Contents

WJEC GCSE SCIENCE
WJEC GCSE ADDITIONAL SCIENCE
GCSE BIOLOGY, GCSE CHEMISTRY, GCSE PHYSICS

2007 and 2008

SUMMARY OF ASSESSMENT

GCSE *Science* involves 3 units, externally assessed (45 minutes for both Foundation and Higher Tier), plus an internally assessed, untiered assessment, covering biology, chemistry and physics.

GCSE *Additional Science* involves another 3 units, externally assessed, plus internal assessment, as above.

The units comprising the assessment are summarised in the table below plus their weighting (in brackets) as a percentage of each qualification.

<table>
<tr><th rowspan="2">Qualification</th><th colspan="3">External Units (% weighting)</th><th></th></tr>
<tr><th>Biology</th><th>Chemistry</th><th>Physics</th><th>Internal</th></tr>
<tr><td>Science</td><td>Biology 1
(25%)</td><td>Chemistry 1
(25%)</td><td>Physics 1
(25%)</td><td>Internal 1
(B+C+P) (25%)</td></tr>
<tr><td>Additional Science</td><td>Biology 2
(25%)</td><td>Chemistry 2
(25%)</td><td>Physics 2
(25%)</td><td>Internal 2
(B+C+P) (25%)</td></tr>
<tr><td></td><td>Biology 3
(25%)</td><td>Chemistry 3
(25%)</td><td>Physics 3
(25%)</td><td></td></tr>
<tr><td></td><td>Internal Biology
(25%)</td><td>Internal Chemistry
(25%)</td><td>Internal Physics
(25%)</td><td></td></tr>
</table>

GCSE *Biology, Chemistry* and *Physics* each consist of the relevant subject units from the GCSE *Science* and GCSE *Additional Science* qualifications plus a further unit for each Separate Science, externally assessed, (45 minutes for both Foundation and Higher Tier). The internal assessment for each of GCSE *Biology, Chemistry* or *Physics* comprises the 3 tasks, two of which are as those available for *Science* and *Additional Science* with one exta subject specific task.

The internal assessment for GCSE *Science* and GCSE *Additional Science* consists **either** of practical work provided by WJEC or written by centres for completion wholly during class time and marked by teachers according to a markscheme provided/approved by WJEC **or** a centre assessed extended report. In addition, candidates for GCSE *Biology, Chemistry* and *Physics* may as an alternative submit a written Inverstigatory Planning Exercise, marked by the centre using board criteria.

Availability of units: Biology, Chemistry and Physics 1 & 2 January and June; Biology, Chemistry and Physics 3 June; Internal Assessment submission in May.

Science
Additional Science
Biology, Chemistry and Physics

1 INTRODUCTION

This document contains a suite of unitised GCSE Science qualifications provided within a common framework: GCSE *Science*, *Additional Science*, *Biology*, *Chemistry* and *Physics*. For ease of reference, the title of the qualification is indicated at the head of each page and, where appropriate, the individual unit at the foot of each page.

Criteria for GCSE

This suite of qualifications has been designed to meet the General Criteria for GCSE (as set out in *The Statutory Regulation of External Qualifications 2004*), the requirements of the National Curriculum Orders for Science for England and Wales, and the Subject Criteria for GCSE Science (March 2005). Assessment for these qualifications is carried out according to Code of Practice published by the regulatory authorities (2005/06).

All GCSE qualifications are reported on an eight-point scale from A* to G, where A* is the highest grade. Candidates who fail to reach the minimum standard for a grade to be awarded are recorded as U (unclassified) and do not receive a qualification certificate.

Rationale

The specifications within this suite are based on an approach which is practically-based, emphasising the role of experimentation in ascertaining the validity of knowledge. The specifications have an emphasis on:

a. evaluating evidence and the implications of science for society;

b. explaining, theorising and modelling in science.

The balance between these is as follows:

In GCSE *Science*, there is an approximately equal emphasis on the two approaches. GCSE *Additional Science* and GCSE *Biology, Chemistry* and *Physics* emphasise the explaining, theorising and modelling aspects.

GCSE *Science* covers the National Curriculum Program of Study for Science at *Key Stage 4* and as such provides a basic study of scientific concepts, knowledge and implications. GCSE *Additional Science* builds on these ideas and introduces further scientific concepts and understanding. GCSE *Biology, Chemistry* and *Physics* explore a wider range of scientific concepts and provide a more detailed knowledge and understanding.

These qualifications may be undertaken through the medium of either English or Welsh. They may be followed by any candidate, irrespective of gender, ethnic, religious or cultural background. They are not age specific and, as such, provide opportunities for candidates to extend their life-long learning.

Pathways
The units which comprise *Science* and *Additional Science* qualifications also form the basis for the respective *Biology*, *Chemistry* and *Physics* qualifications, thereby allowing a student to defer the choice between taking either *Additional Science* or one or more of the separate sciences until the *Science* units have been completed. The common units within these qualifications will also facilitate common teaching of students progressing to *Additional Science* and the separate sciences.

Assessment Opportunities
Externally assessed units are offered in both the Summer and Winter examination series, thus allowing for all qualifications a variety of staged assessment strategies or, alternatively, for end-of-course ('linear') assessment.

Assessment of Practical Work
The internal assessment of practical work is intended to be an integral part of the course and part of normal classroom practice. It is carried out within the centre and is intended to be manageable and simple to administer.

Differentiation
Externally assessed units are tiered in terms of content at two levels: Higher (targeting grades A*-D) and Foundation (targeting grades C-G); internally assessed units are untiered. Subject content in **bold** will be assessed only on the **Higher Tier papers.** Subject content not in bold may be assessed on Foundation and Higher Tier papers. Entry for each external unit may be made according to the level of performance expected from the candidate on the particular content involved, and achievement for all units is reported on a uniform mark scale covering the full range of grades. This will allow the aggregation process to reflect variable performance and for maturation to be taken into account when entry decisions are made.

Rationale for Internal Assessment

The rationale behind the scheme of internal assessment is to promote an understanding of the way that scientists and science as a discipline, work. Because there is ample opportunity in the external assessment units to explore aspects (i) and (iv) of the way in which science works [see page 11], the internal assessment scheme is focused largely upon aspect (ii) **practical and enquiry skills**. Aspect (iii) **communication** is inherent in all aspects of the assessment scheme. In all qualifications, three pieces of work are required: in Science and Additional Science this includes one piece drawn from each of the subject areas Biology, Chemistry and Physics.

The core component of the Internal Assessment scheme in all specifications is the **Practical Task**. As the way in which scientists achieve an understanding of nature is in experimental work, this is seen as fundamental to both the teaching and assessment of candidates in science. However, two optional approaches are also available as appropriate, an **Extended Report** and an **Investigatory Planning Exercise**.

This variety of optional approaches allows individual candidates to use and show different aptitudes and skills during their assessment. Suitable coverage of the assessment objectives is maintained by the rules limiting the number of these optional assessment methods available to individual candidates.

Practical Task
The criteria for the Practical Task have been designed to allow almost any experimental activity to be used in the Internal Assessment. It is also deliberately designed to be restricted in time so that centres can engage in a multiplicity of tasks during the teaching of the specification, giving teachers the opportunities to teach the scientific skills as well as assessing them.

In the assessment of the Practical Task, the candidate is guided through a practical activity, which could be laboratory or field-based and which arises from the relevant subject content of the specification. The task includes all aspects of **practical and enquiry skills,** and addresses Assessment Objectives 2(a) and 3 (a-d). The Board provides a range of such activities for each of the specifications, including a specific candidate worksheet, a list of laboratory or field requirements, teacher guidance and a marking scheme. In order to achieve both accessibility and discrimination, guidance is also provided regarding the help which may be given to candidates to enable them to progress.

Centres are encouraged to write further practical tasks, within the criteria provided in the section "Internal Assessment of Practical Work" of these specifications, and submit them for approval. This is particularly important for centres wishing to develop ecological work as the detailed requirements will vary from location to location. Centre-developed tasks will have the same status as board-developed tasks and will be added to the list of activities to which centres will have access.

Extended Report
A second aspect of the Internal Assessment scheme, which is common to all specifications, is the Extended Report. Various aspects of the specifications lend themselves to a different style of enquiry-based approach, with students investigating, discussing and reporting. This is especially, but not exclusively, the case with those areas of the specification which involve social, ethical and political issues and effects, e.g. GM technology, the siting of wind farms or mobile phone masts, for which science informs but does not determine the debate. The criteria for the Extended Report are given, together with the assessment criteria. The Extended Report may take a variety of forms including written reports, "Power Point" presentations, poster presentations and the assessment could include ephemeral evidence. The Extended Report includes the aspect (iv) **applications and implications of science** of the way science works and addresses Assessment Objectives 2(a-d) and 3(b-d).

In view of the emphasis on practical work in the specifications, no more than *one* of the pieces of Internal Assessment work for any candidate in any specification may be an Extended Report. This enables sufficient weighting to be attached to Assessment Objective 3(a). Assessment Objectives 2(a-d) are also covered in the external assessments.

Investigatory Planning Exercise
For candidates in the separate science qualifications, *Biology*, *Chemistry* and *Physics*, a third type of activity is available for Internal Assessment: the Investigatory Planning Exercise. This recognises the greater experience of these candidates in scientific investigatory work and takes the form of a paper exercise in which the candidate plans an experimental activity involving either an investigation into the relationship between variables or a forensic-style investigation.

The stimulus for this activity arises out of the experience of Sc1 investigations and is to enable candidates to demonstrate their scientific competence arising from carrying out their own investigations previously. The criteria for the Investigatory Planning Exercise, including a generic mark scheme, are given in the section "Internal Assessment of Practical Work" of these specifications and an example is given in the Specimen Assessment Materials.

The Investigatory Planning Exercise includes (ii) **practical and enquiry skills** of the way science works and addresses Assessment Objective 2(b). For each of the separate science qualifications, *Biology*, *Chemistry* and *Physics*, no more than *one* Investigatory Planning Exercise may be submitted.

Prior Learning and Progression

Although there is no specific requirement for prior learning, these specifications build upon the Programmes of Study for Science at Key Stage 3.

Each qualification within the suite provides an appropriate basis for further study. Within the specific area of science, in the case of GCSE *Science* this could be progression to *Additional Science* or to *Applied Science.*

In the case of *Additional Science* or the separate sciences – *Biology, Chemistry, Physics* – this could be to GCE or VCE qualifications in the sciences.

Equally, the skills and understanding developed, including key skills, are relevant to other qualifications at level 3, whether 'general' or 'vocational'.

Access Arrangements and Special Consideration

Details of the special arrangements and special consideration for candidates with particular requirements are contained in the Joint Council for General Qualifications document *Regulations and Guidance Relating to Candidates who are Eligible for Adjustments in Examinations.*. Copies of this document are available from WJEC.

Certification and Classification Codes

A mark for any unit can only be counted towards one GCSE certification. Thus for example Unit B1 may count towards **either** *Science* **or** *Biology*.

The relevant classification codes for this suite of specifications are:

Biology:	**1010**
Chemistry:	**1110**
Physics:	**1210**
Science	**(Single = 1310)**
Additional Science:	**(Double = 1370)**

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.

2 AIMS

The specifications give students opportunities to:

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

The spiritual, moral, ethical and cultural dimension

The specification provides a framework and includes specific content through which individual courses may address spiritual, moral, ethical, social and cultural issues. It aims to provide a stimulus for students to develop an understanding of the usefulness and limitation of scientific method and so appreciate its applicability in everyday life. An examination of scientific and contemporary issues is therefore an integral part of the course.

Contexts are provided to give the opportunity to:

- encourage candidates to discern, consider and discuss questions relating to the origin of the universe, the meaning of life, the nature of humanity and concepts such as infinity, proof, truth and certainty;
- consider scientific interpretations of the structures and development of the modern world.
- consider ethical, cultural and social issues resulting from scientific interpretations and advances in knowledge.

Sensitive Issues

It should also be noted that some aspects of the specification may raise contentious issues e.g. evolution, which should be treated with understanding.

In addition, the inclusion of human infections and diseases in the specification may raise difficulties for individuals, particularly those with personal involvement e.g. genetic disorders, therefore a sensitive approach is required.

PSE/PSHE

This specification is designed to make a contribution to the development, knowledge, skills and understanding of PSE/PSHE. In particular, the practical element will encourage pupils to take an effective part in school-based activities, and to show a willingness and commitment to evaluate such activities critically. In doing so, they will be encouraged to demonstrate personal and group responsibility in their attitudes to themselves and others. The following issues and activities could be addressed through the specification content.

Issue/Activity
Considering the laws on pollution control. The rights of consumers Issues of sustainable development Expressing personal opinions on environmental issues Contributing to group discussions Consider and evaluate the views of others Participating in science - based school and community activities

The European dimension

The approach used in constructing the specification lends itself to the establishment of links with other areas of study, particularly those involving economic and industrial understanding and environmental and health education. It may also be used to illustrate the European dimension.

The approach is exemplified by various sections regarding the need for international co-operation for effective pollution control, species protection, the finite nature of world resources, and regulation of food quality.

Environmental issues, health and safety considerations

WJEC has taken account of the following important issues in preparing this specification and associated specimen materials.

Environmental Issues	*Health and safety Issues*
Energy efficiency Maintenance of biodiversity Exploitation of resources Air, water and pesticide pollution Energy and mineral recycling Aspects of the reprocessing and storage of radioactive materials The depletion of the ozone layer Global warming and its control Acid rain and its control Transmission of electrical energy	Safe practice in the laboratory Smoking and related diseases Dangers of self abuse by alcohol and drugs Radioactivity Health physics The use of chlorine/fluoride in water supplies

Opportunities for use of ICT

This specification is designed to provide a range of opportunities for the use of ICT. The programmes of study in the specification content provide opportunities for the use of ICT in the delivery of the course. In addition, the centre-based element will provide further opportunities for candidates to use ICT in scientific investigations.

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.

Suitable relevant subject content includes ecological investigations, genetic variation, searching for alternative evidence using CD-ROM or the Internet e.g. for the impact on local communities caused by industrial activities and conservation, using data loggers to investigate photosynthesis and motion.

Curriculum Cymreig

The specification framework also allows the use of the Welsh context for course designers in Wales to draw on local examples and priorities, thereby allowing development of the curriculum Cymreig. This allows for the consideration of local sensitivities, views and difficulties and also reflects the possible differences in approach to solutions which take place in Wales.

A specification is available, through the medium of Welsh, as are question papers. In addition, opportunities for the development of Key Skills are provided, especially communication, either through the medium of English or Welsh.

Awarding, Reporting and Re-sitting

The GCSE Science qualifications in this suite are all offered as Single Awards. The certificate will be recorded as a Single Award with grades from A*-G. Results not attaining the minimum standard for the award of a grade will be reported as U (Unclassified).

Individual unit results, both internal and external, will also be reported on a uniform mark scale with the following grade equivalences:

Grade	**Max.**	**A***	**A**	**B**	**C**	**D**	**E**	**F**	**G**
Uniform Marks	80	72	64	56	48	40	32	24	16

For the externally assessed units, which are tiered, the maximum uniform mark available on the Foundation tier of the assessment will be 55 [i.e. 1 mark less than the minimum mark needed to achieve a grade B on that unit]. As the internal assessments are not tiered, the full range of uniform marks is available.

Upon aggregation for the qualification as a whole, based on a maximum uniform mark of 320, the conversion of uniform marks to grades will be as follows:

Grade	**Minimum Uniform Mark**
A*	288
A	256
B	224
C	192
D	160
E	128
F	96
G	64

Students may re-sit each unit an unlimited number of times prior to certification. Students may take the qualification more than once. Individual unit results, prior to certification of the qualification have a shelf-life limited only by the shelf-life of the specification.

Assessment Opportunities

Units 1 and 2 for each discipline [i.e. Biology 1, Biology 2, Chemistry 1, Chemistry 2, Physics 1 & Physics 2] will be available for assessment in January and June (first availablity: Unit 1 - January 2007; Unit 2 - June 2007).

Units Biology 3, Chemistry 3 and Physics 3 will be available for assessment in June (first availability: June 2008).

Internal Assessments will be submitted in May each year (first assessment submission for GCSE *Science* May 2007, first assessment submission for GCSE *Additional Science* and the separate sciences May 2008).

Skills, Knowledge and Understanding

These Science specifications involve the following skills, knowledge and understanding of how science works:

(i) data, evidence, theories and explanations

(a) the collection and analysis of scientific data;

(b) the interpretation of data, using creative thought, to provide evidence for testing ideas and developing theories;

(c) many phenomena can be explained by developing and using scientific theories, models and ideas;

(d) there are some questions that science cannot currently answer, and some that science cannot address.

(ii) practical and enquiry skills

(a) planning to test a scientific idea, answer a scientific question or solve a scientific problem;

(b) collecting data from primary or secondary sources, including the use of ICT sources and tools;

(c) working accurately and safely, individually and with others, when collecting first-hand data;

(d) evaluating methods of data collection and considering their validity and reliability as evidence.

(iii) communication skills

(a) recalling, analysing, interpreting, applying and questioning scientific information or ideas;

(b) using both qualitative and quantitative approaches;

(c) presenting information, developing an argument and drawing a conclusion, using scientific, technical and mathematical language, conventions and symbols and ICT tools.

(iv) application and implications of science

(a) the use of contemporary scientific and technological developments and their benefits, drawbacks and risks;

(b) how and why decisions about science and technology are made, including those that raise ethical issues, and about the social, economic and environmental effects of such decisions;

(c) how uncertainties in scientific knowledge and scientific ideas change over time and the role of the scientific community in validating these changes.

3 ASSESSMENT OBJECTIVES

All candidates must demonstrate the following assessment objectives in the context of the prescribed skills, knowledge and understanding. Within the assessment objectives, candidates are required to use communication skills, including ICT, use scientific conventions (including chemical equations) and mathematical language (including formulae), where appropriate.

Assessment Objective 1 (AO1): Knowledge and understanding of science and how science works

Candidates should be able to:

(a) demonstrate knowledge and understanding of the scientific facts, concepts, techniques and terminology in the specification

(b) show understanding of how scientific evidence is collected and its relationship with scientific explanations and theories

(c) show understanding of how scientific knowledge and ideas change over time and how these changes are validated.

Assessment Objective 2 (AO2): Application of skills, knowledge and understanding

Candidates should be able to:

(a) apply concepts, develop arguments or draw conclusions related to familiar and unfamiliar situations

(b) plan a scientific task, such as a practical procedure, testing an idea, answering a question, or solving a problem

(c) show understanding of how decisions about science and technology are made to different situations, including contemporary situations and those raising ethical issues

(d) evaluate the impact of scientific developments or processes on individuals, communities or the environment.

Assessment Objective 3 (AO3): Practical, enquiry and data-handling skills

Candidates should be able to:

(a) carry out practical tasks safely and skilfully

(b) evaluate the methods they use when collecting first-hand and secondary data

(c) analyse and interpret qualitative and quantitative data from different sources

(d) consider the validity and reliability of data in presenting and justifying conclusions.

4 SCHEME OF ASSESSMENT

Candidates entering for the GCSE *Science* qualification should complete 3 external tiered unit assessments plus an internal, untiered, teacher assessed task in each of biology, chemistry and physics.

The GCSE *Additional science* qualification consists of another 3 externally assessed, tiered units plus a further internal, untiered, teacher assessed task in each of biology, chemistry and physics.

The units comprising the assessment are summarised in the table below:

Qualification	External Units			
	Biology	Chemistry	Physics	Internal
Science	Biology 1	Chemistry 1	Physics 1	Internal 1 (B)+(C)+(P)
Additional Science	Biology 2	Chemistry 2	Physics 2	Internal 2 (B)+(C)+(P)

The separate science qualifications in *Biology, Chemistry* and *Physics* each consist of the relevant subject units from the GCSE *Science* and GCSE *Additional Science* qualifications and a further externally assessed, tiered unit for each Separate Science. The internal assessment consists of two relevant tasks, as above, from the appropriate subject areas of *Science* and/or *Additional science* and one further assessment which may be taken from any area of the appropriate specification.

The units comprising the overall scheme of assessment for each of the separate sciences is summarised below.

Biology	
External	Internal
Biology 1	Internal (Biology)
Biology 2	
Biology 3	

Chemistry	
External	Internal
Chemistry 1	Internal (Chemistry)
Chemistry 2	
Chemistry 3	

Physics	
External	Internal
Physics 1	Internal (Physics)
Physics 2	
Physics 3	

Note that Units 1 and 2 are, in each case, common with the *Science* and *Additional Science* units.

The mark allocations for each of the different assessments, at both foundation and higher tier, are as follows:

Qualification	Externally assessed units			Internal (total per qualification)
	Biology	Chemistry	Physics	
Raw Marks Available	50	50	50	75

The examination papers for all externally assessed units are of 45 minutes duration.

Short answer and objective questions account for no more than two-thirds of the total credit assigned to the externally assessed written components. Candidates are provided with opportunities for extended writing. Questions target three levels of demand with some questions, targetting grades C and D, common to both the Foundation and Higher tier papers as shown below:

	Tier	Grades targetted by questions			Total
		E, F, G	C, D	A*, A, B	
Marks available	Foundation	35	15		50
	Higher		15 + 10	25	50

The quality of written communication is inherent in the assessment as, in order to access marks, candidates are expected to express themselves using clear, unambiguous language which conveys a clear meaning.

The weighting of individual units within each qualification is as follows:

Science and ***Additional Science:***

	External Assessment Weighting (%)			Internal Assessment Weighting (%)
Unit	**Biology**	**Chemistry**	**Physics**	
1	25	25	25	25
2	25	25	25	25
Qualification Total	**75**			**25**

The percentage weightings for the assessment objectives given in Section 3 are as follows:

Assessment Objectives	External Assessment	Internal Assessment	Overall Range
AO1	32-37	-	32-37
AO2	25-30	5 – 6	30-36
AO3	12-17	19 – 20	31-37
Total	**75**	**25**	**100**

For the Separate Sciences:

Unit	Weighting (%)
1	25
2	25
3	25
Internal Assessment	25

The percentage weightings for the assessment objectives given in Section 3 are as follows:

Assessment Objectives	External Assessment	Internal Assessment	Overall Range
AO1	32-37	-	32-37
AO2	25-30	5 – 13	37-43
AO3	12-17	12 – 20	24-37
Total	**75**	**25**	**100**

Internal Assessment

The Internal Assessment scheme in this suite of qualifications is designed to promote a variety of good educational practice. The key component is the **Practical Task**, the intention of which is to encourage centres to engage in a wide variety of practical laboratory and field work. Initially, the board has provided a list of suitable assessed practicals. For each practical a specific candidate worksheet is provided together with a list of laboratory or field requirements, teacher guidance and a marking scheme. Each Practical Task is to be completed wholly within class time and in approximately two hours.

Centres are encouraged to write further Practical Tasks, based upon the format provided, in order to extend the range of practical assessment opportunities.

For each of the qualifications, *Science* and *Additional Science* one piece of work is required in **each** of biology, chemistry and physics. As an alternative to **one** of the three Practical Tasks, candidates may submit an **Extended Report** on an aspect of the relevant subject content, e.g. the issues surrounding gene therapy, which is assessed according to criteria provided by the board. The aim of this aspect of the Internal Assessment is to encourage centres to develop alternative enquiry-based learning strategies, which encourage a critical approach. It is particularly suitable for topics involving scientific and technological controversy in which decisions must be made which are not wholly based upon science. The "report" may take a variety of forms including "Power Point" presentations and posters.

Candidates for each of the separate science qualifications, *Biology*, *Chemistry* and *Physics*, should submit three pieces of work for each qualification, as described above. In recognition of the greater experience of these candidates in scientific investigatory work, they may submit, as **one** of their pieces of internal assessment, an **Investigatory Planning Exercise** which is set and marked by the centre using criteria provided by the board. The criteria for the assessment of these planning exercises are written to assess candidates' strategies for solving scientific problems. Separate Science candidates may, therefore, submit a maximum of one Extended Report and one Investigatory Planning Exercise per qualification.

5 SUBJECT CONTENT

It is envisaged that a variety of approaches to the teaching of the content is used. In view of the need to consider the issues, uncertainties and value judgements inherent in some areas of science, a didactic approach may not be appropriate. Case studies, individual projects or discussion groups may be more suitable as a means of exploring such issues.

Scientific Evidence
The development of scientific ideas and an insight into how decisions about science are made should be considered during the course. This is to provide candidates with an appreciation of the cumulative nature of scientific evidence tempered by its limitations and how perceptions and decisions about science are influenced by external attitudes and contexts. Desk studies and ICT are a valid means of introducing a variety of data which may not otherwise be available and so extending areas of study.

How Science Works
References to the skills, knowledge and understanding of *how science works* (as indicated on page 11), notably sections (i) a-d and (iv) a-c, are included alongside relevant subject content (eg w (iv) a). These references are an indication that the content provides an opportunity for a particular aspect of *how science works* to be addressed in teaching **and to be assessed in external or internal assessments.** The reference list is, however, not exhaustive and other content may also be suitable. How science works section (ii) **practical and enquiry skills** can be delivered via all sections of the subject content and will be assessed in all the internal assessments and may also be assessed in the external assessments. How science works section (iii) **communication skills** is implied in all statements of subject content and forms an integral part of all assessments. Because of the ubiquitous nature of sections (ii) and (iii) of how science works, they are not separately flagged up in the subject content.

ICT Skills
ICT is integral to scientific work and as such may be employed in various ways. These include both the collection of data, such as the investigation of information from a variety of sources including the internet and the use of data logging, and the presentation and analysis of information using software packages and databases. Using software simulations is also an effective tool for exemplification, such as how things work, and for modelling systems and effects.

Practical Skills
Practical work is an essential feature of science and as such is integral to the content. It may take different forms, including fieldwork. The practical work could form the focal point of approach as it adds to the candidate's appreciation of the topic. Practical work is, therefore, to be encouraged wherever possible.

Practical skills should be developed via the content throughout the course in order to prepare candidates for the practical assessment.

A variety of practical work is suggested below including some exercises which may be used for practical assessment purposes. Experimental work may be examined on the theory papers.

Each section of content is preceded by a short list of questions which provide the theme for the section. This list is intended as a scene-setter and does not constitute part of the subject content.

Subject content written in bold type will only be examined on the higher tier papers.

Terms used in the Subject Content:

The term ***investigate*** is used in its broadest sense and along with terms such as ***explore*** or ***examine*** refers to a range of activities which can include:

- individual experimental work
- group or class experimental work
- teacher demonstrations
- internet searches or examining other secondary sources
- use of ICT simulations, either as a group/class activity or a teacher demonstration.

This list of possibilities is not exhaustive. The form of activity appropriate in any particular instance is at the discretion of the teacher, taking into account the subject matter, the availability of equipment, Health and Safety and COSHH regulations etc.

Statements which start with terms such as ***investigate, discuss, critically assess*** may be considered suitable topics for the writing of an **Extended Report** option for the internal assessment.

Teacher Guidance Material

Further information on the interpretation of specification statements, the list of Practical Tasks, details of the procedure for the development of new Practical Tasks and suggestions on topics for Extended Reports and Investigatory Planning Exercises are provided in the current ***Teacher Guidance Material for GCSE Science.***

SCIENCE
BIOLOGY 1

For clarification of certain terms used in this unit, see note on page 17.

Genes and Variety

1. ADAPTATION AND COMPETITION

Why and how should organisms be classified?
Which organisms live here and how are they affected by others?
What features enable organisms to survive here?
What affects the numbers of organisms here? Does pollution?

Candidates should:

(a) know that organisms that have similar features and characteristics can be classified together in a logical way. Understand the need for a scientific system for identification and scientific as opposed to 'common' names.

(b) use local first and/or second hand data/ICT simulation:
to compare the variety of organisms which live in particular habitats;
investigate how the organisms in an area are affected by other organisms. (w(i)a)

(c) explore information about the morphological adaptations shown by organisms which enable them to survive in their environment.

(d) know that individuals have a basic need for energy and resources from their environment and that the size of a population of individuals may be affected by competition, for food, space, light; predation, disease, pollution, availability of minerals.

(e) examine how indicator species, changes in pH and oxygen levels may be used as signs of pollution in a stream and the examination of lichens as indicators of air pollution. (w(i)a)

2. VARIATION

Are all individuals in a species the same?
What causes variation?
What causes genes to alter?
What are the risks in the environment?

Candidates should:

(a) examine the variation in height/length in individuals of the same species by collecting and analysing data and know that variation may be due to environmental or genetic causes. (w(i)a)

(b) know that sexual reproduction leads to offspring that are genetically different from the parents unlike asexual reproduction where genetically identical offspring called clones are produced from a single parent. Sexual reproduction therefore gives rise to increased variation.

(c) understand that new genes result from changes, mutations, in existing genes and that mutations occur naturally at random. Mutations may be beneficial or harmful and are increased by exposure to radiation and some toxic chemicals.

(d) variation is the basis of evolution.

3. EVOLUTION

Do species change over time?
What is natural selection?
How does evolution work?
Is evolution still going on?

Candidates should:

(a) examine evidence and interpret data about how organisms and species have changed over time. Suggest reasons why species may become extinct. (w(i)a,b)

(b) consider how individuals with characteristics adapted to their environment are more likely to survive and breed successfully. Consider the uses and limitations of modelling to illustrate the effect of camouflage colouring in prey and predator relationships.

(c) know that the genes which have enabled these better adapted individuals to survive are then passed on to the next generation. This is natural selection. (w(i)c)

(d) **consider the process of data collection, creative interpretation and deduction that lead Charles Darwin to propose the theory of evolution. Discuss the controversy surrounding the acceptance of the theory. Discuss evidence that evolution is ongoing such as data on Warfarin resistance in rats.**
(w(i)a,b,c;(iv)a,c)

4. INHERITANCE

What are chromosomes made of and what is DNA?
What are genes and how do they affect cells?
What effect does cell division have on the genetic composition of cells?
What causes offspring to be male or female?
Are other features inherited in the same way?
How was the mechanism worked out?
Can some conditions be passed on in families?

Candidates should:

(a) know that chromosomes are strands of DNA. DNA contains coded information that determines how cells function due to the types of proteins coded for. DNA can be extracted from cells, such as Kiwi fruit.

(b) know that DNA can be analysed by 'genetic fingerprinting' which can be used to show the similarity between two DNA samples, for instance in criminal and paternity cases. (w(iv)a)

(c) assess the issues surrounding 'gene ownership' as a result of DNA analysis and consider whether the ethical issues involved are a matter for society and beyond the scope of science to solve. (w(i)d;(iv)a,b)

(d) understand the significance of mitosis and meiosis.

(e) know that genes are sections of DNA molecules that determine inherited characteristics and are in pairs. Genes have different forms, called alleles.

(f) know that in human body cells, one of the pairs of chromosomes carries the genes which determine sex, XX or XY. These separate and combine randomly at fertilisation.

(g) consider the scientific process of experimentation, observation and deduction that led Gregor Mendel to propose the mechanism of inheritance. Discuss why the significance of the work was not recognised and validated by scientists for many years. (w(i)a,b;(iv)c)

(h) be able to complete Punnet squares and explain the outcomes of monohybrid crosses.

(i) understand that some mutations cause conditions which may be passed on in families, as shown by the mechanism of inheritance of cystic fibrosis, and be able to interpret family trees.

5. GENE TECHNOLOGY

Why should anyone need genetically identical individuals?
Can genes be transferred between organisms artificially?
Why is this done?
Are there any ethical issues surrounding this technology?
Is there a planning or control process surrounding the use of this technology?

Candidates should:

(a) know the commercial applications of clones of plants and animals. (w(iv)a)

(b) know that genes can be transferred artificially from one organism to another, and understand that the introduction of genes from resistant plants into Soya bean plants, so increasing their resistance to herbicides, may increase the crop yield. (w(iv)a)

(c) critically assess the issues surrounding this GM crop technology and how decisions are made, including the need to plan scientifically valid, suitable trials to assess the possible effects in order to inform the debate:
for the scientific community,
government policy departments,
wider public opinion. (w(i)a;(iv)b,c)

Body Maintenance and Protection

6. HOMEOSTASIS

Why is the temperature of the body always around 37 degrees?
How does the body keep it constant?
Why should the level of glucose in the blood vary and so needs to be kept constant?
What happens when the control mechanism fails to work efficiently?

Candidates should:

(a) understand that animals need to regulate the conditions inside their bodies to keep them relatively constant and protected from harmful effects.

(b) recognise and label a simplified given diagram of a vertical section through the skin and understand its role in temperature regulation

(c) use data to draw conclusions about the relationship between glucose and insulin levels in the blood and understand that glucose levels need to be kept within a constant range. (w(i)a)

(d) know that diabetes is a condition in which a person's blood glucose may rise to a fatally high level because the body does not produce enough insulin. It can be diagnosed by the presence of glucose in the urine.

(e) plan and carry out testing of artificial urine samples for glucose.

7. NERVOUS SYSTEM

How does the body check on its surroundings?
Why are some reactions very fast?
What is a reflex arc?

Candidates should:

(a) know that sense organs are groups of receptor cells, which respond to specific stimuli: light, sound, touch, temperature, chemicals, and then relay this information as electrical signals, called nerve impulses, to the brain.

(b) know that some responses in animals are reflex actions. These reactions are fast, automatic and some are protective, as exemplified by the withdrawal reflex.

(c) **know that a reflex arc involves stimulus → receptor → coordinator → effector. Recognise and label a given diagram of a reflex arc to show: receptor, sensory nerve cell, connecting nerve cell in spinal cord, motor nerve cell, effector, synapses.**

(d) plan and carry out practical work on sensitivity and reaction times.

8. HEALTH

What is health?
What causes ill health?
How can ill health be treated?
Are there ethical issues involved with these treatments and how should decisions be made?

Candidates should:

(a) know that health is affected by a variety of factors and that science and technology may provide the answer to some health problems.

(b) know that some conditions can be prevented and that some can be treated by drugs or by other therapies.

(c) know that gene therapy has been tried but there are difficulties in targetting the appropriate cells. It has been used to alleviate symptoms in Cystic Fibrosis sufferers but is not a cure for the underlying genetic condition and there may be side effects. (w(iv)a)

(d) discuss the implications of genetic counselling and the ethical problems posed by an individual's prior knowledge of a genetic trait. (w(iv)a,b)

(e) discuss:
- the ethical issues surrounding, and
- how decisions are made about

the use of animals for testing drugs (w(iv)a,b)

(f) investigate experimentally the comparative energy content from burning food and understand that energy from food, which is in excess, is stored as fat by the body.

(g) explore and discuss available data, e.g. from ICT searches and food labelling, about the energy and additives in highly processed and less processed foods and the implications, particularly for health. (w(i)a;(iv)a)

(h) know that some conditions are due to lifestyle choices and use information/data to explore the effects that alcohol, nicotine and drug abuse have on the chemical processes in peoples' bodies. Discuss how the attitudes to smoking have changed over time as scientific evidence about its effects has accumulated. (w(iv)a,c)

SCIENCE
CHEMISTRY 1

For clarification of certain terms used in this unit, see note on page 17.

1. ATOMIC STRUCTURE, ELEMENTS AND THE PERIODIC TABLE

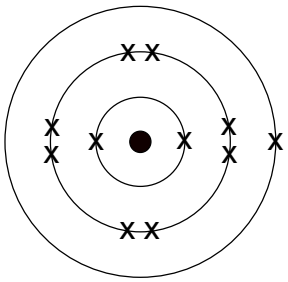
Why are some elements similar and others quite different?
How do scientists classify elements?
Are there patterns in the reactions of elements?
Who decides whether to put fluoride into drinking water and why?
How can elements be used?

Candidates should:

(a) know that atoms consist of a central nucleus containing protons and neutrons surrounded by 'orbiting' electrons

(b) use data, given in the form $^{23}_{11}Na$, to represent the electronic structure of elements with atomic numbers 1 to 20 inclusive, in the following form: (w(i)a)

for sodium



(c) understand that elements are the basic building blocks of all substances and cannot be broken down into simpler substances by chemical means.

(d) use data to establish the relationship between electronic structure and the position of the element in the first three rows of the modern periodic table (w(i)a)

(e) be aware that Mendeléev, in developing the modern form of the periodic table, observed recurring patterns in the properties of elements when arranged in order of increasing relative atomic mass, but used creative thought to realise that he needed to leave gaps for elements that had not been discovered at that time; this enabled him to predict the properties of the undiscovered elements (w(i)b,c;(iv)c)

(f) use and interpret given data to distinguish between metals and non-metals (w(i)a)

(g) use data about the physical properties of elements in Group 1 and Group 7 to establish trends within each group and to make predictions based on these trends (w(i)a)

(h) investigate the chemical reactions of Group1 elements with oxygen in the air, with water and with Group 7 elements, by observation or using secondary sources, in order to draw conclusions about patterns of similarity and difference within the group and be able to write and interpret word and balanced symbol equations for the reactions (w(i)a)

(i) investigate the displacement reactions of Group 7 elements in order to establish the trend in reactivity within the group, be able to make predictions based on this trend and write and interpret word and balanced symbol equations for the reactions (w(i)a)

(j) be able to use flame tests and silver nitrate solution to distinguish between sodium chloride, sodium iodide, potassium chloride and potassium iodide

(k) examine evidence that has lead to the fluoridation of the water supply in some areas, including how data is collected (survey technique), and be able to discuss the factors involved in decision-making, including ethical issues (w(i)a,d;(iv)a,b)

(l) understand that the uses of a material depend on its properties

(m) be able to link the common uses of chlorine, iodine, helium, neon and argon to their properties

2. COMPOUNDS

Why are there so many compounds?
How can we show the contents of a compound?
Are there patterns in the reactions of compounds, such as acids?

Candidates should:

(a) know that new substances called compounds are formed when two or more different elements combine together and that each compound has its own chemical formula.

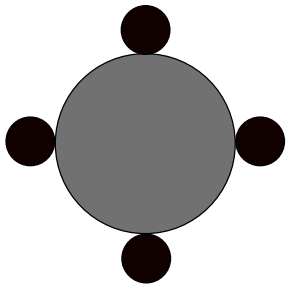
(b) be able to interpret a given formula, name the elements and number the atoms present

(c) be able to write formulae for simple binary compounds formed between Group 1 or 2 elements and elements of Group 6 or 7, using the formulae of the ions that they contain. (w(i)c)

(d) **be able to write formulae for ionic compounds containing hydroxide, nitrate, sulphate or carbonate ions, using the formulae of the ions that they contain.** (w(i)c)

(e) be able to draw and interpret space filler type diagrams for simple molecules using a key, (w(i)c)

e.g. for methane



(f) explore the reactions of acids with metals, bases (including alkalis) and carbonates, drawing conclusions about the patterns that exist and using these patterns to make predictions, test for carbonates and plan procedures to distinguish between named substances, e.g. sodium chloride and sodium carbonate (w(i)a)

3. USING CHEMICAL REACTIONS TO MAKE NEW MATERIALS

What happens to the atoms in a chemical reaction?
How can we tell if a reaction has occurred?
Where do raw materials come from?
How can we use reactions to make useful products?

Candidates should:

(a) know that the chemical industry obtains raw materials from the earth, sea and air and that chemical reactions are then used to change raw materials into useful products, such as fuels, plastics, medicines, fertilisers, metals, etc.

(b) know that chemical reactions use up reactants and produce new substances called products.

(c) know that in a chemical reaction, atoms are rearranged but no new atoms are produced nor are any atoms destroyed.

(d) recognise that signs of a chemical change occurring may include colour change, formation of a precipitate, gas evolution and temperature change.

(e) know that reactions in which the temperature rises are exothermic and that reactions in which the temperature falls are endothermic.

4. RATES OF CHEMICAL CHANGE

How can we measure how fast a reaction goes?
What makes a reaction go faster or slower?
How do scientists explain changes in the speed of a reaction?

Candidates should:

(a) explore the effects of changing concentration, temperature, and particle size on the rates of chemical reactions, using ICT where appropriate; this should include:

- planning the collection of reliable data, analysing the data, drawing conclusions and evaluating the procedures used,
- understanding the advantages of using ICT tools, in terms of recording, continuous monitoring and instantaneous display,
- explaining the outcomes in terms of particle theory. (w(i)a-c;(iv)a)

(b) understand the meaning of the term catalyst and know that the development of better catalysts is extremely important as it can lead to new ways of making materials that may use less energy, use renewable raw materials or use fewer steps. (w(iv)a)

5. NANOSCIENCE

What is a nanoparticle?
What are the potential benefits and drawbacks of advances in nanotechnology?

Candidates should:

(a) understand the concept of nanometre and appreciate that nano-science involves the study and use of particles that have sizes in the range 1-100 nm.

(b) be aware that reducing the size of particles to the nano-scale can produce new properties in a material, which may lead to new uses, e.g. the antibacterial, antiviral and antifungal properties of nano-sized silver particles used in sterilising sprays to clean operating theatres in hospitals and to coat the inner surfaces of refrigerators.

(c) discuss the potential benefits, risks and drawbacks associated with developments in nanoscience (w(i)d;(iv)a,b)

6. THE PRODUCTION AND USE OF FUELS

How do we make fuels?
What are the drawbacks of using fossil fuels?
How can we calculate the overall energy change in a reaction?

Candidates should:

(a) understand the principles involved in the fractional distillation of crude oil

(b) use the combustion of hydrocarbons to recognise that new substances are produced in a chemical reaction as a result of the making and breaking of bonds and that the combustion of a hydrocarbon involves the breaking of the C–C and C–H bonds followed by the formation of bonds with oxygen atoms. (w(i)c)

(c) **know that breaking a chemical bond requires energy and making a chemical bond releases energy.** (w(i)c)

(d) **understand that if energy released from forming new bonds is greater than energy needed to break existing bonds, the reaction is exothermic and vice-versa for an endothermic reaction.** (w(i)c)

(e) **use given data (energy needed to break bonds), to predict whether a reaction is exothermic or endothermic and calculate the overall energy change** (w(i)c)

(f) explain the environmental effects of the combustion of fossil fuels and evaluate the social, economic and environmental impact (w(i)ad;(iv)a,b)

(g) evaluate given data with regard to proposed solutions to the problem of acid rain (w(i)a,d;(iv)a,b)

7. EVOLUTION AND MAINTENANCE OF THE ATMOSPHERE

Where did our atmosphere come from?
Why does the amount of oxygen in the atmosphere stay roughly the same?
Why is the amount of carbon dioxide in the atmosphere increasing slightly and why are scientists worried about this?

Candidates should:

(a) investigate data on the composition of the atmosphere over geological time in order to draw conclusions about the changes in composition that have taken place (w(i)a)

(b) be aware of the accepted explanation for the origin of the atmosphere and the changes that have occurred over geological time (w(i)d)

(c) understand the roles of respiration, combustion and photosynthesis in the maintenance of the levels of oxygen and carbon dioxide in the atmosphere

(d) know that there is debate in the scientific community on the issue of global warming and be aware that many scientists attribute the main cause of global warming to the increase in carbon dioxide in the atmosphere caused by the combustion of fossil fuels (w(i)d;(iv)b,c)

(e) examine and evaluate given data on global warming (w(i)a)

(f) appreciate some effects and consequences of global warming

(g) evaluate given data with regard to proposed solutions to the problem of global warming (w(i)a,d;(iv)a,b)

8. GEOLOGICAL PROCESSES

Has Britain always been in the same place on the Earth?
What causes earthquakes and volcanoes?
How do scientists come up with new ideas to explain what they observe?
When do their ideas become accepted by other scientists?

Candidates should:

(a) use the development of the theory of continental drift to display their understanding that observations, through creative thought, lead to an idea to explain them but the explanation may not be accepted until sufficient evidence exists, as follows:

- in 1915, Alfred Wegener suggested that the Earth's continents were once joined and had moved apart to their present positions;
- he based his idea on the close fit of coastlines, and the similar patterns of rocks and fossils, of continents separated by large oceans;
- he was unable to convincingly explain how the continents could move;
- the current theory of plate tectonics became widely accepted in the 1960's, by which time other scientists had found evidence to show that it is the Earth's plates that move and that they do so as a result of convection currents in the mantle. (w(i)a-c;(iv)c)

(b) use evidence about the location of earthquakes and volcanoes to appreciate that the Earth's lithosphere is composed of a number of large pieces called plates, which are moving very slowly, and know that this movement drives the rock cycle (w(i)a,c)

(c) know that rocks can be:

- formed where tectonic plates move apart and magma rises to fill the gap producing new igneous rock

- deformed and/or recycled where tectonic plates move towards each other driving down the denser plate which may melt to form magma that on cooling forms igneous rock.

SCIENCE
PHYSICS 1

For clarification of certain terms used in this unit, see note on page 17.

Energy, Radiation and the Universe

1. GENERATION OF ELECTRICITY

What things influence the types of power stations we build?
Who decides on whether to build wind farms?

Candidates should:

(a) discuss the factors which are involved in the decisions about the types of power stations, including commissioning and decommissioning costs, types of energy sources, fuel costs and environmental factors as well as personal views which are not scientifically based. (w(iv)a,b)

(b) be aware of the planning processes involved in the development of power stations based upon renewable resources, e.g. wind and wave farms. (w(iv)b)

2. TRANSMISSION OF ELECTRICITY

Why do we have pylons and overhead power lines?
Why is power transmitted at high voltage, but used at low voltage?

Candidates should:

(a) understand the need for an electricity distribution system

(b) select and use the equation:

power = voltage × current

(c) describe the National Grid, including the use of ICT for monitoring power use and responding to changing demand. (w(iv)a,b)

(d) use physics knowledge to explain why electricity is transmitted at high voltages but used at low voltages in the home. (w(iv)a,b)

(e) understand the need for transformers in the transmission of electrical energy from the power station to the home. (w(iv)b)

3. HEATING AND THE HOME

How much electrical energy do we use in the home?
How much does it cost?
What sort of heating is most economic to use?
Is it worth installing alternative energy sources?

(a) distinguish between power and energy and select and use the equation:

energy transfer = power × time

(b) collect information, either directly or using secondary sources on the power ratings of domestic electrical appliances and use it to investigate the cost of using them. (w(i)a)

(c) select and use the equations:

Units used = power (kW) × time (h)
cost = units used × cost per unit

(d) use data to compare the cost of different sources of domestic energy, including electricity, gas, oil and coal. (w(i)a,b)

(e) use data to explore the cost-effectiveness of introducing domestic solar and wind energy equipment, including fuel-cost savings and payback time. (w(i)a,b;(iv)b)

4. ENERGY, TEMPERATURE AND THE TRANSFER OF HEAT ENERGY

How does heat flow from place to place?
How can we help heat flow or keep the heat in?
Is it worth getting double glazing or insulating the loft?

Candidates should:

(a) explore, experimentally and using secondary sources, using ICT where appropriate, how temperature differences lead to the transfer of thermal energy by conduction, convection and radiation. (w(i)a-c)

(b) use data from investigations to make comparisons of heat transfer.

(c) know the factors which affect the rate of heat transfer, including the use of insulators in reducing conduction and the nature of the surface in radiative transfer. (w(i)c)

(d) use their understanding of heat transfer to analyse the processes involved in domestic situations and to suggest how the heat transfer can be promoted or restricted [e.g. by the use of insulation].

(e) use data to compare the cost-effectiveness of different methods of reducing heat loss from the home, including loft insulation, cavity wall insulation, double-glazing and draught excluders and discuss the ethical issues surrounding controlling heat loss from the home. (w(i)a,b,d;(iv)a,b)

5. ENERGY EFFICIENCY

How much of the energy we use is wasted?
Can we use less energy by doing things in different ways?

Candidates should:

(a) understand qualitatively the idea of energy efficiency in terms of input energy, useful output energy and wasted energy.

(b) select and use the equation:

$$\text{efficiency} = \frac{\text{useful energy transfer}}{\text{total energy input}} \times 100\% .$$

(c) plan and carry out investigations, experimentally or by using secondary sources, into the cost and efficiency of energy transfer in a variety of contexts, e.g. comparing an electric kettle with an electric cooker ring for boiling water

6. THE CHARACTERISTICS OF WAVES

How can I measure waves?

Candidates should:

(a) characterise waves in terms of their wavelength, frequency, speed and amplitude.

(b) plan and carry out an investigation into waves e.g. investigating the factors which affect the speed of waves on water. (w(i)a)

(c) apply the equations

$$\text{wave speed} = \text{wavelength} \times \text{frequency} \quad \text{and} \quad \text{speed} = \frac{\text{distance}}{\text{time}}$$

to the motion of waves

7. THE ELECTRO-MAGNETIC SPECTRUM

What sorts of electromagnetic waves are there?
How do we use these waves and how are they dangerous?
Is it better to use optical fibres or satellites for communication?
How dangerous are mobile phone masts?

Candidates should:

(a) distinguish between the different regions of the electromagnetic spectrum [radio waves, microwaves, infra red, visible light, ultra violet, X rays and gamma rays] in terms of their wavelength and frequency (with an awareness of how these wave properties are related) and appreciate that they all travel at the same speed in a vacuum.

(b) Investigate, using secondary sources (e.g. an internet search), and know the uses of microwaves, infrared and visible radiation in energy transfer, and the hazards associated with the high-energy ionizing radiations, ultra-violet, X-rays and gamma rays.

(c) investigate experimentally the conditions under which total internal reflection occurs within parallel-sided glass blocks and explain, **in terms of total internal reflection,** how optical fibres enable long distance communication (w(i)c)

(d) Compare the use of microwaves and infra-red radiation in long distance communication, including a consideration of geosynchronous satellites, mobile phone technology and intercontinental optical fibre links. (w(iv)a,b)

(e) Investigate and make a report on or take part in a discussion on claimed health risks associated with mobile phone and Tetra communications and understand the planning requirements for the communication masts. (w(iv)a-c)

8. THE SOLAR SYSTEM

What objects are in the Solar System and how do they move?
How did the Solar System form?

Candidates should:

(a) know the theory of the origin of the Solar System in terms of the gravitational collapse of a cloud of gas (largely hydrogen and helium) and dust. (w(iv)c)

(b) describe the main features of the Solar System, including the Sun, the rocky and gas planets, moons, asteroids and comets, relating these features to the origin of the Solar System.

(c) interpret data on the orbits of planets and other bodies in the Solar System.

(d) understand the effect of gravity on the orbital motion of planets, comets, moons and artificial satellites **and use a model of radiation pressure to account for cometary tails**. (w(i)c)

(e) know how new discoveries of solar system objects are made by the use of ICT to detect movement.

9. STARS

What are stars made of and how do we know?
Where do the elements come from that make us up?
How do stars form, get their energy and what will happen to them in the end?

Candidates should:

(a) know that, in the 19th and early 20th centuries, the source of the Sun's energy became a problem as Geologists discovered that the Earth was millions of years old, and the model of the Sun's being powered by Chemical energy could not account for its shining for more than a few thousand years. (w(i)d;(iv)c)

(b) know that studies of the light from stars, including our Sun, show that they are composed mainly of hydrogen and helium and that their energy is supplied by the fusion of hydrogen into helium, which is able to supply energy at the current rate for about 10 000 million years. (w(i)b,c)

(c) appreciate the role of previous generations of stars in the existence of elements heavier than helium in the Solar System and that the fraction of heavier elements in the universe is gradually increasing as a result of the processes in stars. (w(i)c)

(d) model the stability of stars in terms of the balance between gravitational force and gas/radiation pressure and describe the stages in the evolution of low and high mass stars. (w(i)c)

10. THE UNIVERSE

How do we know that the universe is expanding?
How can we find out how old the universe is?

Candidates should:

(a) know how studies of the electromagnetic radiation from distant galaxies lead to a model of an expanding universe **and that the further they are away, the bigger their speed**.

(b) know that Red Shift measurements provide evidence that the universe started with a hot Big Bang which, according to current measurements, occurred 12-15 thousand million years ago.

ADDITIONAL SCIENCE BIOLOGY 2

For clarification of certain terms used in this unit, see note on page 17.

Cells and Cell Processes

1. CELLS

Are all cells the same?
Do all organisms grow and develop in the same way?
What are enzymes and is their activity constant?

Candidates should:

(a) observe that plant and animal cells are fundamentally similar but do show some differences in structure. Draw and label diagrams of plant and animal cells.

(b) understand that cell division enables organisms to grow, replace worn out cells and repair damaged tissues.

(c) know that plants and animals have different patterns of growth and development. Plants retain the ability to regenerate from undifferentiated cells more so than animals. Animals tend to grow to a finite size more so than plants.

(d) appreciate that embryonic, animal stem cells retain the ability to differentiate into different types of cells and so have potential for replacing damaged tissue. Discuss the issues surrounding this technology including the ethical dilemmas which have wider implications for society and which are beyond the scope of science to solve.
(w(i)d;(iv)a,b)

(e) know that chemical reactions in cells are controlled by enzymes and that enzymes are proteins made by living cells which speed up/catalyse the rate of chemical reactions. They work best at a particular pH and temperature. Boiling destroys enzyme action.

(f) plan and investigate experimentally the effect of temperature on enzyme action.

2. RESPIRATION

Why is respiration important to cells?
Is oxygen needed for respiration?
What is produced as a result of respiration?

Candidates should:

(a) know that aerobic respiration occurs in cells when oxygen is available. During aerobic respiration, chemical reactions occur, controlled by enzymes, which use glucose and oxygen, release energy and produce carbon dioxide and water. Understand the importance of this process to all cells, plant and animal.

(b) investigate experimentally energy release as heat during respiration.

(c) **understand that in the absence of oxygen, anaerobic respiration may occur. This is less efficient than aerobic respiration. In humans energy is released from glucose and lactic acid is produced. An oxygen debt may occur.**

3. SUBSTANCES ENTER AND LEAVE CELLS THROUGH THE CELL MEMBRANE.

How do substances enter and leave cells?
What is diffusion?
What is osmosis?
Why does some transport need energy?

Candidates should:

(a) know that diffusion is the movement of substances down a concentration gradient. The process does not require energy and only certain substances pass through the cell membrane in this way.

(b) **know that osmosis is the diffusion of water through a selectively permeable membrane, from a region of high-water concentration to region of low-water concentration.**

(c) **carry out experimental work using living plant material and visking tubing as non-living material and be able to interpret experimental results in terms of membrane pore and particle size: the pore size is large enough to allow water molecules through but restricts the movement of solute molecules.** (w(i)b)

(d) **understand active transport as an energy requiring process whereby substances can enter cells against a concentration gradient.**

4. ANIMAL NUTRITION

Why is digestion needed?
How does the digestive system work?
What happens to the end products?

Candidates should:

(a) know that fats, made up of fatty acids and glycerol, proteins, made up of amino acids, and starch (a carbohydrate), made up of a chain of glucose, in our food are insoluble. They are broken down during digestion into soluble substances so that they can be absorbed through the wall of the small intestine into the bloodstream. Consider the use of visking tubing as a model gut and the limitations of the model. (w(i)c)

(b) recognise and label on a given diagram of the human digestive system and associated structures: the mouth, oesophagus/gullet, stomach, pancreas, small intestine, large intestine, anus and understand the role of the following organs in digestion: mouth, stomach, pancreas, small intestine.

(c) know that during digestion, the breakdown of large molecules into smaller molecules is carried out by enzymes which are specific for each type of molecule.

(d) know that the body cells need the digested products of fats and carbohydrates to provide energy whilst amino acids are needed to build proteins in the body.

5. PLANT NUTRITION

Why is photosynthesis important to plants?
What do plants need to carry out photosynthesis?
What is produced as a result of the process?
Is photosynthesis affected by external factors?

Candidates should:

(a) understand the importance of photosynthesis whereby green plants use chlorophyll to absorb light energy and convert carbon dioxide and water into glucose, producing oxygen as a by-product.

(b) know that the rate of photosynthesis may be decreased by low temperature, shortage of carbon dioxide, low light intensity.

(c) investigate experimentally and/or using ICT/ simulations the effect of light intensity on the rate of photosynthesis. (w(i)b)

(d) know the uses made by plant cells of the glucose produced in photosynthesis.

Interdependence of Organisms

6. ENERGY AND NUTRIENT TRANSFER

Why are organisms dependent on each other?
Where does energy come from and where does it go?
What happens to waste materials?
Is decay a waste of resources?

Candidates should:

(a) use data to construct and interpret pyramids of numbers and biomass and understand that food chains and food webs show the transfer of energy between organisms. (w(i)a)

(b) know that radiation from the Sun is the source of energy for all ecosystems/communities of living organisms and that green plants capture a small percentage of the solar energy which reaches them.

(c) understand that at each stage in the food chain energy is lost in waste materials, in repair and maintenance of cells and as heat during respiration.

(d) know that materials decay because they are broken down by bacteria and fungi which use these digested materials for growth and other life processes so continually recycling materials. In a stable community, the processes which remove materials are balanced by processes which return materials.

(e) know that carbon is constantly recycled in nature by the carbon cycle via photosynthesis, food chains and respiration.

(f) know that when plants and animals die, microbes feed on their bodies bringing about decay. These microbes respire and release carbon dioxide into the atmosphere.

(g) understand what happens when decay is prevented. Burning fossil fuels releases carbon dioxide and substances which contribute towards acid rain.

(h) **know that nitrogen is also recycled through the activity of soil bacteria and fungi acting as decomposers, converting proteins and urea into ammonia. This is converted to nitrates which are taken up by plant roots and used to make new protein.**

(i) **investigate the action of urease on urea.**

7. THE IMPACT OF HUMAN ACTIVITY ON THE ENVIRONMENT

What effects do people have on the environment?
Can science help to understand these effects?
Can scientific knowledge be used to find alternative answers?
Should environmental issues stop economic development?
What agencies are involved in decision making?
Does loss of species matter?

Candidates should:

(a) using data/ICT investigate how the Earth's human population has changed over time and understand that the effects of human activity on the environment have also changed. (w(i)a)

(b) appreciate the need to collect detailed, reliable scientific information in order to assess the changes in species types and numbers and the use of such information as Environmental Impact Assessments prior to building developments. (w(i)a;(iv)a,b)

(c) explore information about the causes for the destruction of habitat and a reduction in biodiversity. Assess the need to balance the requirements for food, attitudes of people towards economic development and the needs of wildlife. (w(iv)b)

(d) discuss the advantages and drawbacks of intensive farming methods, such as using fertilisers, pesticides, disease control and battery methods to increase yields. Investigate the issues surrounding the question of the source of TB infection in cattle, including the role of the scientific community in planning valid experiments in order to inform policy decisions. (w(iv)a,b,c)

(e) **know that water may become polluted by fertilisers and untreated sewage which may cause rapid growth of water plants. The plants die and are decayed by microbes which use the oxygen in the water so affecting fish.**

(f) explore information about the heavy metals which are present in industrial waste and the types of pesticides used on crops. Some of these toxic chemicals enter the food chain, accumulate in animal bodies and may reach a toxic level. Understand the need to monitor the effects and control the use of these chemicals. (w(iv)a)

(g) explore information about the use of biological control agents and the introduction of alien species and their effects on the local wildlife. Understand the issues surrounding the use of biological control agents and how the approach to using this method of control has changed. (w(i)b;(iv)a,b,c)

(h) discuss the need for and issues surrounding sustainable development: the problem of increased consumption of resources and their continued supply; the problem of waste materials and recycling as a way of dealing with waste; use of degradable materials; development of Ecotourism. (w(iv)a,b)

(i) discuss the issues surrounding the maintenance of biodiversity and investigate ways by which biodiversity and endangered species can be conserved, including the role of different agencies and State organisations. (w(iv)a)

ADDITIONAL SCIENCE CHEMISTRY 2

For clarification of certain terms used in this unit, see note on page 17.

1. ATOMIC STRUCTURE

What makes atoms of different elements different from each other?

Candidates should:

(a) know that the relative masses of protons, neutrons and electrons and their relative electric charges are as shown:

	mass	charge
proton	1	+1
neutron	1	0
electron	negligible	-1

(b) understand that the atom as a whole has no electrical charge because the number of electrons in the orbits (shells) is equal to the number of protons in the nucleus.

(c) know that all atoms of a particular element have the same number of protons and atoms of different elements have different numbers of protons.

(d) understand the terms atomic number and mass number.

(e) use data given in the form $^{23}_{11}Na$ to give the number of protons, neutrons and electrons present in the atom. (w(i)a)

2. CHEMICAL BONDING, STRUCTURE AND PROPERTIES

How do atoms join together?
How can we explain the behaviour of different materials?

Candidates should:

(a) know that the uses of a material depend on its properties (the way it behaves) and that the properties are closely related to the structure and bonding within the material.

(b) know that modern materials are designed by chemists for specific purposes.

(c) examine the properties of substances and use collected data to classify substances as metals, ionic compounds, simple molecular covalent substances or giant covalent substances (w(i)a,c)

(d) use the accepted structural model for metals to explain their physical properties **and to explain differences in strength between metals such as sodium and aluminium** (w(i)c)

(e) compare the structure of a metallic glass with that of a typical metal and understand how it leads to differences in properties (w(i)c;(iv)a)

(f) **use their understanding of atomic structure to explain, diagrammatically or otherwise, how ions are formed and how ionic bonding takes place in simple binary compounds, for example, compounds of Li, Na, K, Mg or Ca with O, S, F or Cl** (w(i)c)

(g) use the accepted structural model for giant ionic structures to explain the physical properties of ionic substances such as sodium chloride (w(i)c)

(h) **use their understanding of atomic structure to explain, diagrammatically or otherwise, how covalent bonding takes place to form simple molecules, for example, hydrogen, chlorine, hydrogen chloride, water, methane and ammonia** (w(i)c)

(i) use the accepted structural model for simple molecular structures to explain the physical properties of simple molecular substances, for example, methane (w(i)c)

(j) recognise diagrams of the structures of diamond and graphite **and describe the bonding present** (w(i)c)

(k) **relate the uses of diamond and graphite to their properties** (w(i)c)

(l) **relate the properties of diamond and graphite to their structures and bonding** (w(i)c)

(m) **recognise the structure of carbon nanotubes from given diagrams and understand their intended use in miniature electronic circuitry** (w(i)c(iv)a)

(n) use given data to evaluate the benefits, risks and drawbacks of new developments in material science, such as metallic glasses, carbon nanotubes and new alloys (w(i)d;(iv)a,b)

3. THE PRODUCTION AND USE OF METALS

How can we make metals?
Can we use the same method for all metals?

Candidates should:

(a) examine the relationship between the method of extraction of a metal from its ore and its position in the Reactivity Series (e.g. aluminium, a reactive metal, is extracted by electrolysis; iron, a less reactive metal, by chemical reduction).

(b) use displacement and competition reactions of metals to determine their relative reactivity

(c) explain the terms reduction (removal of oxygen) and oxidation (gain of oxygen) and recognise their occurrence in reactions

(d) know that extraction of a metal requires the process of reduction

(e) know the meaning of the terms electrolysis, electrode, anode, cathode and electrolyte

(f) know the processes involved in the commercial extraction of aluminium, including being able to write and interpret word and **balanced symbol equations** for the reactions at the anode and cathode

(g) know the reasons for the high cost of the process and how those costs are minimised (w(iv)b)

(h) know that recycling aluminium uses only about 5% of the energy needed to extract it from bauxite and saves waste. (w(iv)b)

(i) discuss the factors affecting the siting of an aluminium extraction plant. (w(i)d;(iv)b)

(j) relate the uses of aluminium, copper and titanium to their properties

(k) relate the uses of different steels to their composition and properties

(l) know that steel is recycled on a large scale and that recycling steel saves 50% of the energy used in the extraction of iron, helps to conserve iron ore and also cuts down on the emission of greenhouse gases

(m) evaluate the social, economic and environmental impact of the use and extraction of metals (w(i)a,d;(iv)b)

4. CHEMICAL CALCULATIONS

How do scientists compare the masses of different atoms?
How can we work out the formula of a compound?
How much product can we get from a reaction?
Why is atom economy important?

Candidates should:

(a) know that atoms of different elements have different masses.

(b) know that the mass of an atom of an element is measured on a scale which compares masses of atoms with each other, and that this mass is called the relative atomic mass (A_r).

(c) be able to calculate the relative molecular (formula) mass (M_r) of a compound whose formula is supplied.

(d) **be able to calculate the formulae of binary compounds from given experimental data.**

(e) **be able to calculate the reacting masses of reactants or products, given a balanced symbol equation for the reaction.**

(f) **be able to calculate the percentage yield of a reaction** (w(iv)b)

(g) **be able to calculate the atom economy of a reaction from a given equation, using the relation**

$$\textbf{atom economy} = \frac{\textbf{theoretical mass of required product}}{\textbf{total mass of reactants used}} \times \textbf{100\%}$$

(w(iv)b

(h) **appreciate the importance of the concept of atom economy in assessing the level of waste in a reaction, e.g. by using given data to calculate and compare the atom economy of the traditional method of extracting Ti with the modern electrolytic method** (w(i)c;(iv)b)

5. AMMONIA AND FERTILISERS

What is a reversible reaction?
How do we make fertilisers?
What are the benefits and drawbacks of using fertilisers?

Candidates should:

(a) know that ammonia is made from atmospheric nitrogen by the reversible reaction

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

(b) **interpret given data to show how the yield of product depends upon the conditions used in the manufacture of ammonia** (w(i)a,d;(iv)b)

(c) know how nitrogenous fertilisers such as ammonium sulphate and ammonium nitrate are obtained by neutralising ammonia solution with sulphuric acid or nitric acid, respectively.

(d) evaluate the advantages and disadvantages of using nitrogenous fertilisers for individuals, communities and the environment. (w(i)a;(iv)b)

(e) **identify the presence of an ammonium salt by reaction with sodium hydroxide solution to produce ammonia gas.**

(f) **identify the alkaline gas ammonia by its action on damp red litmus paper**

6. ALKANES, ALKENES AND POLYMERS

What are polymers and how do we make them?
Why do some polymers soften when heated but others do not?
What are the benefits and drawbacks of the use of plastics?

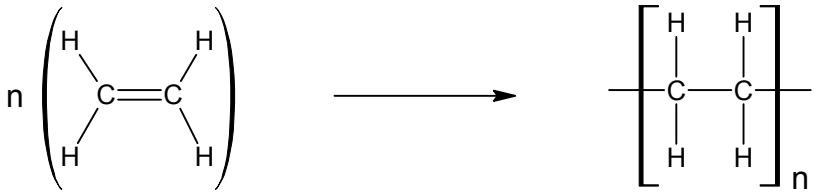
Candidates should:

(a) be able to write structural formulae for simple alkanes (C1-C5) and ethene

(b) **know the meaning of the terms saturated and unsaturated**

(c) know how large **saturated** hydrocarbons (alkanes) can be cracked by heating in the presence of a catalyst to form smaller more useful hydrocarbon molecules including monomers (alkenes) for making polymers

(d) know the process of addition polymerisation of ethene to produce polythene **and be able to write and interpret the following equation:**



ethene polythene

(e) **be able to draw the repeating unit for the addition polymers, poly(ethene), poly(tetrafluoroethene) (PTFE) and polyvinyl chloride (PVC) in the form:**

PTFE PVC

(f) relate the uses of polythene, PVC and PTFE to their properties (w(i)a,c;(iv)b)

(g) relate the uses of thermoplastics and thermosets to their properties and structure (w(i)a,c;(iv)b)

(h) use given data to compare the properties and uses of polymers and traditional materials. (w(i)a,d;(iv)a,b)

(i) evaluate the social, economic and environmental impact of the widespread use of plastic products, for individuals, communities and the environment. (w(i)a,d(iv)a,b)

7. SMART MATERIALS

What is a smart material?
Should smart materials be called 'intelligent'?
How can smart materials be used?

Candidates should:

(a) know that the term *smart material* has been given to a range of modern materials whose properties change with a change in the surroundings, such as changes in temperature, light, pH etc, for example:

- thermochromic paint, which changes colour when heated
- photochromic paint, which changes colour on exposure to light

- shape memory alloy, such as NiTi or nitinol, an alloy of nickel and titanium, which has the ability to regain it's original shape when heated; uses include coffeepot thermostat, superelastic spectacle frames, stents for veins, etc.

- shape memory polymer, which has the ability to regain its original shape when heated; potential uses include biodegradable surgical sutures that will automatically tighten to the correct tension and self repairing car bodies that will recover shape on gentle heating after a dent

- polymer gels, such as hydrogels, have a cross linked polymer structure inflated with a solvent, such as water; the gel has the ability to swell or shrink (up to 1000 times in volume) due to small changes in, e.g. temperature or pH; intended uses include artificial muscles, robot actuators, absorbers of toxic chemicals, etc. (w(i)c)

(b) use given data to evaluate the social, economic and environmental impact of the use of smart materials (w(i)d;(iv)a,b)

8. WATER

How is water made drinkable?
How can we measure the ability of a compound to dissolve?
Why does some water use a lot of soap?

Candidates should:

(a) describe in outline the treatment of the public water supply, using filter beds and chlorination.

(b) be able to draw and interpret solubility curves using given data on change of solubility with temperature

(c) know the causes of hardness in water and distinguish between a hard and a soft water by their action with soap

(d) plan and carry out experiments to measure the type (temporary or permanent) and amount of hardness using soap solution

(e) know how the methods of boiling, adding sodium carbonate and ion exchange work to soften water and discuss their advantages and disadvantages

(f) evaluate the advantages and disadvantages of soft and hard water (w(iv)b)

ADDITIONAL SCIENCE PHYSICS 2

For clarification of certain terms used in this unit, see note on page 17.

Radioactivity, Electricity, Forces and Motion
Radioactivity

1. RADIOACTIVE EMISSIONS

Where does radiation come from?
How dangerous is it?
How can I protect myself?

Candidates should:

(a) know that radioactive emissions from unstable atomic nuclei arise **because of an imbalance between the numbers of protons and neutrons.** (w(i)c)

(b) use secondary sources, e.g. the website of the Health Protection Agency, to investigate the sources of background radiation.

(c) be aware of the dangers associated with radon in the home and use secondary sources to investigate the geographical distribution of radon-affected houses, and the measures that can be taken against radon. (w(iv)a)

(d) investigate experimentally, or use secondary sources to investigate the penetrating power of nuclear radiation and to determine the types of radiation, α (alpha), β (beta) or γ (gamma) emitted by a radioactive material. (w(i)b)

(e) know how the different penetrating powers of α, β and γ radiation relate to the dangers of external and internal exposure to radioactive sources. (w(i)c)

(f) discuss the health risks associated with exposure to radioactive emissions, discuss the ethics of using radiation-based treatments and describe the precautions needed to protect medical staff and patients from over-exposure to radioactivity. (w(i)d;(iv)a,b)

2. THE HALF LIFE OF RADIOACTIVE MATERIALS

How long does a radioactive material last?

Candidates should:

(a) investigate experimentally, or using an ICT simulation or secondary sources, the decay of a short-lived radioactive material and determine its half life. (w(i)a)

(b) perform simple calculations involving the activity and half life of radioactive materials.

3. USES AND DANGERS OF RADIOACTIVITY

How can we make use of radioactivity and what problems are there?

(a) use physics knowledge to respond to information describing contemporary uses of radioactive materials, relating to the half life, penetrating power and biological effects of the radiation e.g. *radioactive tracers, carbon dating, thickness monitoring and cancer treatment.* (w(i)d)

(b) discuss the scientific and ethical problems associated with the long-term disposal of radioactive waste materials and appreciate the problems posed by the uncertainties in the behaviour of these materials and their containers over thousands of year. (w(i)d;(iv)b,c)

Electricity

4. SIMPLE ELECTRICAL CIRCUITS

How can we make control electricity and make measurements?

Candidates should:

(a) use voltmeters and ammeters to measure the voltage across and current through electrical components. (w(i)a)

(b) understand qualitatively, the relationship between current, voltage and resistance.

(c) select and use the equation:

$$\text{resistance} = \frac{\text{voltage}}{\text{current}}$$

(d) use a circuit, which includes a variable resistor, to investigate how current changes with voltage for a resistor (or wire) at constant temperature, a filament lamp and a diode. (w(i)a)

5. SAFETY FEATURES USED IN MAINS CIRCUITS

How do we protect ourselves from the dangers of electricity?

Candidates should:

(a) understand the roles of the live, neutral and earth leads and insulation in domestic electrical circuits.

(b) know how the earth lead and fuse operate to protect consumers against fire and electrical shocks. (w(iv)a)

(c) select and use the equation:

$$\text{current} = \frac{\text{power of appliance}}{\text{voltage}}.$$

to calculate the current taken by the appliance in normal use and hence the correct fuse required to protect the cable to the appliance.

(d) explain the roles of miniature circuit breakers (m.c.b.) and residual current devices (r.c.d.) and compare their actions to those of fuses. (w(iv)b)

(e) discuss how ideas of risk and cost play a part in deciding what voltage domestic electricity supplies should use and appreciate that different countries have adopted different voltages. (w(i)d;(iv)b)

Forces and Motion

6. DISTANCE, SPEED AND ACCELERATION

How can we measure and display motion?

Candidates should:

(a) describe motion using speed, acceleration, speed-time and distance-time graphs.

(b) select and use the equations:

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

and

$$\text{acceleration [or deceleration]} = \frac{\text{change in speed}}{\text{time}}$$

in the context of the motion of objects.

7. THE EFFECT OF FORCES

How do forces affect the movement of objects?
Why do things reach a steady speed?

Candidates should:

(a) investigate experimentally, e.g. using an air track and data logger, or computer simulation, the effect of balanced and unbalanced forces on an object. (w(i)a,b)

(b) select and use the equation:

$$\text{resultant force} = \text{mass} \times \text{acceleration}$$

(c) distinguish between the weight and mass of an object **and use the approximation that the weight of an object of mass 1 kg is 10 N.**

(d) use knowledge of forces and their effects to explain the behaviour of objects moving through the air, including the concept of terminal speed. (w(i)c)

8. INTERACTIONS BETWEEN OBJECTS

Where do forces come from?
How do objects gain or lose energy?
How do we keep ourselves safe in and around cars?

Candidates should:

(a) appreciate that forces arise between objects and that the forces on the two objects are equal and opposite

(b) know that when a force acts on a moving body, energy is transferred although the total amount of energy remains constant.

(c) select and use the equation:

$$\text{work} = \text{Force} \times \text{distance}$$

to calculate work / energy transfer, force or distance.

(e) **select and use the equations:**

$$\textbf{kinetic energy} = \frac{\textbf{mass} \times \textbf{speed}^2}{\textbf{2}}$$

and

$$\textbf{change in potential energy} = \textbf{mass} \times \textbf{gravitational field strength} \times \textbf{change in height}$$

(f) apply the principles of forces and motion to the safe stopping of vehicles, including knowledge of the terms reaction time, thinking distance, braking distance and overall stopping distance and discuss the factors which effect these distances. (w(i)c;(iv)a)

(g) apply the principles of forces and motion to an analysis of safety features of modern cars: air bags and crumple zones. (w(i)c;(iv)a)

(h) discuss the reasons for introducing speed restrictions and speed cameras to promote road safety. (w(i)d;(iv)b)

SEPARATE SCIENCES BIOLOGY 3

For clarification of certain terms used in this unit, see note on page 17.

Transport and Water Relations

1. HOW PLANTS TAKE UP WATER AND TRANSPIRE

Do plants have a circulatory system?
How are substances carried throughout a plant?
What evidence is there for this transport?
What substances do plants need?

Candidates should:

(a) understand the role of osmosis and transpiration in the movement of water through a plant.

(b) observe root hairs; investigate water loss in plants using a bell jar, nail varnish replicas to show stomata, the use of a simple potometer to demonstrate water uptake.

(c) know the role of xylem and phloem in transport within plants and carry out an investigation into the movement of a dye through the xylem.

(d) appreciate that modelling may be used to understand how processes may work as illustrated by the representation of areas of a plant by the model proposed by Munch and the uses and limitations of the model (details of Mass Flow hypothesis not required). (w(i)c)

(e) know the importance of water to plants and its use in photosynthesis, transport of minerals and support.

(f) know that for healthy growth plants require nitrate, potassium and phosphate.

(g) observe the effects of minerals on plant growth.

2. BLOOD AND CIRCULATION

Why do animals need a circulatory system?
How does the heart work?
What is blood and why is it important?

Candidates should:

(a) understand the need for and the structure of the human circulatory system and know that there are two separate circulations, one to the lungs and one to the other organs of the body.

(b) be able to draw and label diagrams of a white blood cell/phagocyte and a red blood cell and know the differences between them; know the functions of the four main parts of the blood: red cells, platelets, plasma, white cells.

(c) observe a dissected/model of heart and examine prepared slides of blood smears.

(d) know that the heart
- pumps blood around the body,
- is made mainly of muscle
- has its own blood supply through the coronary vessels

and that the blood flows to the organs through arteries and returns to the heart through veins.

(e) recognise and label on a given diagram of the heart: the atria, ventricles, valves, pulmonary artery, pulmonary vein, aorta and vena cava

(f) be able to describe the passage of blood through the heart including the functions of the valves in preventing backflow of blood.

(g) know that in the organs blood flows through very small blood vessels called capillaries. Substances needed by cells pass/diffuse out of the blood to the tissues, and substances produced by the cells pass/diffuse into the blood, through the walls of the capillaries.

3. WASTE PRODUCTS OF BODY FUNCTIONS ARE REMOVED BY THE KIDNEYS

Why do animals need an excretory system?
What parts make up the excretory system?
How does a kidney work?
What can be done if the system does not function?

Candidates should:

(a) know that the kidneys regulate the water content of the blood and remove waste products from the blood.

(b) recognise and label a given diagram of the human excretory system to show: kidneys, renal artery, renal vein, ureters, urethra, bladder.

(c) know that the waste, a solution containing urea and excess salts called urine, passes from the kidneys in the ureters to the bladder where it is stored before being passed out of the body. Interpret data about the level of substances present in urine and during passage through the kidney. (w(i)a)

(d) observe gross structure of a section through a kidney

(e) recognise and label a given diagram of a section through a kidney to include: cortex, medulla, pelvis, ureter and position of nephrons.

(f) **recognise and label a given simplified diagram of a nephron and its associated blood supply to show: capillary knot, Bowman's capsule, tubule, collecting duct, capillary network.**

(g) **understand the process of filtration under pressure and know that selective reabsorption of glucose, some salts, and much of the water takes place in the tubule.**

(h) know that the kidneys regulate the water content of the blood by producing dilute urine if there is too much water in the blood or concentrated urine if there is a shortage of water in the blood.

(i) know that kidney failure may be treated by a transplant or by a dialysis machine and compare the advantages and disadvantages of the use of these methods. (w(iv)a,b)

(j) **know that a diseased kidney may be replaced by a healthy one by transplant from a donor of a similar 'tissue type' to the recipient. The donor kidney may be rejected, attacked by the immune system, unless anti-rejection drugs are taken.** (w(iv)a)

(k) **understand that in a dialysis machine a person's blood flows between selectively permeable membranes. It is important that useful substances in the blood, such as glucose and salts, are not lost. To prevent this the dialysis fluid contains the same concentration of these substances as blood plasma. This ensures that only urea and excess salts and water diffuse into the dialysis fluid. This treatment has to be carried out at regular intervals.** (w(iv)a)

Microbes and Mankind

4. NATURE OF MICROBES

What are microbes and are there different types?
How are they seen?
How can they be grown?
How were their effects first proved?

Candidates should:

(a) know that microbes include bacteria, viruses and fungi. A bacterial cell consists of cytoplasm, cell membrane and a cell wall. There is no distinct nucleus. Bacteria reproduce by dividing into two.

(b) know that viruses are smaller than bacteria. They consist of a protein coat surrounding a small number of genes and can only reproduce inside a host cell. The production of new viruses results in the destruction of the host cell and the release of new viruses which can then attack new cells.

(c) know that yeasts are fungi. Yeast cells are larger than bacteria and have a nucleus, cytoplasm and a membrane surrounded by a cell wall. Yeasts reproduce by budding.

(d) understand the safe use of basic aseptic techniques involved in inoculating, plating and incubating microbes.

(e) investigate the presence of bacteria in milk using agar plates.

(f) explore information about the effect of temperature on the growth of bacteria and understand its application in food storage.

(g) understand how Pasteur used scientific method to devise experiments and make deductions. This resolved the controversy about the, traditionally held, theory of 'spontaneous generation', whereby non-living substances could give rise to life, and proved the role of microorganisms as the source of food spoilage. (w(i)b(iv)a)

5. MICROBES AND DISEASE

How does the body defend itself against infectious disease?
How does immunisation work?
What are antibiotics?
Are there problems with using antibiotics?

Candidates should:

(a) know that some microorganisms, called pathogens, cause diseases and intact skin forms a barrier against them. The body also defends itself by: blood clots to seal wounds; white cells in the blood ingest microbes, produce antibodies and antitoxins.

(b) understand that immunisation can be used to protect humans from infectious disease although it raises dilemmas for individuals and for society. Evaluate the factors influencing parents in decisions about whether to have children vaccinated or not including the roles of scientific evidence and public opinion. This indicates a moral responsibility which may ultimately be outside the scope of science. (w(i)d(iv)a,b)

(c) **know that an antigen is a protein, foreign to an individual, that triggers a response by some white blood cells which secrete antibodies specific to the antigen that is present. Antibodies destroy the cells bearing the antigen.**

(d) **assess data showing how, after an antigen has been encountered, memory cells remain in the body and antibodies are produced very quickly if the same antigen is encountered a second time. This memory provides immunity following a natural infection and after vaccination. The response is highly specific to the antigen involved.** (w(i)a)

(e) **understand why most people suffer from measles only once, but suffer from common colds many times during their lives.**

(f) **know that a vaccine contains antigens derived from a disease-causing organism which will protect against infection by that organism by stimulating the white blood cells to produce antibodies. The memory cells remain and, when the disease causing organism is encountered, the rapid response is triggered which makes a person immune. Vaccines may be produced against bacteria and viruses.**

(g) understand the effect of penicillin on bacteria growing on agar plates. Antibiotics, including penicillin, are medicines produced by living organisms which help to cure bacterial disease by killing the infecting bacteria.

(h) know that antibiotics may kill some bacteria, but not viruses and understand that resistant bacteria such as MRSA can result from the over use of antibiotics. Discuss the issues surrounding increasing bacterial resistance to antibiotics. (w(iv)a,b)

6. MICROBES CAN MAKE USEFUL PRODUCTS

What products are made by microbes?
What are the advantages of using microbes?
How is commercial production carried out?

Candidates should:

(a) know that there are advantages to using microbes for food production: rapid growth; contained growth so minimum space is used; predictable product is made under controlled conditions; they may grow on waste materials from other processes.

(b) know that in the production of yoghurt, a starter culture of bacteria is added to warm/30°C milk. The bacteria ferment the milk sugar/lactose, producing lactic acid. This causes the milk protein to form a solid material.

(c) know that in baking, a mixture of yeast, sugar and flour is left in a warm place. The yeast respires, producing carbon dioxide. The gas bubbles cause the dough to rise.

(d) investigate the factors that affect the rate of fermentation in yeast. (w(i)a,b)

(e) know that antibiotics, such as penicillin, are secreted by fungi which can be grown commercially.

(f) understand the advantages of growing a culture of the fungus *Penicillium* in a fermenter and the factors which influence its growth. The penicillin is extracted from the surrounding medium.

(g) know that enzymes bring about reactions at normal temperatures and pressures which would otherwise require expensive, energy demanding equipment.

(h) know that proteases are used to 'pre-digest' the protein in baby food and that pectinases are used for extracting fruit juice.

(i) investigate the extraction of fruit juice using pectinase.

(j) know that Biological washing powders contain digestive enzymes: lipases, proteases and carbohydrases and their use in removing stains from textiles.

SEPARATE SCIENCES CHEMISTRY 3

For clarification of certain terms used in this unit, see note on page 17.

1. ORGANIC CHEMISTRY

Are there patterns in the structures and reactions of carbon compounds?
How can we use enzymes to make chemicals?

Candidates should:

(a) investigate patterns in the molecular formulae and structural formulae of compounds within the homologous series alkanes, alkenes (ethane and propene) and (monohydric) alcohols (methanol and ethanol)

(b) be able to name and write full structural formulae for alkanes from C1 to C5, for the alkenes, ethene and propene and the alcohols, methanol and ethanol

(c) **be able to write structural formulae for the chain isomers of alkanes for C4 and C5**

(d) investigate the addition reactions of alkenes with hydrogen, bromine and bromine water in order to appreciate the patterns that exist **and to relate these patterns to unsaturation;** be able to describe the conditions for, and uses of, the reactions and write and interpret word and balanced symbol equations (w(i)a,c)

(e) know that enzymes are catalysts produced by living cells and understand how the rates of enzyme catalysed reactions are affected by temperature

(f) know how ethanol is made from sugars by the process of fermentation, the conditions used and the method of obtaining alcohol from the reaction mixture: be able to write and interpret a word or balanced symbol equation to represent the process

(g) know the use of ethanol in alcoholic drinks, as a solvent and as a fuel (e.g. methylated spirits).

(h) know that ethanol can be used as a fuel for cars, producing about 70% as much energy per dm^3 as petrol but the development of this use is affected by factors such as the amount of sunlight and arable land available in a country (w(iv)b)

(i) apply their understanding of the causes of combustion (fire triangle) to methods of fire prevention

(j) discuss the social, economic and environmental impact of the use of alcohol in drinks (w(i)d;(iv)b)

(k) know that ethanol, when exposed to air for a period of time, undergoes microbial oxidation to ethanoic acid (vinegar), which is a weak acid.

(l) know that ethanoic acid reacts with sodium carbonate solution to give off carbon dioxide gas and this reaction can be used to test for carboxylic acids.

2. SULPHURIC ACID

How do we make sulphuric acid?
Are all acids as strong as each other?

Candidates should:

(a) know the stages in the Contact process for the manufacture of sulphuric acid, being able to write and interpret word and balanced symbol equations for the reactions involved

(b) **interpret given data relating to the temperature, pressure and catalyst used in the manufacture of sulphur trioxide to show how the yield of product depends upon the conditions** (w(i)a;(iv)b)

(c) know that concentrated sulphuric acid can remove the elements of water from substances, such as sugar

(d) **be familiar with the stages in the development of the ionic model for acids and bases and use this model to explain acid behaviour and the terms *strong* and *weak* acid** (w(i)b,c;(iv)c)

(e) know that neutralisation involves the reaction of a base (including alkalis) with an acid to make a salt and water, is exothermic, **and can be summarised by the following equation:**

$$\mathbf{H^+ + OH^- \rightarrow H_2O}$$

(f) interpret given data about indicators (colour/pH) to recognise acidic, alkaline and neutral substances and the relative strength of acids and alkalis (w(i)a,c)

(g) investigate the reactions of dilute sulphuric acid as a typical strong acid and compare them with the reactions of ethanoic acid as a typical weak acid

3. CHEMICAL CALCULATIONS

How can we measure the amount of a substance?
How can we compare and measure the concentration of a dissolved chemical?

Candidates should:

(a) **know that the relative molecular (formula) mass of a compound in grams is equivalent to one mole of that substance.** (w(i)a,c)

(b) **calculate the molar mass of a compound whose formula is supplied.** (w(i)a,c)

(c) **convert the mass to amount of a substance in moles and vice versa, given formulae and relative atomic or molecular (formula) masses.** (w(i)ac)

(d) **calculate the concentration of a solution in mol dm^{-3}, given the amount of substance and volume of solution.** (w(i)a,c)

(e) **calculate the number of moles or mass of a substance in a solution of given volume and concentration (mol dm^{-3}).** (w(i)a,c)

(f) use titration data to compare the concentrations of solutions.

(g) **perform calculations involving neutralisation reactions in solution, given a balanced equation where appropriate.**

4. LIMESTONE

What is limestone made of?
Are there patterns in the reactions of carbonates, e.g., when heated?
Should we dig up beautiful countryside to quarry limestone?

Candidates should:

(a) investigate the thermal decomposition of the carbonates of calcium, copper and sodium and be able to write and interpret word and balanced symbol equations for any reactions that occur.

(b) investigate the reaction of quicklime with water to produce slaked lime and be able to write and interpret a word and balanced symbol equation for the reaction

(c) know that limestone is used in the production of iron and steel, in road-making, to neutralise soil acidity and to make cement.

(d) evaluate the social, economic and environmental effects of limestone quarrying. (w(i)a,c;(iv)b)

5. INORGANIC QUALITATIVE ANALYSIS

How can we find out what's in a compound?

Candidates should:

(a) use the following in problem-solving situations where they plan and carry out procedures to identify given substances:

- flame tests to distinguish between Na^+, K^+, Ca^{2+} and Mg^{2+} ions, describing any observations.
- precipitation reactions of NaOH(aq) with aqueous Mg^{2+}, Zn^{2+}, Fe^{2+}, Fe^{3+}, and Cu^{2+} ions in order to distinguish between them, writing word **and balanced symbol** equations for the reactions that occur.
- tests to identify NH_4^+, Cl^-, Br^- , I^- , CO_3^{2-} and SO_4^{2-} ions, being able to describe positive outcomes and write word **and balanced symbol** equations for the reactions that occur.
- tests for the gases oxygen, hydrogen, carbon dioxide and ammonia. (w(i)a)

(b) use the following practical techniques in problem-solving situations where they plan and carry out procedures to analyse mixtures, separate substances from reaction mixtures and purify substances:

- chromatography
- distillation
- filtration
- crystallisation

SEPARATE SCIENCES
PHYSICS 3

For clarification of certain terms used in this unit, see note on page 17.

Electromagnetic Induction, Waves, Motion & Nuclear Physics

Electromagnetic Induction

1. ELECTROMAGNETIC INDUCTION AND GENERATORS

How is electricity generated?

Candidates should:

(a) investigate the conditions in which a current is induced in circuits by changes in magnetic fields and the position of wires. (w(i)a-c)

(b) consider the benefits of a pictorial model of electromagnetic induction in terms of cutting or changing flux. (w(i)b)

(c) use knowledge of electromagnetic induction to explain the operation of a simple a.c. electric generator including the factors upon which its output depends.

(d) apply Fleming's Right Hand Rule to the situation where a coil rotates in a magnetic field. (w(i)c)

(e) understand how the use of a radial field, multiple coils and electromagnets improves the effectiveness of modern generators. (w(iv)a)

2. TRANSFORMERS

How can we increase or decrease the voltage?

Candidates should:

(a) investigate model transformers experimentally, e.g. using linked C-cores or demountable transformers, know qualitatively how the output voltage depends upon the number of turns on the coils and explain their operation qualitatively by reference to electromagnetic induction.

(b) **select and use the equation:**

$$\frac{V_1}{V_2} = \frac{N_1}{N_2}$$

in the context of 100% efficient step-up and step-down transformers.

Waves

3. REFRACTION OF PLANE WAVES

Why does refraction occur?

Candidates should:

(a) distinguish between transverse and longitudinal waves.

(b) explain refraction in terms of the speed of waves on either side of a refracting boundary. (w(i)c)

(c) draw and interpret diagrams of plane waves being reflected or refracted at plane boundaries, *e.g. as shown in the ripple tank*. (w(i)b)

4. ULTRASONIC WAVES

How do ultra scans work?
What can ultrasound be used for?

Candidates should:

(a) understand the nature of ultrasonic waves.

(b) understand the conditions under which the reflection of ultrasonic waves occurs, the wavelength requirements for a useful image and the consequence for the useful frequencies for ultrasonic waves.

(c) **select and use the equation:**

$$\textbf{wave speed} = \textbf{frequency} \times \textbf{wavelength}$$

in the context of ultrasonic waves

(d) use physics knowledge to respond to information describing contemporary uses of ultrasound including cleaning, medical and industrial scanning, *e.g. fault finding in castings*. (w(iv)a)

5. SEISMIC WAVES

What are seismic waves?
How can scientists use them to probe the structure of the Earth?

Candidates should:

(a) understand the properties of seismic P-waves, S-waves and surface waves, in terms of their nature, speed and ability to penetrate different materials

(b) **select and use the equation:**

$$\textbf{speed} = \frac{\textbf{distance}}{\textbf{time}}$$

in the context of seismic waves.

(c) interpret the information on simplified seismic records, including the lag time and the presence or not of S-waves to reveal information about the location of an earthquake. (w(i)b)

(d) know how the study of seismic records, including the identification of an S-wave shadow zone, has enabled geo-physicists to investigate the structure of the earth, leading to a model of a solid mantle and a liquid core. (w(i)c)

Motion

6. MOTION

How can I find out the speed and position of objects which are accelerating?
What happens when objects collide?
How do things change direction?

Candidates should:

(a) develop their understanding of motion to include an appreciation of the importance of direction and to distinguish between speed and velocity.

(b) develop their ability to use velocity-time and distance-time graphs in order to determine acceleration, mean velocity and distance travelled.

(c) appreciate that the motion of objects can be modelled using the equations

$$v = u + at$$
$$\mathbf{v^2 = u^2 + 2ax}$$
$$\mathbf{x = ut + \tfrac{1}{2}at^2}$$
$$x = \tfrac{1}{2}(u + v)t,$$

understand the condition under which these equations are valid and select and use these equations to solve problems. (w(i)c)

(d) explore experimentally, or using IT simulations, the collisions of objects under conditions in which externally applied forces are negligible, to develop an appreciation of the significance of the momentum of a body. (w(i)a-c)

(e) select and use the equation:

momentum = mass × velocity

(f) understand qualitatively that change in momentum is related to the force and the time for which it acts and apply this in a given situation, *e.g. crumple zones, air bags*. (w(iv)a)

(g) **use the law of conservation of momentum to perform calculations involving collisions or explosions, including selecting and use the equation.** (w(i)b)

$$\textbf{kinetic energy} = \frac{\mathbf{mv^2}}{\mathbf{2}}$$

to compare the kinetic energy before and after a collision.

(h) **know that change in momentum is related to the force and time according to the equation**

$$\textbf{Force} = \frac{\textbf{change in momentum}}{\textbf{time}},$$

select and use the equation to calculate Force, change in momentum or time.

(i) **know that changes in the direction of motion require a force to be applied and that, in the case of motion in a circle at a constant speed, the resultant force acts towards the centre of the circle.**

(j) **understand how space scientists use the concepts of conservation of energy and momentum in working out energy-saving sling-shot orbits in the exploration of the Solar System**. (w(iv)a)

Nuclear Physics

7. ATOMIC STRUCTURE

How did scientists work out what atoms are like?
What happens to an atom when it decays?
How can we use the decay of uranium to help us date rocks?

Candidates should:

(a) know that Thomson developed the plum pudding model of the atom in an attempt to explain its properties, that the results of the α-particle scattering experiment were incompatible with this model and this led Rutherford to propose the nuclear model.

(b) **appreciate qualitatively how the nuclear model was further developed by Bohr to explain atomic spectra.** (w(i)b,c)

(c) understand the terms *mass [or nucleon] number(A), atomic [or proton] number(Z)* and *isotope* and relate them to the number of protons, neutrons and electrons in a neutral atom.

(d) use nuclear symbols of the form ${}^{A}_{Z}\mathrm{X}$ in the context of transformations including radioactive decay, nuclear fission and nuclear fusion, **and use them in producing nuclear equations from data and balancing them.**

(e) recall and use the symbols ${}^{4}_{2}\alpha$, ${}^{4}_{2}\mathrm{He}$, ${}^{0}_{-1}\beta$, ${}^{0}_{-1}\mathrm{e}$ for alpha and beta particles.

(f) **use tables of isotopes to investigate nuclear decay series and appreciate the significance of these to investigations into the age of rocks and the age of the Earth and Solar System.** (w(i)c,d;(iv)c)

8. NUCLEAR FISSION

How does nuclear fission work?
How can we control fission in nuclear reactors?

Candidates should:

(a) know that processes which result in the splitting of heavy nuclei into lighter fragments (nuclear fission) release energy.

(b) recall that $^{235}_{92}\mathrm{U}$ and $^{239}_{94}\mathrm{Pu}$ undergo spontaneous fission with the emission of neutrons and that they also undergo induced fission when hit by neutrons.

(c) know how the induced fission of $^{235}_{92}\mathrm{U}$ and $^{239}_{94}\mathrm{Pu}$ can lead to an uncontrolled chain reaction releasing very large amounts of energy in a nuclear explosion and know how this is controlled in nuclear reactors. (w(iv)a)

(d) know that both controlled and uncontrolled fission reactions result in large quantities of unstable neutron-rich fission products, with a wide range of half lives. (w(iv)a)

9. NUCLEAR FUSION

How do stars obtain their energy?
Could we use the same process to provide energy on the Earth?

Candidates should:

(a) understand that processes which combine light nuclei, such as hydrogen and helium, into heavier nuclei (nuclear fusion) release energy.

(b) be able to provide a simple description of nuclear fusion in terms of combining hydrogen nuclei to produce helium nuclei under conditions of very high temperature and pressure such as those found in the Sun.

(c) know why it has been difficult to replicate this under controlled conditions on the Earth, but that there is a very large potential fuel supply in the form of deuterium $\left(^{2}_{1}\mathrm{H}\right)$ in the oceans. (w(i)d)

(d) recognise and discuss the following fusion reaction as a potential source of energy:

$$^{2}_{1}\mathrm{H} + ^{3}_{1}\mathrm{H} \rightarrow ^{4}_{2}\mathrm{He} + ^{1}_{0}\mathrm{n}$$

(w(iv)d)

6 INTERNAL ASSESSMENT

The Nature of the Tasks which may be used for Internal Assessment

(i) There are three types of task which may be used for Internal Assessment
- Practical Task
- Extended Report
- Planning Task

(ii) In each of GCSE *Science* and *Additional Science*, candidates should undertake **three** tasks: one in each discipline, Biology, Chemistry and Physics. Of these tasks, **at least two** should be Practical Tasks and **one** may be an Extended Report.

(iii) In each of GCSE *Biology*, *Chemistry* and *Physics*, candidates should undertake **three** tasks. Of these tasks, **at least one** should be a practical task, **one** may be an Extended Report and **one** may be a Planning Task.

(iv) All three types of Internal Assessment task are marked out of 25 and are untiered, producing a maximum raw Internal Assessment mark for all specifications of 75.

(v) Details for these tasks are given below.

General Principles for the Assessment of Practical Tasks

(i) The assessment of practical work is carried out by teachers as part of the normal teaching process and must be in the context of the subject content of the relevant specification and based upon the skills developed throughout the course.

(ii) Assessments will be made in two main skill areas:

A. Carrying Out procedures and Recording Information;

B. Planning, Analysis and Evaluation.

(iii) Assessment is via exercises provided by the board and marked by the teacher.

(iv) Both skill areas could be assessed in one exercise. Alternatively, *Carrying out* and *Recording* could be assessed on one occasion with *Planning, Analysis* and *Evaluation* assessed separately using a different assessment exercise.

(v) Data obtained in class activities could be used by candidates for *Analysis* and *Evaluation.* Data generated from other sources could also be used for these skill areas.

(vi) It is envisaged that each assessment exercise covering both skill areas will take approximately two hours of normal lesson time. The time could be divided into two sessions, the first session involving *Carrying out and Recording* to obtain data and the subsequent session involving the processing of the data. It would be preferable for the candidates if the two sessions were close together.

(vii) Suitable practical activities will be provided by the WJEC for use in centres (see booklet: Assessment of Practical Work). For each of the activities, the following will be provided:

- guidance notes for the supervising teacher, including apparatus requirements;
- an exercise for completion by the candidates, including instructions and a series of questions;
- a marking scheme for teachers to use in the assessment of their pupils.

(viii) Centres may select the assessment exercises they wish to use from the list of suitable assessed practical exercises supplied by the Board.

(ix) Centres may, if they wish, substitute other assessments for the ones provided by the WJEC. In this case, they must submit proposals for approval to the WJEC six months in advance. The proposal should consist of the same information as in (vii). The aim of submitting the proposed assessments is to achieve consistency of demand between assessments and no assessment should be used unless it has been approved.

(x) In principle, almost any piece of practical work could be used for internal assessment. There is no requirement for it to be an investigation of the effect of one variable upon another. Areas of practical activity such as microscope work, fieldwork, qualitative analysis and the determination of a physical quantity, which were ruled out of the previous Science 1 scheme, are available for assessment. It is hoped that the quantity of practical work undertaken by candidates will be larger than in the recent past, as any practical activity could be used to prepare candidates for internal assessments.

(xi) Candidates may undertake any number of practical assessments, with the best marks in each of the two skill areas, A and B, being submitted. Skill areas A(i) and A(ii) [see paragraph (xv) below] must be assessed together, as must skill areas B(i), B(ii) and B(iii).

(xii) A candidate may not undertake the same assessment on more than one occasion, nor be assessed on an activity which has previously been encountered as a class activity.

(xiii) The assessed work may involve group working for the *Carrying out* skill. However, all written work should be that of the candidate only. The assessments should be carried out under supervised conditions and under no circumstances should work be removed from the laboratory by the candidate or amended subsequently. If the skill areas are addressed over two sessions, the exercises should be collected by the supervisor and kept under secure conditions in between sessions.

(xv) The list of assessed practical tasks will be reviewed annually. Some tasks may be withdrawn and others added at the Board's discretion. A practial which has been withdrawn is no longer available for assessment purposes.

(xvi) Marking is to be carried out by the supervisor according to the specific marking schemes supplied by the board for each practical exercise.

A generic marking scheme is shown below showing the skills to be assessed and examples of possible aspects for which marks may be allocated.

Skill Areas			Marks
A.	(i)	Carrying Out Procedures. Teacher assessment of candidates' ability to follow instructions; contribute to group activity; work safely.	
	(ii)	Recording Information. Table of data with marks allocated for construction of table, headings and units or drawings with marks allocated for labelling.	**10**
B.	(i)	Analysis Marks allocated for processing data; interpretation of data; graphical representation of data; drawing conclusions.	
	(ii)	Evaluation. Marks allocated for consideration of the procedure; the results; validity of the conclusion; suggestions for further work.	
	(iii)	Planning **Either** extend the instructions of the current task **or** use the experience gained from the task to plan a subsequent procedure **or** a combination of the two.	**15**
		Total	**25**

This generic markscheme may be varied slightly as marks are allocated for specific practical activities as appropriate. Not all aspects are addressed on all occasions, but 5 marks will be allocated for planning in each activity.

General Principles for the Assessment of Extended Reports

(i) An extended report is a written task undertaken individually by a candidate. It can take the form of either a report or a presentation. The candidate carries out research into available information about a relevant topic in the specification, e.g. the desirability of erecting wind-farms, analyses and discusses the information, draws conclusions and communicates the findings. The communications could take the form of a written report, a poster display or a presentation.

(ii) Sufficient work for the extended report should be carried out under teacher supervision to enable the supervisor to authenticate the work with confidence as being the candidate's own.

(iii) The Extended Report is assessed under the following headings:

Planning
Collecting and Presenting Information
Analysing Information and Summarising Issues
Evaluating the data and their method of collecting it
Drawing conclusions and presenting them

The criteria for these headings are to be found in Appendix 7.

General Principles for the Assessment of Planning Tasks [Separate Sciences only]

(i) A Planning Task is a paper exercise in which the candidates, working individually under supervision, plan an experimental investigation. The investigation could be one into the relationship between variables or a forensic-style investigation into the nature of unknown materials.

(ii) The Planning Task should involve contexts and be of a complexity appropriate for candidates across the whole range of achievement. It should be submitted to the Board for prior approval.

(iii) The candidates should be presented with an unseen experimental problem involving concepts which they have met in the course. The task should be presented in a written format containing all the information required by the candidate.

(iv) The time allowed for the completion of the Planning Task is 50 minutes and it should be carried out individually under controlled classroom conditions.

(v) The Planning Task should require them to:

		Marks
a.	Identify the aim of the investigation	[2]
b.	Relate the investigation to theory and make a prediction, as appropriate.	[3]
c.	Identify apparatus which is to be used and indicate how it is to be used.	[3]
d.	In the context of an investigation of the relationships between variables, identify the independent, dependent and controlled variables, and biological control as appropriate, stating the units of measurement of the variables, if appropriate. In the context of a forensic-style investigation, explain the appropriateness of the techniques and the way in which they will be used to make identifications.	[5]
e.	Make an assessment of significant risks and state how they will be minimised.	[2]
f.	Describe the experimental procedure; the description to include or consist of: • the sequence of activities • the use of repeats and precautions to ensure accuracy and reliability • any necessary preliminary work to establish sensible ranges • the anticipated method of displaying/analysing results to produce a conclusion • a coherent, scientific account	[10]
	Total Marks	**25**

(vi) Candidates may undertake as many Planning Tasks as desired with the best mark being used in the final assessment, but no candidate may retake a specific Planning Task for Internal Assessment purposes, nor use a planning task which is very similar to exercises previously met in lessons.

The submission of Internal Assessment Marks

(i) The marks should be submitted on *C-forms* using the standard WJEC procedures.

(ii) The marked work should be retained by centres and an appropriate sample, using standard WJEC procedures, should be sent off for moderation in accordance with instructions supplied by WJEC.

Marking and standardisation of internal assessment

Where more than one teacher is involved in assessment, centres are responsible for standardising assessment across the teachers and the teaching groups in order to produce uniform standard across all candidates.

Centres may be required to submit work to a Moderator in the following instances:

(i) if standardisation of assessment between teachers is not achieved;

(ii) where there has been a major misinterpretation of the syllabus requirements;

(iii) where a significant adjustment has been necessary to a centre's marks in the previous year's examination.

Supervision and authentication

(i) Before the course starts, the supervising teacher is responsible for warning candidates of the WJEC regulations concerning malpractice. Candidates are forbidden to indulge in any unfair practice in the preparation of work required for assessment as part of the examination. Any candidate who uses, or is suspected of using or attempting to use, any unfair means is to be reported to the WJEC immediately.

(ii) Centres entering candidates will be expected to provide sufficient supervision to enable them to give an assurance that the work submitted is the work of the candidates concerned. **The work must be conducted in the laboratory/field under the direct supervision of teachers.**

Recording and submission of assessments

(i) The Individual Candidate Record Sheets for those candidates whose work is selected for moderation should be posted, together with the centre's sample, to the moderator by the end of the Easter term. [The exact date will be given in the Coursework Manual, which centres will receive earlier in the term]. The remainder must be retained by the centre, should a further sample be required.

(ii) Instructions relating to the selection of candidates' work for moderation will also be given in the Coursework Manual. A sample covering each qualification for which candidates are entered should be submitted.

Moderation and supporting evidence

(i) It is necessary to provide some method of moderating internal assessments of candidates' work to ensure that no injustice occurs to candidates as a result of variation in the standards applied by different centres.

(ii) The WJEC will provide centres with further details of the moderation procedures including arrangements for:

- calling for additional samples, or for all relevant work from all candidates;
- establishing whether a centre's assessments need adjustment, determining the nature of any required adjustment and making the necessary changes;
- giving centres details of and, where necessary, reasons for any adjustments made;
- providing further guidance where the WJEC judges that teachers are uncertain about requirements.

(iii) For each candidate included in the sample, the work provided for inspection by a moderator must support the final mark submitted. The evidence must be presented in a clear and helpful way for the moderator, and must be marked appropriately.

(iv) Normally a centre's judgements about the attainment order of candidates will be accepted. Adjustments to the practical assessments submitted by a centre made on the basis of the initial sample will normally ensure that the order of merit is unaltered, and will be made to bring a centre's assessments into line with standards generally. Where major discrepancies are found, the WJEC reserves the right to alter the order and inform the centre accordingly.

(v) The inspection of the work of additional candidates may be required in cases where the scrutiny of the initial sample indicates particular inconsistency of standards.

(vi) After results have been issued, centres will be notified of any adjustments made. Where major adjustments are made to a centre's recommendations, or where the order of merit is changed, a report will be sent to the centre explaining the reasons for these changes.

(vii) Samples of practical work will be returned to centres by the Autumn term following the examination.

Problems with individual candidates

(i) In a scheme of internal assessment of candidates' work, teachers should be able to accommodate occasional absence by ensuring that the opportunity is given for candidates to make up assessments missed by absence.

(ii) The marks for candidates where no assessment can be made for one or more skills should be aggregated in the normal way, using a zero where no assessment is possible. Where it is not possible to make any assessment for a candidate for the coursework as a whole, no mark should be awarded and 'ABS' should be recorded on the Individual Candidate Record Sheet.

(iii) Where, as a result of illness or other exceptional circumstances, the work available from a candidate does not meet the scheme's requirements or where it meets the requirements but does not support the mark which the centre feels appropriate for the candidate, the centre should provide all relevant information about the circumstances of the assessment made by submitting a request for special consideration to the WJEC, using the relevant form, accompanied, as appropriate, by medical evidence. A similar procedure should be followed in cases where a candidate has completed work but is eligible for adjustments (see 'Regulations and Guidance' reference p.5).

(iv) Where work is misplaced in circumstances beyond the candidate's control, the WJEC should be notified immediately of the date of the loss, how it occurred and upon whom the responsibility for the loss rests. The WJEC will provide details of the procedures to be followed in such cases.

(v) Where special help, which goes beyond the normal learning support, is given the WJEC must be informed so that account can be taken of such help when assessment and moderation takes place.

(vi) Candidates who move from one centre to another during the course sometimes present a problem for a scheme of internal assessment. Possible courses of action depend upon the stage at which such a move takes place. If the move occurs early in the course the candidate should be able to be catered for by the centre to which he or she moves. If the move occurs late in the course it might be possible to accept the assessments made at the previous centre. In situations in which a candidate transfers from one centre to another, and the action to be taken is unclear, the WJEC should be informed as soon as possible by the centre to which the candidate has been transferred so that consideration can be given to the particular case and to the most appropriate course of action.

(vii) It is appreciated that problems can arise with a scheme of internal assessment in a situation where a teacher leaves a centre during the period of assessment. It is hoped that the keeping of complete and effective records of assessment will reduce the problems arising from a change of teaching staff and should enable another teacher to take over.

Retention of evidence

Centres are asked to retain candidates' marked practical work under secure conditions, as far as is practicable, until 31 October following the examination, to allow for the possibility of enquiry about results or a request for a review of results.

7 GRADE DESCRIPTIONS

Grade descriptions are provided to give a general indication of the standards of achievement likely to have been shown by candidates awarded particular grades. The descriptions must be interpreted in relation to the content specified by the specification; they are not designed to define that content. The grade awarded will depend in practice upon the extent to which the candidate has met the assessment objectives overall. Shortcomings in some aspects of the examination may be balanced by better performances in others

Grade F

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

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

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

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

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

Grade C

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

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

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

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

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

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

Grade A

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

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

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

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

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

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

Appendix 1

Mathematical Demands

The following mathematical understanding and abilities will be expected for all candidates, unless emboldened. The emboldened abilities will only be expected for the more able candidates i.e. those entered for the Higher tier paper.

1. The ability to perform simple mathematical operations involving the four basic rules of addition, subtraction, multiplication and division.

2. The ability to use vulgar and decimal fractions.

3. **The ability to use percentages in calculations.**

4. **An understanding of the ideas of direct and inverse proportions.**

5. The ability to construct and interpret graphs.

6. **The ability to determine the slope of and the area under a straight line graph.**

7. **The ability to use and understand standard form**.

8. The ability to select, use and **rearrange** simple formulae.

Appendix 2

The style of questions involving equations in Physics papers at GCSE

Equations are described in the specification as "select and use" and will be treated as follows:

- Low demand questions, those aimed at grades E, F and G, which form about 70% of marks on Foundation Tier papers will include the equation, in the form in which candidates will be expected to use it. Any term in the equation could form the subject and candidates will not need to transpose it.

  e.g. the equation relating speed, distance and time could be presented as:
  $\text{speed} = \frac{\text{distance}}{\text{time}}$, $\text{distance} = \text{speed} \times \text{time}$ or $\text{time} = \frac{\text{distance}}{\text{speed}}$,
  depending on the requirements of the question.

- Intermediate demand questions, those aimed at grades C and D, which form about 30% of the marks on Foundation papers and about 50% of marks on Higher Tier papers, will instruct the candidates to select the relevant equation from a list of equations. These equations will be on page 2 of the examination paper. The use of the equation will be confined to the form in which it is presented in the list and, as with the low demand questions, any term in the equation could be the subject. There will be a mark available for the correct selection of the equation.

- Higher demand questions, those aimed at grades A*, A and B, which form about 50% of marks on Higher Tier papers, will instruct the candidates to select the relevant equation from a list of equations. The candidates may be expected to manipulate the equation. There will be a mark available for the correct selection of the equation.

Appendix 3

Lines of best fit

If there is a continuous relationship between the two variables plotted on a graph, a line of best fit should be drawn joining, or approximating to, the points. Mathematical relationships may be deduced from this line.

In a great deal of biological data there is no such continuous relationship. In this case a series of straight lines should be used to join successive points. The values between the points cannot be shown on the graph and cannot be deduced from the readings. A smooth curve should therefore only be used if there is good reason to think that the intermediate values would fall on that curve. Joining points by straight lines indicates that the points in between recorded points are unknown and, in addition, how they vary between recorded points is also unknown.

In some disciplines a 'line of best fit' is regarded as the norm and the possibility of straight line joining of points is not considered. Therefore, an awareness of the particular requirements for presenting biological data is required and the need for appropriate explanation to enable an understanding of why this difference occurs.

Appendix 4

Quantities and Units

Candidates will be expected to be familiar with the SI units of quantities referred to in the specification, e.g. in Physics 1, the equation power = voltage × current is specified, so candidates will be expected to be familiar with watt, volt and amp and their symbols; W, V and A. Exceptions to this rule are indicated in the content of the specification, so the costing of domestic electricity involves the use of hours (h), kilowatts (kW) and kilowatt hours (kWh).

With the exception of cm, km and kW, only basic SI units will be used on foundation tier papers. Apart from this, the use of SI multipliers and standard notation will be restricted to higher tier papers.

Appendix 5

EXEMPLIFICATION OF KEY SKILLS

Key Skills	Examples of opportunities for developing the key skill or for generating key skills portfolio evidence NB these are illustrative only
N1.1 Interpret straightforward information from **two** different sources. At least **one** source must include a table, chart, diagram or graph.	Investigations and/or experiments lend themselves to all aspects of application of number.
N1.2 a Carry out and check calculations to do with amounts and sizes.	Investigations and/or experiments lend themselves to all aspects of application of number.
N1.2 b Carry out and check calculations to do with scales and proportion.	Investigations and/or experiments lend themselves to all aspects of application of number.
N1.2 c Carry out and check calculations to do with handling statistics.	Investigations and/or experiments lend themselves to all aspects of application of number.
N1.3 Interpret the results of your calculations and present your findings two different ways using charts or diagrams.	Investigations and/or experiments lend themselves to all aspects of application of number.

C1.1 Take part in a **one-to-one** discussion and a **group** discussion.	One-to-one and group discussion on a scientific issue e.g. conservation, electricity generation.
C1.2 Read and obtain information from at least **one** document.	Answers to questions requiring information from two sources e.g. a text book, a worksheet or the Internet.
C1.3 Write **two** different types of documents.	A report or an essay including diagrams on a selected topic e.g. cell structure, the solar system.
ICT 1.1 Find and select relevant information.	Search for scientific data, written/visual sources on a website or CD ROM. The information found would be used to inform a discussion, develop an assignment, contribute to practical work etc. e.g. endangered species, Tetra radio masts.
ICT 1.2 Enter and develop information to suit the task	The information gained from a search of sources e.g. the Internet could be presented using various formats.
ITC 1.3 Develop the presentation so that the final output is accurate and fit for purpose.	The information could be presented as a leaflet or 'publicity' poster e.g. on endangered species, campaign material for and against wind farms.

WO1.1 Confirm you understand the given objectives and plan for working together.	A group activity in Science e.g. students contribute jointly to the planning of an experiment/investigation.
WO1.2 Work with others towards achieving given objectives.	Students establish links with other members of the class to gather information/illustrations or produce texts/diagrams/drawings. They exchange ideas with other members of the group.
WO1.3 Identify ways you helped to achieve things and how to improve your work with others.	Review of the progress made in collecting and presenting the information or evidence reflecting on ways in which collaborative working could be improved.
LP1.1 Confirm your targets and plan how to meet these, with the person setting them.	Establish with the teacher, targets for enhancing performance. (e.g. identification of a topic and plan of action for an extended study).
LP1.2 Follow your plan, to help meet targets. Improve your performance.	Produce a log showing stages of development of an extended study in accordance with targets.
LP1.3 Review your progress and achievements in meeting targets, with an appropriate person.	Keep a portfolio of tasks which have been assessed during a course of study and how, possibly through a log, learning and performance have been improved from comments, both verbal and written, made by the teacher and others.

PS1.1 Confirm with an appropriate person that you understand the given problem and identify different ways of tackling it.	Students choose a Scientific topic for an extended essay and make notes or essay plans considering two ways of approaching it. This could involve group/ class discussion of aspects/approaches and of possible sources of information (e.g. alternative ways of finding information). The topic might itself contain problems on which there are different Scientific perspectives.
PS1.2 Confirm with an appropriate person what you will do and follow your plan for solving the problem.	Present notes or essay plan which is discussed with the teacher and then executed through the writing of a piece of work. Review the piece of work produced with a view to modifying, expanding or restructuring it.
PS1.3 Check with an appropriate person if the problem has been solved and how to improve your problem solving skills.	Discuss with the teacher the piece of work to ensure that the problem or issue has been addressed appropriately. Describe the results in a log of procedural research.
N2.1 Interpret information from a suitable source.	Investigations and/or experiments lend themselves to all aspects of application of number.
N2.2 a Carry out calculations with amounts or sizes.	Investigations and/or experiments lend themselves to all aspects of application of number.

N2.2 b Carry out calculations with scales and proportions.	Investigations and/or experiments lend themselves to all aspects of application of number.
N2.2 c Carry out calculations with handling statistics.	Investigations and/or experiments lend themselves to all aspects of application of number.
N2.2 d Carry out calculations with using formulae.	Investigations and/or experiments lend themselves to all aspects of application of number.
N2.3 Interpret the results of your calculations and present your findings.	Investigations and/or experiments lend themselves to all aspects of application of number.
C2.1 a Take part in a group discussion.	Classroom discussion on a scientific issue e.g. conservation, electricity transmission.
C2.1 b Give a short talk of at least four minutes.	Use an OHP to give a brief explanation of a scientific topic to others e.g. differences between plant and animal cells/how simple a.c. generators work, nuclear fission and fusion.
C2.2 Read and summarise information from **two** documents about the same subject. Each document must be a minimum of 500 words long.	Notes or annotations of different sources relating to a scientific topic e.g. fossil record as evidence for evolution, evidence for the 'Big Bang'.

C2.3 Write two different types of documents each one giving different information. One document must be at least 500 words long.	Write an account or report which includes a diagram, chart or graph on a scientific topic e.g. food chains/the arrangement of electrons in atoms.
ITC 2.1 Search for and select information to meet your needs. Use different information sources for each task and multiple search criteria in at least one case.	Search for scientific data, written/visual sources on a website or CD ROM. The information found would be used to inform a discussion, develop an assignment, contribute to practical work etc. e.g. endangered species.
ITC 2.2 Enter and develop information to suit the task and derive new information.	The information gained from a search of sources e.g. the Internet could be developed and enhanced using various formats e.g. a leaflet or 'publicity' poster on endangered species, campaign material for and against wind farms.
ITC 2.3 Present combined information such as with text with image, text with number, image with number.	Information obtained through the use of IT and developed using a variety of software packages (e.g. word processing, graphics, DTP) could be presented in an extended essay.
WO2.1 Plan work with others.	A class or group activity in Science e.g. students pan and organise a presentation or debate on an aspect of Science e.g. genetic engineering/the coal and oil versus nuclear fuel debate for generating electricity.

WO2.2 Work co-operatively towards achieving the identified objectives.	Students establish links with other members of the class to gather information/illustrations or produce texts/diagrams/drawings. They exchange ideas with other members of the group.
WO2.3 Review your contributions and agree ways to improve work with others.	Review of the progress made in collecting and presenting the information or evidence reflecting on ways in which collaborative working could be improved.
LP2.1 Help set short-term targets with an appropriate person and plan how these will be met.	Establish with the teacher and/or others, through one-to-one and group discussion, targets for enhancing performance. (e.g. identification of a topic and plan of action).
LP2.2 Take responsibility for some decisions about your learning, using your plan to help meet targets.	Produce a log of procedural research, monitoring progress and how issues and problems were tackled in the context of study. Log should include details of how a straightforward topic or issue in Science was approached (e.g. gathering together evidence and sources for the assignment).
LP2.3 Review progress with an appropriate person and provide evidence of your achievements.	Keep a portfolio of tasks which have been assessed during a course of study and how, possibly through a log, learning and performance have been improved from comments, both verbal and written, made by the teacher and others.

PS2.1 Identify a problem with help from an appropriate person, and identify different ways of tackling it.	Students identify a Scientific topic for an extended essay and make notes or essay plans considering two ways of approaching it. This could involve group/class discussion of aspects/ approaches and of possible sources of information (e.g. alternative ways of finding information). The topic might itself contain a problem on which there are different Scientific perspectives.
PS2.2 Plan and try out at least one way of solving the problem.	Present notes or essay plan which is discussed with the teacher and then executed through the writing of a piece of work. Review the piece of work produced with a view to modifying, expanding or restructuring it.
PS2.3 Check if the problem has been solved and identify ways to improve problem-solving skills.	Discuss with teacher the piece of work to ensure that the problem or issue has been addressed appropriately. Describe the results in a log of procedural research.

Appendix 6

Command Words and Phrases

The command words and phrases used in examination papers are listed below.

Calculate/work out …	Implies that the candidate must produce a numerical answer.
Compare …	Implies that that candidate needs to describe the similarities and/or differences in material arising from the specification content or in sets of data provided.
Complete …	Implies that the candidate needs to enter the answer in spaces provided in a diagram, table etc.
Describe …	Implies that the candidate must state in words, or as diagrams, the important points of the topic.
Draw a bar chart …	Implies that: • for a graph where the axes are labelled and scaled the candidate needs to plot as bars a series of values; • for a graph where the axes are labelled and not scaled the candidate needs to add scales and plot as bars a series of values.
Draw a graph …	Implies that: • for a graph where the axes are labelled and scaled the candidate needs to plot as points a series of values and then draw an appropriate line; • for a graph where the axes are labelled and not scaled the candidate needs to add scales, plot as points a series of values and then draw an appropriate line.
Explain how/why …	Implies that the candidate must apply reasoning to the recall of theory. (This command phrase is not used if the answer required is no more than a list of reasons.)
Give a reason/how/why ..	Implies that a reason is needed which is an application of scientific knowledge.
Give/name/state/write down …	Implies that a concise answer is required without supporting evidence.
List …	Implies that a series of concise answers is required, each answer being written one after the other.

Predict …	Implies that a consider answer is required without supporting evidence, and that the answer is based on the candidate making logical links between various pieces of information.
Sketch a graph …	Implies that the candidate needs to draw a line on a grid indicating a trend or pattern without the need first to plot a series of points.
Suggest …	Implies that there is no unique answer, and that candidates are expected to base the answer on scientific knowledge and/or scientific principles.
Use the information …	Implies that the answer must be based on information provided within the context of the question.
Use your understanding/ideas of … to …	Implies the concept around which the answer should be framed.
What is meant by …	Implies that a definition should be given, together with some relevant comment on the significance or context of the question.

APPENDIX 7

Criteria for Assessment of Extended Reports

demand		Planning	Collecting & Presenting/ Displaying data/information	Analysing & Summarising Issues	Evaluating	Drawing Conclusions & Presentation
↓	1	Implements a supplied plan with little modification	Presents/displays given information in a simple way	Answers directed questions/ reports what the information shows.	Answers directed questions/shows awareness regarding reliability of the information	Answers directed questions to draw a conclusion/produces simple report.
	3	Uses a supplied plan and develops it to successfully fulfil the task	Collects and presents/displays basic relevant information in an organised way.	Analyses and discusses the implications of simple information competently.	Evaluates either the information or the method basically for a straightforward case	Produces a structured report for a straightforward case and draws simple conclusions
	5	Develops own plan to collect information, analyse and display it	Collects a variety of relevant information and presents/displays it well for ease of analysis.	Analyses and discusses the implications of complicated information showing good understanding.	Evaluates the information and method well for a difficult case	Produces a comprehensive report for a difficult investigation and draws well-argued conclusions.

Notes:

1. 0 is only awarded on no evidence – otherwise the minimum mark in any field is 1.
2. The idea of "Best Fit" should be applied. A mark of 3 can be given for basic work handled well or a reasonable attempt at more complicated work.
3. In most cases there are two factors in each field. The intermediate marks, 2 and 4, can be used for intermediate performance in both factors or if there is better performance in one than another