan="2">Increasing demand of activity</td></tr>
<tr><td>Candidates</td></tr>
<tr><td>2 marks</td><td>O.2a</td><td>collect some evidence using a simple and safe procedure</td><td rowspan="4">  </td></tr>
<tr><td rowspan="2">4 marks</td><td>O.4a</td><td>collect appropriate evidence which is adequate for the activity</td></tr>
<tr><td>O.4b</td><td>record the evidence</td></tr>
<tr><td rowspan="2">6 marks</td><td>O.6a</td><td>collect sufficient systematic and accurate evidence and repeat or check where appropriate</td></tr>
<tr><td>O.6b</td><td>record clearly and accurately the evidence collected</td></tr>
<tr><td>8 marks</td><td>O.8a</td><td>use a procedure with precision and skill to obtain and record an appropriate range of reliable evidence</td></tr>
</table>

Skill Area A: Analysing and considering evidence

Programme of Study requirements

Candidates should be taught to:

k use diagrams, tables, charts and graphs and explain patterns or relationships in data;

l present the results of calculations to an appropriate degree of accuracy;

m use observations, measurements or other data to draw conclusions;

n explain to what extent these conclusions support any predictions made, and enable further predictions to be made;

o use scientific knowledge and understanding to explain and interpret observations, measurements or other data, and conclusions.

Mark descriptions			
		The mark descriptions are designed to be hierarchical. All work should be assessed in the context of the specification. Candidates	Increasing demand of activity
2 marks	A.2a	state simply what is shown by the evidence	↓
4 marks	A.4a	use simple diagrams, charts or graphs as a basis for explaining the evidence	
	A.4b	identify trends and patterns in the evidence	
6 marks	A.6a	construct and use suitable diagrams, charts, graphs (with lines of best fit, where appropriate), or use numerical methods, to process evidence for a conclusion	
	A.6b	draw a conclusion consistent with the evidence and explain it using scientific knowledge and understanding	
8 marks	A.8a	use detailed scientific knowledge and understanding to explain a valid conclusion drawn from processed evidence	
	A.8b	explain the extent to which the conclusion supports the prediction, if one has been made	

Skill Area E: Evaluating

Programme of Study requirements

Candidates should be taught to:

p consider anomalous data giving reasons for rejecting or accepting them, and consider the reliability of data in terms of uncertainty of measurements and observations;

q consider whether the evidence collected is sufficient to support any conclusions or interpretations made;

r suggest improvements to the methods used;

s suggest further investigations.

Mark descriptions			
		The mark descriptions are designed to be hierarchical. All work should be assessed in the context of the specification.	Increasing demand of activity
		Candidates	
2 marks	E.2a	make a relevant comment about the procedure used or the evidence obtained	↓
4 marks	E.4a	comment on the quality of the evidence, identifying any anomalies	
	E.4b	comment on the suitability of the procedure, and where appropriate, suggest changes to improve it	
6 marks	E.6a	consider critically the reliability of the evidence and whether it is sufficient to support the conclusion, accounting for any anomalies	
	E.6b	describe, in detail, further work to provide additional relevant evidence	

7.4 MODERATION

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

It is the responsibility of the Centre to carry out effective internal standardisation to ensure that similar standards are applied by each teacher involved in the assessment. The Moderator will require a written statement describing how internal standardisation has been carried out within the Centre.

External moderation will be by postal sample selected by the Moderator.

The sample will represent performance across the whole ability range from the Centre. The sample of work which is presented to the Moderator for moderation must show how the marks have been awarded in relation to the mark descriptions defined in Part 7.3.

A separate cover sheet must be used for each candidate in the sample submitted for moderation.

7.5 MINIMUM REQUIREMENTS FOR INTERNALLY ASSESSED WORK

If a candidate submits no work for this internally assessed component, then the candidate should be indicated as being absent from that component on the mark sheets submitted to OCR. If a candidate completes any work at all for an internally assessed component, then the work should be assessed according to the criteria and mark descriptions and the appropriate mark awarded, which may be zero.

SECTION E: FURTHER INFORMATION

8 Opportunities for Teaching

8.1 ICT

In order to play a full part in modern society, candidates need to be confident and effective users of ICT. Schemes of work based on this specification should offer a wide variety of opportunities for candidates to use different areas of ICT in order to develop their skills.

Study of the applications of science can provide opportunities for gathering information from the Internet or from CD-ROM based resources.

Sc1, Scientific enquiry, can be enhanced by the use of ICT both in terms of the collection of data and in the processing of data. Reports of practical activities or case studies can be enhanced by using desk-top publishing; experiments can be monitored using sensors connected to computers or data-storage devices; data gathered from experiments or field studies can be processed using spread-sheets and simulations of experiments that are difficult or impossible to be carried out individually can be used to allow candidates to collect data, identify trends and patterns and to analyse data.

This section offers some examples that can be used as opportunities for developing and using ICT during the course. The list is not exhaustive but does indicate the breadth of ICT that may be used when teaching this specification.

ICT application	Opportunity
Datalogging	
• measuring the loss of mass during the reaction of calcium carbonate and acid	CD1 PoS 3.3n, 3.3o and 3.3p
• monitoring the appearance of the sulphur precipitate in the reaction between hydrochloric acid and aqueous sodium thiosulphate using a light sensor	CD1 PoS 3.3n, 3.3o and 3.3p
• monitoring the change in temperature during neutralisation using a temperature sensor	CD5 PoS 3.3k
• to investigate the relationship between current, voltage and resistance in a range of devices	PD4 PoS 4.1c and 4.1d
Simulation	
• multimedia simulation of a nerve impulse	BD2 PoS 2.2g and 2.2h
• to explore models of the atom including electron arrangement and the relationship to the periodic table	CD6 PoS 3.1a, 3.1b, 3.1c and 3.1d
• explore wave models	PD1 PoS 4.3a and 4.3b
• explore the movements of objects in the solar system and the universe	PD6 PoS 4.4a and 4.4b

Spreadsheet	
• to model the effects of competition and predation	BD3 PoS 2.5a
• to model the energy loss in a house	PD2 PoS 4.5a
• design and use of a spreadsheet to record and analyse experimental observations e.g during calorimetry experiments involving liquid fuels	CD2
• to model the cost of making chemicals	CD5
Internet	
• to find out information about current developments in cloning and genetic engineering	BD4 PoS 2.4h D7 PoS 1.1b, 1.1c and 1.1d
• to find out current information on industrial processes	CD2 PoS 3.2a, 3.2b and 3.2e CD5
• to find out about current information about different diseases (could also be linked to Sc1.1 Ideas and Evidence)	BD6 PoS 2.2p and 2.2q
• to find out current and new applications of science e.g. in biotechnology	CD1 PoS 3.3r
Database	
• database of the properties of the elements could allow candidates to explore patterns	CD6 PoS 3.3e, 3.3f, 3.3g and 3.3h
Desk top Publishing	
• Sc1 Coursework reports	
• producing an information leaflet about saving energy in the home	PD2 PoS 4.5a and 4.5b
• producing a leaflet on the benefits of immunisation and how it works	BD6 PoS 2.2p
• producing a fact sheet explaining about the problems caused by the increasing world population	BD3 PoS 2.5b

Further details of the opportunities provided by this specification for the development of candidates' ICT skills are given in the key skills section (Part 9) of this specification. The key skills are also signposted in the specification content (Part 5) by a  symbol.

8.2 CITIZENSHIP

From September 2002, the National Curriculum for England at Key Stage 4 includes a mandatory Programme of Study for Citizenship. Parts of this Programme of Study may be delivered through an appropriate treatment of other subjects.

This section offers guidance on opportunities for developing knowledge, skills and understanding of citizenship issues during the course. These opportunities are also indicated within the content of Part 5 by a  symbol.

Citizenship Programme of Study	Opportunities for Teaching Citizenship Issues during the Course
1c the work of parliament, the government and the courts in making and shaping the law	Study on biodiversity and endangered species and possible legislation (BD3 PoS 2.5c) Study of global pollution issues e.g. air pollution (CD3 PoS 3.3k) Discussion on alcohol and drug abuse - both scientific issues and the effects of legislation (BD6 PoS 2.2q) Discussion on genetic modification, selective breeding and cloning; scientific debate and the need for legislation (BD4 PoS 2.4h)
1i the United Kingdom's relations in Europe, including the European Union, and relations with the Commonwealth and the United Nations	Discussion of intensive farming methods in different parts of the world (BD3 PoS 2.5b and 2.5g) Study of biodiversity and endangered species and possible legislation (BD3 PoS 2.5c)
1j the wider issues and challenges of global interdependence and responsibility, including sustainable development and Local Agenda 21	Discussion of the issues of an oil based society in relation to fuels and petrochemicals (CD2 PoS 3.2b and CD4 PoS 3.21) Study of global pollution issues e.g. air pollution (CD3 PoS 3.3k) Discussion of the need for building controls and emergency plans in earthquake zones (CD3 Pos 4.3n and PD1 PoS 4.3n) Survey different methods of dealing with plastic waste (CD2 PoS 3.2i)

2a research a topical, spiritual, moral, social or cultural issue, problem or event by analysing information from different sources including ICT 2b express, justify and defend orally and in writing a personal opinion about such issues, problems or events 2c contribute to group and exploratory class discussions, and take part in formal debates	Discussion of intensive farming methods in different parts of the world (BD3 PoS 2.5b and 2.5g) Study of biodiversity and endangered species and possible legislation (BD3 PoS 2.5c) Discussion on alcohol and drug abuse - both scientific issues and the effects of legislation (BD6 PoS 2.2q) Discussion on genetic modification, selective breeding and cloning; scientific debate and the need for legislation (BD4 PoS 2.4h)
3a use their own imagination to consider other people's experiences and be able to think about, express, explain and critically evaluate views that are not their own	Discussion of intensive farming methods in different parts of the world (BD3 PoS 2.5b and 2.5g) Discussion on alcohol and drug abuse - both scientific issues and the effects of legislation (BD6 PoS 2.2q) Discussion on genetic modification, selective breeding and cloning; scientific debate and the need for legislation (BD4 PoS 2.4h)

8.3 SPIRITUAL, MORAL, ETHICAL, SOCIAL AND CULTURAL ISSUES

Studies of Ideas and Evidence in Science (Sc1.1) provide an opportunity to address these issues in relation to the acceptability of scientific ideas and technological developments.

This specification provides many other opportunities to address these issues, some of which are illustrated below.

Issue	Opportunities for Teaching the Issue
The endeavour of science in describing the structure and functioning of the natural and modern world	BD1 PoS 2.1a and 2.1e BD4 PoS 2.1d, 2.1c, 2.4g, 2.4i and 2.4j BD6 PoS 2.2p
A sense of awe and wonder at the scale and impact of physical processes and phenomena	CD2 PoS 3.2p CD3 PoS 4.3n PD4 PoS 4.1l PD6 PoS 4.4d and 4.4c
The ethical and moral implications of some of the applications of science and technology	BD2 PoS 2.2j and 2.2k BD3 PoS 2.5a, 2.5b, 2.5c and 2.5g BD4 PoS 2.4h
The implication for the storage and reprocessing of radioactive material	PD6 PoS 4.6b and 4.6c
The importance of plants, animals and micro-organisms to life on Earth	BD PoS 3 2.5a and 2.5f All of module BD5 CD2 PoS 3.2q
A sense of awe and wonder at the atomic and molecular workings of the material world	CD4 PoS 3.1g and 3.1j CD5 PoS 3.1a, 3.1b, 3.1c, 3.1d, 3.1g and 3.1h
The endeavour of scientists in the development of knowledge and understanding of the material world	CD4 PoS 3.1k, 3.1j and 3.2f
Aspects of drug dependency	BD6 PoS 2.2q
Pollution	CD2 air pollution CD4 PoS 2.2m

8.4 HEALTH, SAFETY AND ENVIRONMENTAL ISSUES

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

In planning schemes of work, teachers must bear in mind the need to ensure the safety of candidates, who are not experienced in laboratory procedures. Advice on safety matters is available from LEA advisers. Particular care is needed in checking candidates' plans for coursework investigations, especially where the task is open-ended or involves less familiar materials or procedures.

The specification addresses health, safety and environmental issues some of which are illustrated below.

Issue	Opportunities for Teaching the Issue
Environmental Issues	
Aspects of the reprocessing and storage of radioactive materials	PD6 PoS 4.6b and 4.6c
Energy and mineral recycling	CD4 PoS 3.2f PD5 PoS 4.5b
The interdependency of living things	BD3 PoS 2.5a and 2.5f BD5 PoS 2.3a and 2.3b
Biodiversity	BD3
The management of ecosystems and sustainable agricultural practices	BD3 PoS 2.5c
Air, water and pesticide pollution	BD3 PoS 2.5b and 2.5g CD2 PoS 3.2m CD5 PoS 3.2m
Conservation of resources	BD3 PoS 2.5b CD4 PoS 3.2e
The control of pollution to acceptable environmental limits	BD3 PoS 2.5b CD4 PoS 3.2f CD5 PoS 3.2m
Aspects of clean technology in industrial processes	CD3 PoS 3.2l, 3.2j and 3.2k CD5
The use of satellite imagery to view the environment	PD5 PoS 4.3l and 4.3j
Acid rain and its control	BD3 PoS 2.5b CD2

Health and Safety Issues	
Radioactivity	PD6 PoS 4.6a, 4.6b, 4.6c and 4.6d
Health physics	PD1 PoS 4.3g and 4.3l PD5 PoS 4.3h PD6 PoS 4.6e
Safe practice in the laboratory	PD2 PoS 4.1h PoS 1.2 (coursework investigations
Road Safety	PD3 PoS 4.2b
Smoking and related diseases	BD6 PoS 2.2q
Infectious diseases and their treatment	BD4 PoS 2.4f BD6 PoS 2.2p
Immunity and vaccinations	BD6 PoS 2.2p
Genetic disorders	BD4 PoS 2.4f
Effect of alcohol on the body	BD6 PoS 2.2q
Use of chlorine in potable water	CD6 PoS 3.3h
Diabetes	BD1 PoS 2.2j and 2.2k
Fertility Treatment	BD1 PoS 2.2j and 2.2k

8.5 THE EUROPEAN DIMENSION

OCR has taken account of the 1988 Resolution of the Council of the European Community in preparing this specification and associated specimen assessments. European examples should be used where appropriate in the delivery of the subject content.

Although this specification does not make specific reference to the European dimension it may be drawn into the course of study in a number of ways. The table below shows some appropriate illustrations.

Issue	Opportunities for Teaching the Issue
European co-operation in research	PoS 1.1a opportunities are highlighted in Part 5 of the specification
Reprocessing and storage of radioactive materials	PD6 PoS 4.6a, 4.6b, 4.6c and 4.6d
Chemical pollution and European regulation	BD3 PoS 2.5b and 2.5g CD5 PoS 3.2m
Biodiversity	BD3
Road safety in Europe	PD3 PoS 4.2b
Legislation of scientific research throughout Europe	D7 PoS 1.1 opportunities are highlighted in Part 5 of the specification BD4 PoS 2.4h

Recycling policies across Europe	CD4 PoS 3.2e
Air pollution and European regulation	CD2 PoS 3.2m
Illness and disease	BD4 PoS 4.4f BD6 BD4 PoS 2.4f BD6 PoS 2.2p BD6 PoS 2.2p
The management of ecosystems and sustainable agricultural practices	BD3 PoS 2.5c

9 Key Skills

Key Skills are central to successful employment and underpin further success in learning independently. Whilst they are certificated separately, the Key Skills guidance for this qualification has been designed to support the teaching and learning of the content. Opportunities for developing the generic Key Skills of Communication, Application of Number and Information Technology are indicted through the use of the key symbol in Part 5. The wider Key Skills of Working with Others, Problem Solving and Improving Own Learning and Performance may also be developed through the teaching programmes associated with the specification.

The following matrix indicates those Key Skills for which opportunities for at least some coverage of the relevant Key Skills unit exist.

	Communication	Application of Number	IT	Working with Others	Improving Own Learning and Performance	Problem Solving
Level 1	✓	✓	✓	✓	✓	✓
Level 2	✓	✓	✓	✓	✓	✓

Detailed opportunities for generating Key Skills evidence through this specification are posted on the OCR website. A summary document for Key Skills co-ordinators showing ways in which opportunities for Key Skills arise within GCSE courses will be published during 2001.

10 Reading List

The following list of suggested titles is not intended to be exhaustive nor does inclusion on the list constitute a recommendation of the suitability of the book for the specification. The list details the texts available at the time of the preparation of the specification (May 2000). The possibility exists that more up to date texts which have been prepared for the revised GCSE specifications may become available.

Teachers will need to use their professional judgement in assessing the suitability of the material contained in this list.

Resources written to match syllabus 1777 will still be applicable to the new specification. These can be obtained through Collins Educational and support both phase 1 and phase 2 of the course.

Coordinated Science GCSE Student Book 1 (phase 1)	ISBN 0 00 327850 6
Coordinated Science Teacher Pack 1 (phase 1)	ISBN 0 00 327851 4
Coordinated Science GCSE Student Book 2 (phase 2)	ISBN 0 00 327853 0
Coordinated Science Teacher Pack 2 (phase 2)	ISBN 0 00327854 9

Other textbooks written to match the science content for Double Award are also useful but the content will not match the phase 1 and phase 2 organisation of the Learning Outcomes of this specification.

11 Arrangements for Candidates with Special Needs

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 the OCR Special Requirements team (tel 01223 552505) as early as possible during the course.

12 Support and In-service Training for Teachers

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

- A full programme of In-Service training meetings arranged by the Training and Customer Support Division (telephone 01223 552950).
- Specimen question papers and mark schemes, available from the Publications department (telephone 0870 870 6622 fax 01223 552930).
- Past question papers and mark schemes, available from the Publications department (telephone 0870 870 6622 fax 01223 552930).
- Coursework guidance materials.
- Case study material available for 'Ideas and Evidence'.
- End of module tests available for formative and diagnostic testing.
- Written advice on coursework proposals.
- A report on the examination, compiled by senior examining personnel after each examination session.
- Individual feedback to each Centre on the moderation of internally assessed work.

Appendix A: Requirements Related to Mathematics

During the course of study for this specification, many opportunities will arise for quantitative work, including appropriate calculations. The mathematical requirements which form part of the specification are listed below. Items in the first table may be examined in written papers covering both Tiers. Items in the second table may be examined only in written papers covering the Higher Tier Only.

Both Tiers
add, subtract, multiply and divide whole numbers
recognise and use expressions in decimal form
make approximations and estimates to obtain reasonable answers
use simple formulae expressed in words
understand and use averages
read, interpret, and draw simple inferences from tables and statistical diagrams
find fractions or percentages of quantities
construct and interpret pie-charts
calculate with fractions, decimals, percentage or ratio
solve simple equations
substitute numbers in simple equations
interpret and use graphs
plot graphs from data provided, given the axes and scales
choose by simple inspection and then draw the best smooth curve through a set of points on a graph
Higher Tier Only
recognise and use expressions in standard form
manipulate equations
select appropriate axes and scales for graph plotting
determine the intercept of a linear graph
understand and use inverse proportion

Appendix B: Physical Quantities and Units

It is expected that candidates will show an understanding of the physical quantities and corresponding SI units listed below and will be able to use them in quantitative work and calculations.

Fundamental physical quantities

Physical quantity	*Unit(s)*
length	metre (m); kilometre (km), centimetre (cm); millimetre (mm)
mass	kilogram (kg); gram (g); milligram (mg)
time	seconds (s); millisecond (ms)
temperature	degree Celsius (^{o}C); kelvin (K)
current	ampere (A); milliampere (mA)

Derived quantities and units

Physical quantity	*Unit(s)*
area	cm^2; m^2
volume	cm^3; dm^3; m^3; litre (l); millilitre (ml)
density	kg/m^3; g/cm^3
force	newton (N)
pressure	pascal (Pa or N/m^2) ; N/cm^2
speed	m/s; km/h
acceleration	m/s^2
energy	joule (J) ; kilojoule (kJ); megajoule (MJ)
power	watt (W); kilowatt (kW); megawatt (MW)
frequency	hertz (Hz); kilohertz (kHz)
electrical charge	coulomb (C)
potential difference	volt (V)
resistance	ohm (Ω)
gravitational field strength	N/kg
radioactivity	becquerel (Bq)
sound intensity	decibel (dB)

Appendix C: Quantitative Relationships Which Will Not Be Provided For Candidates in Question Papers

The relationships listed below will not be provided for candidates in question papers either in the form given or in re-arranged form.

1	the relationship between speed, distance and time	$speed = \frac{distance}{time\ taken}$
2	the relationship between force, mass and acceleration	$force = mass \times acceleration$ $acceleration = \frac{change\ in\ velocity}{time\ taken}$
3	the relationship between density, mass and volume	$density = \frac{mass}{volume}$
4	the relationship between force, distance and work	*work done = force* x *distance moved in direction of force*
5	the energy relationships	*energy transferred = work done* $kinetic\ energy = \frac{1}{2} \times mass \times speed^2$ *change in potential energy = mass* x *gravitational field strength* x *change in height*
6	the relationship between mass, weight and gravitational field strength	*weight = mass* x *gravitational field strength*
7	the relationship between an applied force, the area over which it acts and the resulting pressure	$pressure = \frac{force}{area}$
8	the relationship between the moment of a force and its distance from the pivot	*moment = force* x *perpendicular distance from pivot*
9	the relationships between charge, current, voltage, resistance and electrical power	*charge = current* x *time* *voltage = current* x *resistance* *electrical power = voltage* x *current*
10	the relationship between speed, frequency and wavelength	*wave speed = frequency* x *wavelength*
11	the relationship between the voltage across the coils in a transformer and the number of turns in them	$\frac{voltage\ across\ secondary}{voltage\ across\ primary} = \frac{number\ of\ turns\ in\ secondary}{number\ of\ turns\ in\ primary}$

Appendix D: Health and Safety

In UK law, health and safety is the responsibility of the employer. For most entering candidates for GCSE examinations this is likely to be the Local Education Authority or the Governing Body. Teachers 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

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;

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

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

Hazcards, 1995 with 1998 update, CLEAPSS School Science Service*;

CLEAPSS Laboratary Handbock, 1997, CLEAPSS School Science Service*;

CLEAPSS Shorter Handbook (CLEAPSS 2000) CLEAPSS School Science Service'*;

Hazardous Chemicals, A manual for Science Education, (SSERC, 1997) ISBN 0 9531776 0 2.

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

Where an employer has adopted these or other publications as the basis of their model risk assessments, an individual Centre 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.

When candidates are planning their own investigative work the teacher has a duty to check the plans before the practical work starts and to monitor the activity as it proceeds.

Appendix E: Explanation of Terms Used in Learning Outcomes

All the Learning Outcomes in the content section of the specification are expressed in terms of what the candidates know, understand or can do, and are prefixed by *'Candidates should be able to…..'* which is immediately followed by a *'command'* word.

This appendix, which is not intended to be exhaustive or prescriptive, provides some guidance about the meanings of these command words.

It must be stressed that the meaning of a term depends on the context in which it is set, and consequently it is not possible to provide precise definitions of these words which can be rigidly applied in all circumstances. Nevertheless, it is hoped that this general guidance will be of use in helping to interpret both the specification content and the assessment of this content in written papers.

Command words associated with scientific knowledge and understanding (AO1)

Candidates are expected to remember the facts, concepts, laws and principles which they have been taught. Command words in this category include Learning Outcomes beginning :

...state… ...recognise.. …name... ...draw... describe….

The words used on examination papers in connection with the assessment of these Learning Outcomes may include:

Describe... List... Give... Name... Draw... Write... What... How... What is meant by.. ?

e.g. *`What is meant by the term `producer' ?'*

`Name parts A, B and C on the diagram.'

Command words associated with interpretation, evaluation, calculation and communication (AO2)

The command words include:

...relate... ...interpret... ...carry out... …deduce.. ...explain... ...evaluate...

...predict... ...use… ...discuss... ...construct... ...suggest... ...calculate..

...demonstrate...

The use of these words involves the ability to recall the appropriate material from the specification content and to apply this knowledge and understanding.

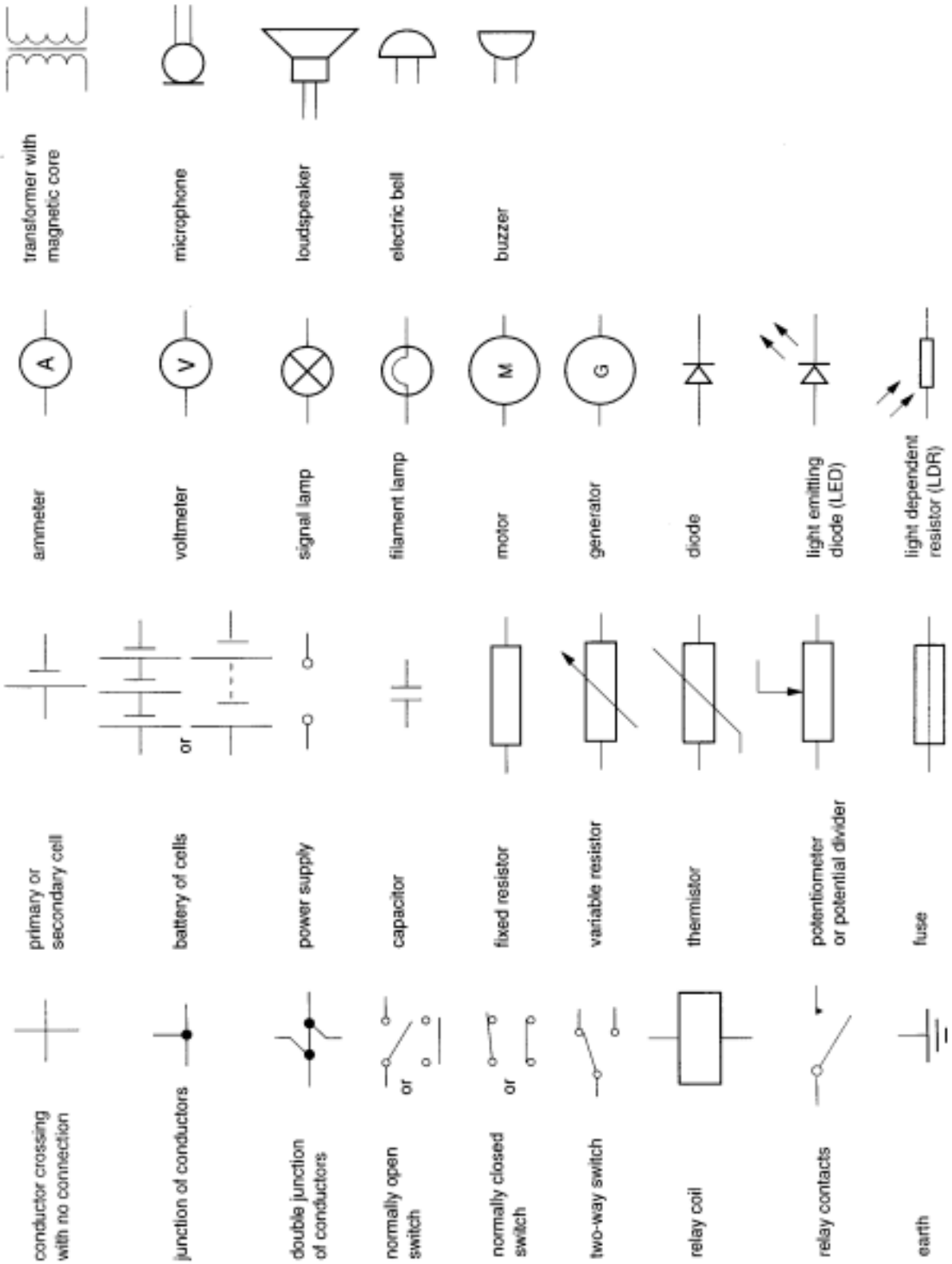
Questions in this category may include the command words listed above together with *Why... Complete... Work out... How would you know that... ? Suggest...*

e.g. *`Use the graph to calculate the acceleration of the cyclist.'*

`Explain why it is important for animal and plant species to be conserved.'

`Suggest two advantages of growing crops which are nitrogen-fixing.'

Appendix F: Electrical and Electronic Symbols to be Used in Question Papers



DATA SHEET
The Periodic Table of the Elements

Group																	
I	II											III	IV	V	VI	VII	0
							1 **H** Hydrogen 1										4 **He** Helium 2
7 **Li** Lithium 3	9 **Be** Beryllium 4											11 **B** Boron 5	12 **C** Carbon 6	14 **N** Nitrogen 7	16 **O** Oxygen 8	19 **F** Fluorine 9	20 **Ne** Neon 10
23 **Na** Sodium 11	24 **Mg** Magnesium 12											27 **Al** Aluminium 13	28 **Si** Silicon 14	31 **P** Phosphorus 15	32 **S** Sulphur 16	35.5 **Cl** Chlorine 17	40 **Ar** Argon 18
39 **K** Potassium 19	40 **Ca** Calcium 20	45 **Sc** Scandium 21	48 **Ti** Titanium 22	51 **V** Vanadium 23	52 **Cr** Chromium 24	55 **Mn** Manganese 25	56 **Fe** Iron 26	59 **Co** Cobalt 27	59 **Ni** Nickel 28	64 **Cu** Copper 29	65 **Zn** Zinc 30	70 **Ga** Gallium 31	73 **Ge** Germanium 32	75 **As** Arsenic 33	79 **Se** Selenium 34	80 **Br** Bromine 35	84 **Kr** Krypton 36
85 **Rb** Rubidium 37	88 **Sr** Strontium 38	89 **Y** Yttrium 39	91 **Zr** Zirconium 40	93 **Nb** Niobium 41	96 **Mo** Molybdenum 42	**Tc** Technetium 43	101 **Ru** Ruthenium 44	103 **Rh** Rhodium 45	106 **Pd** Palladium 46	108 **Ag** Silver 47	112 **Cd** Cadmium 48	115 **In** Indium 49	119 **Sn** Tin 50	122 **Sb** Antimony 51	128 **Te** Tellurium 52	127 **I** Iodine 53	131 **Xe** Xenon 54
133 **Cs** Caesium 55	137 **Ba** Barium 56	139 **La** Lanthanum 57 *	178 **Hf** Hafnium 72	181 **Ta** Tantalum 73	184 **W** Tungsten 74	186 **Re** Rhenium 75	190 **Os** Osmium 76	192 **Ir** Iridium 77	195 **Pt** Platinum 78	197 **Au** Gold 79	201 **Hg** Mercury 80	204 **Tl** Thallium 81	207 **Pb** Lead 82	209 **Bi** Bismuth 83	**Po** Polonium 84	**At** Astatine 85	**Rn** Radon 86
Fr Francium 87	226 **Ra** Radium 88	227 **Ac** Actinium 89 †															

140 **Ce** Cerium 58	141 **Pr** Praseodymium 59	144 **Nd** Neodymium 60	**Pm** Promethium 61	150 **Sm** Samarium 62	152 **Eu** Europium 63	157 **Gd** Gadolinium 64	159 **Tb** Terbium 65	162 **Dy** Dysprosium 66	165 **Ho** Holmium 67	167 **Er** Erbium 68	169 **Tm** Thulium 69	173 **Yb** Ytterbium 70	175 **Lu** Lutetium 71
232 **Th** Thorium 90	**Pa** Protactinium 91	238 **U** Uranium 92	**Np** Neptunium 93	**Pu** Plutonium 94	**Am** Americium 95	**Cm** Curium 96	**Bk** Berkelium 97	**Cf** Californium 98	**Es** Einsteinium 99	**Fm** Fermium 100	**Md** Mendelevium 101	**No** Nobelium 102	**Lr** Lawrencium 103

*58-71 Lanthanoid series
†90-103 Actinoid series

Key: (a above X, b below)
a = relative atomic mass
X = atomic symbol
b = proton (atomic) number

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.)

Appendix H: National Curriculum Orders for Wales

The following topics are required by the Programme of Study for Wales but are not covered by this specification.

Teachers in Centres in Wales which are subject to National Curriculum requirements will need to amend their schemes of work to include these topics.

2.2.23	the dangers of contracting HIV and hepatitis by the use of intravenous drugs
2.3	how the presence of starch, sugar and protein in foods can be detected by testing
2.5.4	about ways of conserving bio-diversity in the varied environments of Wales
3.2.1	how fossil fuels are formed
4.2.12	how extension varies with applied force for familiar materials e.g. steel springs, rubber bands
4.2.13	the quantitative relationship between the volume of a fixed mass of gas at constant temperature and its pressure

Appendix I: National Curriculum Orders for Northern Ireland

The following topics are required by the Programme of Study for Northern Ireland but are not covered by this specification.

Teachers in Centres in Northern Ireland which are subject to National Curriculum requirements will need to amend their schemes of work to include these topics.

Sc2

Reproduction

(l) the human reproductive system

(m) responsible sexual behaviour

Excretion

(n) (part of) function of the liver in breaking down excess amino acids

Nervous system

(r) (part of) antagonistic action of pairs of muscles at joints

Sc3

Properties and uses

(a) relationship between pressure and volume for a gas

(d) composite materials

Chemical change

(c) precipitation related to separation, purification and recognition of ions

(d) hardness of water and methods of softening

Kinetic theory

(a) explaining changes of state

Sc4

Forces

(e) momentum
(f) centre of mass
(g) role of a centripetal force in circular motion
(h) relation between force and extension for a range of materials

Sound, light and waves

(d) dispersion
(i) vibration and resonance
(j) pitch, loudness and sound quality

Earth in space

(d) possibilities and limitations of space travel