General Certificate of Education

Applied Science 8771/73/76/77/79

2014

Special Features

- Units are set in a real-world vocational context
- Simple assessment structure
- Choice of optional units

Material accompanying this Specification

- Specimen and Past Papers and Mark Schemes
- Reports on the Examination
- Teachers’ Guide

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

Vertical black lines indicate a significant change or addition to the specification published for 2013.

Further copies of this specification booklet are available from:

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Telephone: 0870 410 1036  Fax: 0161 953 1177
or
can be downloaded from the AQA Website:  www.aqa.org.uk

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Advanced Subsidiary (AS) and Advanced Level (AS + A2) Specifications for 2014

1.1 Introduction

In September 2005 a new suite of GCE Advanced Level (AS/A2) specifications were developed to carry forward and enhance the vocational emphasis of the Advanced Vocational Certificate of Education (VCE) specifications. The emphasis on portfolio work has been retained but the opportunity has been taken to introduce a two-stage learning and assessment programme (AS/A2) the first of which (AS) can be separately certificated. In contrast to the previous VCE AS qualification the level of demand at AS and A2 will not be identical. The programme of learning and assessment of AS units is set at a significantly lower level of demand in comparison to those at A2 (see Section 1.3).

1.2 Rationale

This specification builds upon the broad educational and vocational framework set out in the AS and Advanced GCE General and Subject Criteria produced by the Qualifications and Curriculum Authority. These AS and Advanced GCEs are broad-based vocational qualifications designed to allow students flexible progression routes, moving on to higher education or further training and/or employment.

The AS and Advanced GCE in Applied Science have been designed to form qualifications which provide knowledge and understanding of this vocational area. They are ideal qualifications for those students who want a broad background in science, which will allow them to progress to further or higher education, training or employment. They are designed to be delivered through full-time or part-time education courses.

The course of study prescribed by this specification can reasonably be undertaken by candidates entering this vocational area for the first time. Progression through Advanced Level will provide a suitable basis for further study in related subjects in Higher Education as well as a valuable preparation for careers in any area of science.

The fundamental philosophy of this specification is that, in order to understand the nature of science, students must actively experience the science environment. This can be achieved through a variety of approaches including work experience, links with local employers, case studies and research.
The specification is flexible, with a unit structure designed to allow for a variety of pathways.

Assessment is designed to give credit for what students can do as well as what they know and understand. It is based both on portfolio evidence which is marked by the centre and moderated by AQA and external assessments which are set and marked by AQA.

AS and Advanced GCE Applied Science provides a worthwhile course for candidates of various ages and from diverse backgrounds in terms of general education and lifelong learning.

This specification is supported by a range of professional institutes and Further and Higher Education Institutions.

1.3 Advanced Subsidiary (AS)

Advanced Subsidiary (AS) courses were introduced from September 2005 for the award of the first qualification in August 2006. They may be used in one of two ways:

- to lead to a final Advanced Subsidiary qualification (single or double award), allowing candidates to broaden their studies and to defer decisions about specialism;
- to make up the first half (50%) of an Advanced Level qualification (single or double award).

AS is designed to provide an appropriate assessment of knowledge, understanding and skills expected of candidates who have completed the first half of a full Advanced Level qualification. The level of demand of the AS assessment is that expected of candidates half-way through a full Advanced Level course of study.

The Advanced Subsidiary single award will comprise three AS units.

The Advanced Subsidiary double award will comprise six AS units.

1.4 Advanced Level (AS+A2)

Advanced Level (A Level) course of study were available for assessment from January 2007 and for the award of the first qualification in August 2007. The A-Level assessment is in two parts:

- Advanced Subsidiary (Single or Double) Award – 50% of the total Advanced Level (Single or Double) Award;
- a second stage, called A2 – 50% of the total award.

Both Advanced Subsidiary and Advanced Level are available as a single or double award.

The Advanced Level single award will comprise three AS units and a further three A2 units. The A2 units, set at a higher level than AS, are designed to assess knowledge, understanding and skills expected of candidates who have completed the second half of a full Advanced Level qualification.
The Advanced Level double award will comprise six AS units plus a further six A2 units.

The format of Advanced Level courses allows centres to devise an assessment schedule to meet their own and their candidates’ needs. For example:

- assessment units may be taken at stages throughout the course, at the end of each year or at the end of the total course;
- AS may be completed at the end of the first year and A2 by the end of the second year;
- AS and A2 may be completed at the end of the same year.

A nine-unit award is available, called Advanced Level with Advanced Subsidiary (additional). This consists of six AS units and three A2 units. To be eligible for this award, candidates must meet the requirements for Advanced Subsidiary Double Award and Advanced Level Single Award.

1.5 Support for the specification
In addition, all centres indicating an intention to enter candidates for this specification will be allocated an AQA-appointed portfolio adviser who will be available to assist centres with any matters relating to portfolio units. Further information on portfolio advisers is provided in Section 28.1. Centres are also required to send a representative to a Standardising Meeting to ensure that the internal assessment of candidates’ work is both accurate and consistent with the standards required by AQA. Details of these meetings are provided in Section 30.1.

AQA have produced a Teachers’ Guide to accompany this specification. Within the Teachers’ Guide there are sections identifying resources available to support the teaching and learning of individual units, guidance on delivery and, where appropriate, assessment in a vocational context, possible teaching strategies that could be employed and further details about the opportunities to deliver and generate evidence of achievement in Key Skills. One copy of the Teachers’ Guide is available, free of charge, to all centres indicating an intention to enter candidates for this specification. Copies of the Teachers’ Guide are posted on the AQA Website.

1.6 Guided learning hours
The acknowledged guided learning hours for this specification are 180 hours for the Advanced Subsidiary qualification, 360 for the Advanced Subsidiary Double Award, 360 for the Advanced Level Single and 720 for the Advanced Level Double Award.
## Specification at a Glance

### Applied Science

### 2.1 Qualifications Available

<table>
<thead>
<tr>
<th>Qualification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Subsidiary GCE (3 AS Units)</td>
<td>Units 1, 2* and 3</td>
</tr>
<tr>
<td>Advanced Subsidiary GCE (Double Award) (6 AS Units)</td>
<td>Units 1, 2*, 3, 4, 5* and 6</td>
</tr>
<tr>
<td>Advanced Level GCE (3 AS + 3 A2 Units)</td>
<td>Units 1, 2*, 3 and 7&lt;br&gt;Plus <strong>one</strong> from 8*, 11* or 14*&lt;br&gt;and <strong>one</strong> from 9, 10, 12, 13, 15 or 16</td>
</tr>
<tr>
<td>Advanced GCE with Advanced Subsidiary GCE (Additional) (6 AS units and 3 A2 units)</td>
<td>Units 1, 2*, 3 plus three AS units (Units 4, 5* and 6) plus A2 unit 7 and two A2 units (from A2 Units 8 – 16).&lt;br&gt;At least one of the A2 units must be externally assessed.</td>
</tr>
<tr>
<td>Advanced Level GCE (Double Award) (6 AS + 6 A2 Units)</td>
<td>Units 1, 2*, 3, 4, 5*, 6 and 7&lt;br&gt;Plus <strong>two</strong> from 8*, 11* or 14*&lt;br&gt;and <strong>three</strong> from 9, 10, 12, 13, 15 or 16</td>
</tr>
</tbody>
</table>

All units have an equal weighting.<br>Units marked with an asterisk (*) will be externally assessed.<br>All other units will be internally assessed through portfolio evidence.

### 2.2 Requirements for Advanced Subsidiary GCE

In order to obtain the Advanced Subsidiary GCE, the following entry code **8771** must be used and candidates must take the following units:

<table>
<thead>
<tr>
<th>Unit</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS Unit 1</td>
<td>Investigating Science at Work</td>
</tr>
<tr>
<td>AS Unit 2*</td>
<td>Energy Transfer Systems *</td>
</tr>
<tr>
<td>AS Unit 3</td>
<td>Finding out about Substances</td>
</tr>
</tbody>
</table>

Units marked with an asterisk (*) will be externally assessed.<br>All other units will be internally assessed through portfolio evidence.
2.3 Advanced Subsidiary GCE (Double Award)

In order to obtain the Advanced Subsidiary GCE (Double Award), the following entry code **8773** must be used and candidates must take the following units.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS Unit 1</td>
<td>Investigating Science at Work</td>
</tr>
<tr>
<td>AS Unit 2*</td>
<td>Energy Transfer Systems *</td>
</tr>
<tr>
<td>AS Unit 3</td>
<td>Finding out about Substances</td>
</tr>
<tr>
<td>AS Unit 4</td>
<td>Food Science and Technology</td>
</tr>
<tr>
<td>AS Unit 5*</td>
<td>Choosing and Using Materials *</td>
</tr>
<tr>
<td>AS Unit 6</td>
<td>Synthesising Organic Compounds</td>
</tr>
</tbody>
</table>

Units marked with an asterisk (*) will be externally assessed. All other units will be internally assessed through portfolio evidence.

2.4 Requirements for Advanced Level GCE

In order to obtain the Advanced Level GCE, the following entry code **8776** must be used and candidates must take the following units.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Compulsory AS</strong></td>
<td></td>
</tr>
<tr>
<td>AS Unit 1</td>
<td>Investigating Science at Work</td>
</tr>
<tr>
<td>AS Unit 2*</td>
<td>Energy Transfer Systems *</td>
</tr>
<tr>
<td>AS Unit 3</td>
<td>Finding out about Substances</td>
</tr>
<tr>
<td><strong>Compulsory A2</strong></td>
<td></td>
</tr>
<tr>
<td>A2 Unit 7</td>
<td>Planning and Carrying out a Scientific Investigation</td>
</tr>
<tr>
<td>plus</td>
<td></td>
</tr>
<tr>
<td>one from</td>
<td></td>
</tr>
<tr>
<td>A2 Unit 8*</td>
<td>Medical Physics *</td>
</tr>
<tr>
<td>A2 Unit 11*</td>
<td>Controlling Chemical Processes *</td>
</tr>
<tr>
<td>A2 Unit 14*</td>
<td>The Healthy Body *</td>
</tr>
<tr>
<td>and one from</td>
<td></td>
</tr>
<tr>
<td>A2 Unit 9</td>
<td>Sports Science</td>
</tr>
<tr>
<td>A2 Unit 10</td>
<td>Physics of Performance Effects</td>
</tr>
<tr>
<td>A2 Unit 12</td>
<td>The Actions and Development of Medicines</td>
</tr>
<tr>
<td>A2 Unit 13</td>
<td>Colour Chemistry</td>
</tr>
<tr>
<td>A2 Unit 15</td>
<td>The Role of the Pathology Service</td>
</tr>
<tr>
<td>A2 Unit 16</td>
<td>Ecology, Conservation and Recycling</td>
</tr>
</tbody>
</table>

Units marked with an asterisk (*) will be externally assessed. All other units will be internally assessed through portfolio evidence.
In order to obtain the Advanced GCE with Advanced Subsidiary GCE (additional), the entry code 8777 must be used and candidates must take the following units.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>compulsory AS</strong></td>
<td></td>
</tr>
<tr>
<td>Unit 1</td>
<td>Investigating Science at Work</td>
</tr>
<tr>
<td>Unit 2*</td>
<td>Energy Transfer Systems*</td>
</tr>
<tr>
<td>Unit 3</td>
<td>Finding out about Substances</td>
</tr>
<tr>
<td>plus</td>
<td></td>
</tr>
<tr>
<td>Unit 4</td>
<td>Food Science and Technology</td>
</tr>
<tr>
<td>Unit 5*</td>
<td>Choosing and Using Materials*</td>
</tr>
<tr>
<td>Unit 6</td>
<td>Synthesising Organic Compounds</td>
</tr>
<tr>
<td><strong>compulsory A2</strong></td>
<td></td>
</tr>
<tr>
<td>Unit 7</td>
<td>Planning and Carrying out a Scientific Investigation</td>
</tr>
<tr>
<td>plus</td>
<td></td>
</tr>
<tr>
<td>Two units from the following including at least one external test</td>
<td></td>
</tr>
<tr>
<td>Unit 8*</td>
<td>Medical Physics*</td>
</tr>
<tr>
<td>Unit 9</td>
<td>Sports Science</td>
</tr>
<tr>
<td>Unit 10</td>
<td>Physics of Performance Effects</td>
</tr>
<tr>
<td>Unit 11*</td>
<td>Controlling Chemical Processes*</td>
</tr>
<tr>
<td>Unit 12</td>
<td>The Actions and Development of Medicines</td>
</tr>
<tr>
<td>Unit 13</td>
<td>Colour Chemistry</td>
</tr>
<tr>
<td>Unit 14*</td>
<td>The Healthy Body*</td>
</tr>
<tr>
<td>Unit 15</td>
<td>The Role of the Pathology Service</td>
</tr>
<tr>
<td>Unit 16</td>
<td>Ecology, Conservation and Recycling</td>
</tr>
</tbody>
</table>

Units marked with an asterisk (*) will be externally assessed. All other units will be internally assessed through portfolio evidence.
2.6 Requirements for Advanced Level GCE (Double Award)

In order to obtain the Advanced Level GCE (Double Award), the following entry code 8779 must be used and candidates must take the following units.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS Unit 1</td>
<td>Investigating Science at Work</td>
</tr>
<tr>
<td>AS Unit 2*</td>
<td>Energy Transfer Systems *</td>
</tr>
<tr>
<td>AS Unit 3</td>
<td>Finding out about Substances</td>
</tr>
<tr>
<td>AS Unit 4</td>
<td>Food Science and Technology</td>
</tr>
<tr>
<td>AS Unit 5*</td>
<td>Choosing and Using Materials *</td>
</tr>
<tr>
<td>AS Unit 6</td>
<td>Synthesising Organic Compounds</td>
</tr>
<tr>
<td>A2 Unit 7</td>
<td>Planning and Carrying out a Scientific Investigation</td>
</tr>
<tr>
<td>A2 Unit 8*</td>
<td>Medical Physics *</td>
</tr>
<tr>
<td>A2 Unit 11*</td>
<td>Controlling Chemical Processes *</td>
</tr>
<tr>
<td>A2 Unit 14*</td>
<td>The Healthy Body *</td>
</tr>
<tr>
<td>A2 Unit 9</td>
<td>Sports Science</td>
</tr>
<tr>
<td>A2 Unit 10</td>
<td>Physics of Performance Effects</td>
</tr>
<tr>
<td>A2 Unit 12</td>
<td>The Actions and Development of Medicines</td>
</tr>
<tr>
<td>A2 Unit 13</td>
<td>Colour Chemistry</td>
</tr>
<tr>
<td>A2 Unit 15</td>
<td>The Role of the Pathology Service</td>
</tr>
<tr>
<td>A2 Unit 16</td>
<td>Ecology, Conservation and Recycling</td>
</tr>
</tbody>
</table>

Units marked with an asterisk (*) will be externally assessed. All other units will be internally assessed through portfolio evidence.
Availability of Assessment Units and Entry Details

3.1 Availability of Units for Assessment
Examinations and certification for this specification are available in June only.

3.2 Sequencing of Units
Whilst the specification is designed to expect candidates to study the AS units and then the A2 units, candidates can be entered for assessment in any unit in any order (see Section 1.4). The opportunities for assessment and availability of the Advanced Subsidiary and Advanced Level qualifications are summarised in Section 3.1.

It is worth noting, however, that some A2 units will be more accessible to candidates who have the knowledge, understanding and skills acquired through study of the appropriate AS units.

3.3 Entry Codes
Normal entry requirements apply, but the following information should be noted.

The following entry unit codes should be used.

<table>
<thead>
<tr>
<th>AS</th>
<th>A2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit 1 – SC01</td>
<td>Unit 7 – SC07</td>
</tr>
<tr>
<td>Unit 2 – SC02</td>
<td>Unit 8 – SC08</td>
</tr>
<tr>
<td>Unit 3 – SC03</td>
<td>Unit 9 – SC09</td>
</tr>
<tr>
<td>Unit 4 – SC04</td>
<td>Unit 10 – SC10</td>
</tr>
<tr>
<td>Unit 5 – SC05</td>
<td>Unit 11 – SC11</td>
</tr>
<tr>
<td>Unit 6 – SC06</td>
<td>Unit 12 – SC12</td>
</tr>
<tr>
<td></td>
<td>Unit 13 – SC13</td>
</tr>
<tr>
<td></td>
<td>Unit 14 – SC14</td>
</tr>
<tr>
<td></td>
<td>Unit 15 – SC15</td>
</tr>
<tr>
<td></td>
<td>Unit 16 – SC16</td>
</tr>
</tbody>
</table>
The **Subject Code** for entry to the Advanced Subsidiary GCE is **8771**.

The **Subject Code** for entry to the Advanced Subsidiary GCE (Double Award) is **8773**.

The **Subject Code** for entry to the Advanced Level GCE is **8776**.

The **Subject Code** for entry to the Advanced GCE with Advanced Subsidiary GCE (additional) is **8777**.

The **Subject Code** for entry to the Advanced Level GCE (Double Award) is **8779**.

### 3.4 Private Candidates

This specification is not available to private candidates.

### 3.5 Access Arrangements and Special Consideration

We have taken note of equality and discrimination legislation and the interests of minority groups in developing and administering this specification.

We follow the guidelines in the Joint Council for Qualifications (JCQ) document: *Access Arrangements, Reasonable Adjustments and Special Consideration: General and Vocational Qualifications*. This is published on the JCQ website (http://www.jcq.org.uk) or you can follow the link from our website (http://www.aqa.org.uk).

### 3.6 Language of Examinations

All assessment Units are provided in English. Centres wishing to have a Welsh translation must notify AQA at least four months before the date of the examination.
4

Introduction

4.1 Prior Level of Attainment and Recommended Prior Learning
No prior level of attainment in science is required for this qualification.

4.2 Progression
This AQA AS and Advanced GCE enables candidates to develop both a broad understanding of a wide range of scientific principles and gives them the opportunity to focus on a specific pathway, e.g. health care, applications of chemistry, environmental science or sports science. In addition, the qualification covers a mixture of teaching and learning experiences from the theoretical through to those with a clear practical emphasis.

It is important that at the start of, and throughout, the AS and Advanced GCE programme candidates are given the opportunity to explore and discuss their interests and aspirations and are provided with realistic guidance about how the qualification (including the selection of optional units) can help to meet their needs.

The qualification allows for a number of progression routes:

- **Higher Education**: the Advanced awards provide a sound basis for progression to a range of HE courses, e.g. biochemical science, chemistry, food technology, human physiology, materials science, medical physics, nursing, sports science or any science-based course;

- **Employment**: the specification aims to maintain and support the recognised standards demanded for science education and training in order to meet the requirements of various science sectors: chemical industry, health care, leisure and associated industries, medical and laboratory based science, food and catering industries;

- **Related qualifications in the National Qualifications Framework**: the awards enable students to progress to other science related qualifications such as GCE and VRQ.
5 Aims

The aims set out below describe the educational purposes of following a course in science. Some of these aims are reflected in the assessment objectives, others are not because they cannot be translated readily into measurable objectives. All, however, are considered essential for any Science course.

These aims apply to both the AS and A Level specification.

5.1 Aims

This specification has been designed to encourage students to develop knowledge, skills and understanding relating to science. This specification can be used to prepare candidates for further study or training in science-related occupations and gives an insight into career opportunities in science-related areas.

The AS and A Level specifications in Applied Science are intended to encourage candidates to:

- develop and sustain an interest in, and enjoyment of, science;
- appreciate how science develops and the impacts such developments may have in present day society;
- develop essential knowledge and understanding relating to science and, where appropriate, the applications of science, and the skills needed for the use of this in new and changing situations;
- develop practical skills relevant to science;
- appreciate the importance of science as a human endeavour which interacts with social, philosophical, economic, environmental and industrial matters;
- encourage candidates to develop skills in communication, application of number and the use of ICT.

5.2 Broad Objectives

AQA GCE Applied Science has the following objectives. It provides:

- a broad background of understanding and core knowledge whilst allowing some scope for candidates to focus on a particular area of interest;
- a student-centred approach to learning, together with the opportunity to apply knowledge of the application of scientific principles in a practical way;
- the opportunity for centres to forge links with industry;
- cross-sector themes and approaches so that students can gain an insight into related sectors such as environmental areas, sport, performances and catering;
• an opportunity for centres to engage in a wide range of teaching and learning styles including the use of ICT in both experimentation and presentation work.

5.3 Subject Specific Focus

In particular, the content of the compulsory and optional units provides students with:

• an awareness of how industry applies science in a wide range of essential functions;
• the opportunity to learn about the basic principles underlying the application of biological, chemical, environmental and physical areas of science and the interrelationships between these areas in particular fields;
• an introduction to a range of career possibilities which use aspects of science as their base point;
• a balanced background of scientific applications and principles to give both breadth and depth to the student’s knowledge, understanding and experience of science.

5.4 Synoptic Assessment and Stretch and Challenge

The definition of synoptic assessment in the context of science is: Synoptic assessment requires candidates to make and use connections within and between different areas of science, for example, by:

• applying knowledge and understanding of more than one area to a particular situation or context;
• using knowledge and understanding of principles and concepts in planning experimental and investigative work and in the analysis and evaluation of data;
• bringing together scientific knowledge and understanding from different areas of the subject and applying them.

Synoptic assessment in Applied Science is formally assessed only in the A2 externally assessed units. The synoptic content for these units will only ever come from either SC01, SC02, SC03 or SC07. The requirement that Stretch and Challenge is included at A2 and will be met in the externally assessed units by:

• using a variety of stems in questions to avoid a formulaic approach through the use of such words as: analyse, evaluate, compare, discuss;
• avoiding assessments being too atomistic, connections between areas of content being used where possible and appropriate;
• having some requirement for extended writing;
• using a range of question types to address different skills i.e. not just short answer/structured questions;
• asking candidates to bring to bear knowledge and the other prescribed skills in answering questions rather than simply demonstrating a range of content coverage.
5.5 Access to Assessment for Disabled Students

AS/A Levels often require assessment of a broader range of competences. This is because they are general qualifications and, as such, prepare candidates for a wide range of occupations and higher level courses.

The revised AS/A Level qualification and subject criteria were reviewed to identify whether any of the competences required by the subject presented a potential barrier to any disabled candidates. If this were the case, the situation was reviewed again to ensure that such competences were included only where essential to the subject. The findings of this process were discussed with disability groups and disabled people.

Reasonable adjustments were made for disabled candidates in order to enable them to access the assessments. For this reason, very few candidates will have a complete barrier to any part of the assessment.

Candidates who are still unable to access a significant part of the assessment, even after exploring all possibilities through reasonable adjustments, may still be able to receive an award. They would be given a grade on the parts of the assessment they had taken and there would be an indication on their certificate that not all of the competences had been addressed. This will be kept under review and may be amended in the future.
## Assessment Objectives

Knowledge, skills and understanding are all closely linked. Candidates are required to demonstrate the following Assessment Objectives (AOs) in the context of the content and skills described.

The Assessment Objectives (AOs) for AS and A2 are the same.

<table>
<thead>
<tr>
<th>6.1</th>
<th>Demonstration of Knowledge and Understanding (AO1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Candidates demonstrate their knowledge and understanding by:</td>
</tr>
<tr>
<td></td>
<td>• recognising and recalling facts, terminology, principles, concepts and practical techniques;</td>
</tr>
<tr>
<td></td>
<td>• selecting, organising and presenting, clearly and logically, information either provided or acquired through systematic research.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>6.2</th>
<th>Application of Knowledge Skills and Understanding (AO2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Candidates apply their knowledge and skills in appropriate vocational contexts:</td>
</tr>
<tr>
<td></td>
<td>• by describing, explaining, interpreting and evaluating information and the impact on society of the work of scientists, including beneficial effects and the need for constraints;</td>
</tr>
<tr>
<td></td>
<td>• in carrying out relevant calculations.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>6.3</th>
<th>Experimentation and Investigation (AO3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Candidates:</td>
</tr>
<tr>
<td></td>
<td>• carry out safely and skilfully practical tasks, making and recording observations and measurements with appropriate precision, processing them appropriately and communicating this information clearly and logically, e.g. in prose, tables and graphs;</td>
</tr>
<tr>
<td></td>
<td>• plan, carry out and evaluate investigative work.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>6.4</th>
<th>Quality of Written Communication</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GCE specifications which require candidates to produce written material in English must:</td>
</tr>
<tr>
<td></td>
<td>• ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;</td>
</tr>
<tr>
<td></td>
<td>• select and use a form and style of writing appropriate to purpose and to complex subject matter</td>
</tr>
<tr>
<td></td>
<td>• organise information clearly and coherently, using specialist vocabulary when appropriate.</td>
</tr>
</tbody>
</table>

In this specification, Quality of Written Communication (QWC) is assessed in:

• all portfolio units. QWC is assessed in strand AO3(ii), with the exception of SC01 where QWC is assessed in AO1.
• the A2 externally assessed units (SC08, SC11, SC14), where there are two opportunities for the assessment of QWC.
In questions which assess QWC, the statement “You will be assessed on the quality of written communication in your answer to this question” will appear directly after the question and before the candidate begins their answer. QWC questions will usually be worth 5 marks; however, there are no discrete marks for QWC.

<table>
<thead>
<tr>
<th>6.5</th>
<th>Weighting of the Assessment Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The weighting of the Assessment Objectives are outlined in Section 7.2 and Section 7.3 for Advanced Subsidiary qualifications and Section 8.4 and Section 8.5 for Advanced Level qualifications.</td>
</tr>
</tbody>
</table>
## Scheme of Assessment

### Advanced Subsidiary (AS)

The Scheme of Assessment has a unitised structure. The Advanced Subsidiary (AS) GCE comprises three assessment units: Unit 1 (Investigating Science at Work), Unit 2 (Energy Transfer Systems) and Unit 3 (Finding out about Substances). All three assessment units are compulsory. Unit 1 and Unit 3 are internally assessed portfolio units. Unit 2 is assessed by an external examination.

The Advanced Subsidiary (AS) GCE (Double Award) comprises the three assessment units for the single award, together with a further three assessment units: Unit 4 (Food Science and Technology), Unit 5 (Choosing and Using Materials) and Unit 6 (Synthesising Organic Compounds). All six assessment units are compulsory. Unit 4 and Unit 6 are internally assessed portfolio units. Unit 5 is assessed by an external examination.

### 7.1 Assessment Units for AS

<table>
<thead>
<tr>
<th>Unit 1</th>
<th>33.3% of the total AS marks (Single Award)</th>
<th>Portfolio 60 marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.7%</td>
<td>of the total AS marks (Double Award)</td>
<td></td>
</tr>
</tbody>
</table>

#### Investigating Science at Work

In this unit you will be required to produce a portfolio of evidence. The portfolio should aim to cover all the Assessment Criteria detailed in Section 10.4. The portfolio should reflect approximately 60 hours of work including teaching time, individual research and analysis together with the time required to produce the portfolio.

This portfolio will be assessed initially in the centre and moderated by AQA.

<table>
<thead>
<tr>
<th>Unit 2</th>
<th>33.3% of the total AS marks (Single Award)</th>
<th>Written Paper 80 marks</th>
<th>1½ hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.7%</td>
<td>of the total AS marks (Double Award)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Energy Transfer Systems

This written paper comprises a series of short answer, structured questions based on the subject content in Section 11.3. All questions are compulsory.

It is anticipated that the delivery time for the content of this unit is...
approximately 60 hours. This includes teaching time and time for independent study.

Unit 3
33.3% of the total AS marks (Single Award)
16.7% of the total AS marks (Double Award)

Finding out about Substances

In this unit you will be required to produce a portfolio of evidence. The portfolio should aim to cover all the Assessment Criteria detailed in Section 12.4. The portfolio should reflect approximately 60 hours of work including teaching time, individual research and analysis together with the time required to produce the portfolio.

This portfolio will be assessed initially in the centre and moderated by AQA.

Unit 4
16.7 % of the total AS marks (Double Award)

Food Science and Technology

In this unit you will be required to produce a portfolio of evidence. The portfolio should aim to cover all the Assessment Criteria detailed in Section 13.4. The portfolio should reflect approximately 60 hours of work including teaching time, individual research and analysis together with the time required to produce the portfolio.

This portfolio will be assessed initially in the centre and moderated by AQA.

Unit 5
16.7 % of the total AS marks (Double Award)

Choosing and Using Materials

This written paper comprises a series of short answer, structured questions based on the subject content in Section 14.3. All questions are compulsory. This written paper may contain a comprehension exercise.

It is anticipated that the delivery time for the content of this unit is approximately 60 hours. This includes teaching time and time for independent study.
**Unit 6**

16.7 % of the total AS marks

(Double Award)

| Portfolio | 60 marks |

**Synthesising Organic Compounds**

In this unit you will be required to produce a portfolio of evidence. The portfolio should aim to cover all the Assessment Criteria detailed in Section 15.4. The portfolio should reflect approximately 60 hours of work including teaching time, individual research and analysis together with the time required to produce the portfolio.

This portfolio will be assessed initially in the centre and moderated by AQA.
## 7.2 Weighting of Assessment Objectives for Advanced Subsidiary single award

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

<table>
<thead>
<tr>
<th>Assessment Objectives</th>
<th>Unit Weightings (%)</th>
<th>Overall Weighting of AOs (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2*</td>
</tr>
<tr>
<td>Demonstration of knowledge and understanding (AO1)</td>
<td>22.2</td>
<td>21.7</td>
</tr>
<tr>
<td>Application of knowledge, skills and understanding (AO2)</td>
<td>11.1</td>
<td>8.3</td>
</tr>
<tr>
<td>Experimentation and investigation (AO3)</td>
<td>-</td>
<td>3.3</td>
</tr>
</tbody>
</table>

| Overall Weighting of Units (%)                  | 33.3| 33.3| 33.2| 100     |

Because of rounding to one decimal place, the totals of the percentages in the rows and columns may be slightly different from the values printed.

* externally examined unit

## 7.3 Weighting of Assessment Objectives for Advanced Subsidiary double award

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

<table>
<thead>
<tr>
<th>Assessment Objectives</th>
<th>Unit Weightings (%)</th>
<th>Overall Weighting of AOs (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2*</td>
</tr>
<tr>
<td>Demonstration of knowledge and understanding (AO1)</td>
<td>11.1</td>
<td>10.8</td>
</tr>
<tr>
<td>Application of knowledge, skills and understanding (AO2)</td>
<td>5.6</td>
<td>4.2</td>
</tr>
<tr>
<td>Experimentation and investigation (AO3)</td>
<td>-</td>
<td>1.7</td>
</tr>
</tbody>
</table>

| Overall Weighting of Units (%)                  | 16.7| 16.7| 16.6| 16.6| 16.6| 16.6| 100     |

Because of rounding to one decimal place, the totals of the percentages in the rows and columns may be slightly different from the values printed.

* externally examined unit
Scheme of Assessment
Advanced Level (AS+A2)

The Scheme of Assessment has a unitised structure. The Advanced Level GCE comprises three assessment units from the AS Scheme of Assessment plus three assessment units from the A2 Scheme of Assessment. All three AS assessment units are compulsory. Unit 1 and Unit 3 are internally assessed portfolio units, and Unit 2 is assessed by an external examination. Three units must also be completed from the A2 Scheme of Assessment: Unit 7, a compulsory portfolio unit, plus one from Unit 8, 11 or 14 and one from Unit 9, 10, 12, 13, 15 or 16 to complete the requirement of six units.

The Advanced Level GCE (Double Award) comprises six assessment units from the AS Scheme of Assessment plus six assessment units from the A2 Scheme of Assessment. All six AS assessment units are compulsory. Unit 1, Unit 3, Unit 4 and Unit 6 are internally assessed portfolio units, Unit 2 and Unit 5 are assessed by a separate, external examination for each unit. Six units must also be completed from the A2 Scheme of Assessment: Unit 7, a compulsory portfolio unit, plus two from Unit 8, 11 or 14 and three from Unit 9, 10, 12, 13, 15 or 16 to complete the requirement for twelve units.

<table>
<thead>
<tr>
<th>8.1</th>
<th>AS Assessment Units</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unit 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>16.7% of the total A Level marks (Single Award)</td>
<td>Portfolio</td>
<td>60 marks</td>
</tr>
<tr>
<td></td>
<td>8.3% of the total A Level marks (Double Award)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unit 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>16.7% of the total A Level marks (Single Award)</td>
<td>Written Paper</td>
<td>80 marks</td>
</tr>
<tr>
<td></td>
<td>8.3% of the total A Level marks (Double Award)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unit 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>16.7% of the total A Level marks (Single Award)</td>
<td>Portfolio</td>
<td>60 marks</td>
</tr>
<tr>
<td></td>
<td>8.3% of the total A Level marks (Double Award)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unit 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8.3% of the total A Level marks (Double Award)</td>
<td>Portfolio</td>
<td>60 marks</td>
</tr>
</tbody>
</table>
### Unit 5
8.3% of the total A Level marks
(Double Award)

| Written Paper | 80 marks | 1½ hours |

### Unit 6
8.3% of the total A Level marks
(Double Award)

| Portfolio | 60 marks |

### Unit 7
16.7% of the total A Level marks
(Single Award)

8.3% of the total A Level marks
for (Double Award)

| Portfolio | 60 marks |

#### Planning and Carrying out a Scientific Investigation

In this unit you will be required to produce a portfolio of evidence. The portfolio should aim to cover all the Assessment Criteria detailed in Section 16.4. The portfolio should reflect approximately 60 hours of work including teaching time, individual research and analysis together with the time required to produce the portfolio.

This unit formally addresses the requirement for synoptic assessment within the specification (see Section 8.3).

This portfolio will be assessed initially in the centre and moderated by AQA.

### Unit 8 (Optional)
16.7% of the total A Level marks
(Single Award)

8.3% of the total A Level marks
for (Double Award)

| Written Paper | 80 marks | 1½ hours |

#### Medical Physics

This written paper comprises a series of short answer, structured questions based on the subject content in Section 17.3, all questions are compulsory. There are 2 opportunities for assessment of QWC.

It is anticipated that the delivery time for the content of this unit is approximately 60 hours. This includes teaching time and time for independent study.
### Unit 9 (Optional)
16.7% of the total A Level marks for (Single Award)
8.3% of the total A Level marks (Double Award)

**Portfolio**
- 60 marks

**Sports Science**

In this unit you will be required to produce a portfolio of evidence. The portfolio should aim to cover all the Assessment Criteria detailed in Section 18.4. The portfolio should reflect approximately 60 hours of work including teaching time, individual research and analysis together with the time required to produce the portfolio.

This portfolio will be assessed initially in the centre and moderated by AQA.

### Unit 10 (Optional)
16.7% of the total A Level marks (Single Award)
8.3% of the total A Level marks (Double Award)

**Portfolio**
- 60 marks

**Physics of Performance Effects**

In this unit you will be required to produce a portfolio of evidence. The portfolio should aim to cover all the Assessment Criteria detailed in Section 19.4. The portfolio should reflect approximately 60 hours of work including teaching time, individual research and analysis together with the time required to produce the portfolio.

This portfolio will be assessed initially in the centre and moderated by AQA.

### Unit 11 (Optional)
16.7% of the total A Level marks for (Single Award)
8.3% of the total A Level marks (Double Award)

**Written paper**
- 80 marks
- 1½ hours

**Controlling Chemical Processes**

This written paper comprises a series of short answer, structured questions based on the subject content in Section 20.3, all questions are compulsory. There are 2 opportunities for assessment of QWC.

It is anticipated that the delivery time for the content of this unit is approximately 60 hours. This includes teaching time and time for independent study.
The Actions and Development of Medicines

In this unit you will be required to produce a portfolio of evidence. The portfolio should aim to cover all the Assessment Criteria detailed in Section 21.4. The portfolio should reflect approximately 60 hours of work including teaching time, individual research and analysis together with the time required to produce the portfolio.

This portfolio will be assessed initially in the centre and moderated by AQA.

Colour Chemistry

In this unit you will be required to produce a portfolio of evidence. The portfolio should aim to cover all the Assessment Criteria detailed in Section 22.4. The portfolio should reflect approximately 60 hours of work including teaching time, individual research and analysis together with the time required to produce the portfolio.

This portfolio will be assessed initially in the centre and moderated by AQA.

The Healthy Body

This written paper comprises a series of short answer, structured questions based on the subject content in Section 23.3, all questions are compulsory. There are 2 opportunities for assessment of QWC.

It is anticipated that the delivery time for the content of this unit is approximately 60 hours. This includes teaching time and time for independent study.
The Role of the Pathology Service

In this unit you will be required to produce a portfolio of evidence. The portfolio should aim to cover all the Assessment Criteria detailed in Section 24.4. The portfolio should reflect approximately 60 hours of work including teaching time, individual research and analysis together with the time required to produce the portfolio.

This portfolio will be assessed initially in the centre and moderated by AQA.

Ecology, Conservation and Recycling

In this unit you will be required to produce a portfolio of evidence. The portfolio should aim to cover all the Assessment Criteria detailed in Section 25.4. The portfolio should reflect approximately 60 hours of work including teaching time, individual research and analysis together with the time required to produce the portfolio.

This portfolio will be assessed initially in the centre and moderated by AQA.
8.3 Synoptic Assessment

The Advanced Subsidiary and Advanced Level Subject Criteria state that A Level specifications must include synoptic assessment, which is the ability to draw together the knowledge, skills and understanding acquired by candidates throughout the course.

The nature of the course of study for this specification and the focus of the application of knowledge, skills and understanding research and evaluation to the identified vocationally-related issues mean that candidates are consistently meeting this demand in both internally and externally assessed units throughout the A2 course of study and assessment.

Synoptic assessment is included at A2 for both the A Level single award and A Level double award. Unit 7 (Planning and Carrying out a Scientific Investigation) formally addresses synoptic assessment and forms a compulsory part of the A Level core (both single award and double award). This unit requires candidates to draw together the individual strands which underpin the specification and is, therefore, explicitly synoptic in nature. However, it is anticipated that all of the portfolio units will have some degree of synopticity built into them. This results from the nature of the portfolio assessment. In order to achieve at the higher levels, candidates will be required to bring together knowledge, skills and understanding from other areas of the specification. The practical skills form a common thread throughout the specification and go some way to meet the synoptic requirements of the specification.

Links from a unit in this specification to other units in this specification are clearly identified at the start of each unit in the section – About this Unit.
### 8.4 Weighting of Assessment Objectives for Advanced Level Single Award

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

<table>
<thead>
<tr>
<th>A Level Assessment units (AS+A2)</th>
<th>Unit Weightings (%)</th>
<th>Overall Weighting of AOs (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Compulsory</td>
<td>Optional =</td>
</tr>
<tr>
<td></td>
<td>1 2* 3 7 1st* 2nd</td>
<td></td>
</tr>
<tr>
<td>Demonstration of knowledge and understanding (AO1)</td>
<td>11.1 10.8 2.2 2.2 6.3 2.2</td>
<td>34.8</td>
</tr>
<tr>
<td>Application of knowledge, skills and understanding (AO2)</td>
<td>5.6 4.2 2.2 3.3 8.3 3.3</td>
<td>26.9</td>
</tr>
<tr>
<td>Experimentation and investigation (AO3)</td>
<td>- 1.7 12.2 11.1 2.1 11.1</td>
<td>38.2</td>
</tr>
<tr>
<td><strong>Overall Weighting of Units (%)</strong></td>
<td>16.7 16.7 16.6 16.6 16.7 16.6</td>
<td>100</td>
</tr>
</tbody>
</table>

Because of rounding to one decimal place, the totals of the percentages in the rows and columns may be slightly different from the values printed.

= See Section 2.4 for details of optional units

* externally examined unit
8.5 **Weighting of Assessment Objectives for Advanced Level double award**

A Level Assessment units (AS+A2)

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

<table>
<thead>
<tr>
<th>Assessment Objectives</th>
<th>Unit Weightings (%)</th>
<th>Overall Weighting of AOs (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Compulsory</td>
<td>Optional =</td>
</tr>
<tr>
<td>Demonstration of knowledge and understanding (AO1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.6 5.4 1.1 1.7 5.4 1.7 1.1 3.1 3.1 1.1 1.1 1.1</td>
<td>31.5</td>
</tr>
<tr>
<td>Application of knowledge, skills and understanding (AO2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.8 2.1 1.1 1.1 2.1 1.1 1.7 4.2 4.2 1.7 1.7 1.7</td>
<td>25.5</td>
</tr>
<tr>
<td>Experimentation and investigation (AO3)</td>
<td>- 0.8 6.1 5.6 0.8 5.6 5.6 1.0 1.0 5.6 5.6 5.6</td>
<td>43.3</td>
</tr>
<tr>
<td><strong>Overall Weighting of Units (%)</strong></td>
<td>8.4 8.3 8.3 8.4 8.3 8.4 8.3 8.3 8.4 8.4 8.4 8.4</td>
<td>100</td>
</tr>
</tbody>
</table>

Because of rounding to one decimal place, the totals of the percentages in the rows and columns may be slightly different from the values printed.

= See Section 2.4 for details of optional units

* externally examined unit
Subject Content

Summary of Subject Content

9.1 AS Units

UNIT 1 – Investigating Science at Work
- The types of organisation which use science
- How science is used in organisations
- How health and safety regulations are used in the workplace
- How the organisation impacts on the local community

UNIT 2 – Energy Transfer Systems *
- The structure and function of the circulatory and respiratory systems
- How to find out about physiological status through monitoring
- The process of respiration
- Ethical issues relating to monitoring, diagnosis and treatment of the circulatory and respiratory systems
- Imaging methods used in monitoring and diagnosis
- Applications of energy transfer

UNIT 3 – Finding out about Substances
- How to obtain and prepare samples for analysis
- Qualitative chemical analysis
- Volumetric analysis
- Chromatographic techniques
- Colorimetric techniques
- Energy changes that take place when substances react
UNIT 4 – Food Science and Technology

The type of diet required for different client groups
The causes of food spoilage and methods of food preservation
The packaging of products
The labelling of products
Legislation relating to the management of hygiene in the food industry
How to prepare a design brief for a new product
Making the product
Testing the product by government agencies

UNIT 5 – Choosing and Using Materials *

Identifying the purposes for which materials are needed
Relating the physical properties of materials to their structure
The different classes of materials
Justifying the use of a particular material
Methods for measuring physical properties
Explaining the changes in the physical properties of modified materials in terms of their structure

UNIT 6 – Synthesising Organic Compounds

Organic compounds and functional groups
Types of chemical reaction
The use of spectroscopic techniques (either infrared mass spectrometry or NMR) in identifying organic compounds
How to make and purify organic compounds
How to determine yield and purity
UNIT 7 – Planning and Carrying out a Scientific Investigation

How to plan an investigation
How to carry out the investigation
Recording and processing the data obtained
Evaluating and drawing conclusions from the investigation
Presenting the outcomes of the investigation

UNIT 8 – Medical Physics *

How physiological measurements are indicators of health
The use of diagnostic techniques
Thermography and its uses
The use of X-rays
Radiation, its uses and dangers
The uses of ultrasound
Lasers and fibre optics in medicine
Magnetic resonance imaging (MRI)
How radioisotopes, ultrasound and light are used in therapy

UNIT 9 – Sports Science

Health and fitness
Sports injuries and conditions
First aid techniques
Prevention of sporting injuries and conditions
Occupations involving the application of science to sport
UNIT 10 – Physics of Performance Effects

The nature of sound and its application to sound systems

Sound control systems

The nature of light and its application to lighting systems

Lighting control systems

Evaluating a performance

UNIT 11 – Controlling Chemical Processes *

The industrial manufacture of chemical compounds

Calculating quantities of substances

Reaction conditions

Laboratory investigations

UNIT 12 – The Actions and Development of Medicines

The different categories of medicines and their actions

The development of a medicine

Methods of analysing medicines

UNIT 13 – Colour Chemistry

The origin of colour in dyes and pigments

The extraction of a natural (plant) dye and preparation of a synthetic dye

Application of dyes to fabric

Scaling up a laboratory preparation to industrial manufacture

The use of coloured pigments in oil-based paints
UNIT 14 – The Healthy Body *

How basic homeostatic mechanisms maintain a healthy body

Cellular respiration

How to monitor concentrations of substances in the blood

- blood pH
- oxygen saturation
- blood glucose

How a healthy diet helps to maintain a healthy body

Monitoring the levels of cholesterol, vitamins and minerals in the body

The structure and function of the digestive system

UNIT 15 – The Role of the Pathology Service

The role of the biochemistry department

The role of the haematology department

The role of the microbiology department

The role of the histopathology department

Working in the biochemistry and microbiology departments

UNIT 16 – Ecology, Conservation and Recycling

The type and populations of organisms that live in a habitat

The relationships of organisms with their physical and biological environment

Environmental change and damage

Managing conservation

Recycling materials
10

AS Unit 1

Investigating Science at Work

10.1 About this Unit

In this unit you will investigate the type of work undertaken in a scientific organisation or workplace and the science involved in this work. The workplace might be a large or small organisation, and some of the people involved may, or may not, be trained scientists.

In this unit you will learn about:

- methods which can be used to identify local organisations and/or businesses who manufacture or process scientific products for sale and provide a scientific service;
- how an organisation uses science in its processes;
- the people employed in an organisation;
- the constraints under which an organisation operates;
- how an organisation can impact on a community.

This unit links to most other GCE Applied Science units through considering the type of work undertaken by scientists. It considers health and safety issues and the need for effective risk assessment when undertaking practical investigations. It also links with other GCEs in science-related subjects. This unit will help you to prepare for higher education courses which use science, and for work in a science-based occupation.

10.2 How you will be assessed

You need to produce a portfolio of evidence to show how science is used to provide products and services in different kinds of science-based organisations.

Your portfolio of evidence should comprise:

A. a summary of local organisations and/or businesses that use scientific skills including:

- the identification and use of a variety of research methods, such as telephone directories, the Internet or local knowledge to give details of organisations and/or businesses that
  - manufacture or process scientific products for sale
  - provide a scientific service.

B. a detailed report of one organisation or business identified in your summary including:

- identification of a single organisation and/or business from your summary;
- the nature of the work done and the area(s) of science represented;
• the process(es) used and the underlying science;
• how ICT is used in the organisation or business;
• the commercial, legal and health and safety constraints which apply to the organisation as a whole and the process(es) they use;
• current health and safety regulations and how these are used within the organisation;
• how the organisation impacts on the community. This will include employment (both direct and indirect), resource demands and contributions to the economy.

10.3 You need to know, understand and be able to demonstrate

In order to complete the requirements of this unit you will need to know, understand and be able to demonstrate relevant knowledge of the following:

• the types of organisation which use science;
• how science is used in organisations;
• how health and safety regulations are used in the workplace;
• how the organisation impacts on the local community.

The types of organisation which use science

Science has an impact on a wide range of organisations. Whether it is in a cutting-edge technology industry, or somewhere such as a small bakery, science forms the foundations of many industries.

Organisations which use science can be broadly grouped into those that manufacture or process scientific products for sale and those that provide a scientific service.

You should be able to:

• identify and use a variety of research methods, such as telephone directories, the Internet or local knowledge to give details of local organisations and/or businesses who use science to
  - manufacture or process scientific products for sale
  - provide a scientific service.

How science is used in organisations

In any organisation which uses science, the scientific knowledge and skills are applied in a variety of ways. There will be a range of people employed in these organisations. Some employees will routinely use science without having a full understanding of how or why the science they use is important. Others will have a formal science background and apply this in their work.

From your summary of organisations and/or businesses which use science you should identify one organisation or business to study in
depth. You should be able to identify:

- the nature of the work done – for example, research, production, quality control, safety, education;
- the processes used that are based on applying current scientific knowledge;
- the scientifically related skills used;
- the roles and responsibilities of the scientifically qualified staff and the types of scientific qualifications they have;
- how ICT is used in the organisation or business;
- the constraints within which the organisation or business operates – for example, commercial, legal, health and safety.

**How health and safety regulations are used in the workplace**

Health and safety regulations are designed to ensure that employers provide their employees with a safe environment in which to work. These regulations protect the people who work in an organisation and those who may be affected by their products or services. Employers are responsible for making arrangements for implementing health and safety measures that are identified as necessary by a risk assessment for any task undertaken.

For your chosen organisation or business you should find out about:

- the use of risk assessments;
- the hazards involved in the operations and details of how these are controlled;
- the site regulations imposed by the managers, the local authority and any other external agencies;
- how particular health and safety laws apply to the organisation;
- any kite marks that the organisation uses in the production of its goods. You need to explain the role of the kite mark and what this will mean to potential customers. You should also understand the processes through which the organisation has to go to achieve a kite mark.

**How the organisation impacts on the local community**

You should consider the socio-economic and environmental effects (beneficial and detrimental) of your chosen organisation, and how it impacts on the local community.

You should identify:

- the ways in which energy consumption is managed in the organisation;
- the demands made on transport and communication systems;
• management of waste materials and the effect this may have on the local environment;
• contributions to the local economy. These could include community use of facilities, sponsorship of local groups etc.
10.4 Assessment Criteria: Unit 1 – Investigating Science at Work

**Assessment evidence**

You need to produce a portfolio of evidence containing:

A. a summary of local organisations and/or businesses that use scientific skills; (AO1)

B. a detailed report on one organisation or business identified in your summary. (AO1, AO2)

<table>
<thead>
<tr>
<th>Mark Band 1</th>
<th>Mark Band 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>AO1</td>
<td>There was an attempt to identify appropriate research methods. These research methods were, in turn, used to identify a range of organisations and/or businesses that manufacture or process scientific products for sale and provide a scientific service. The initial research was incomplete and limited by the range of techniques used. From the initial research, a single organisation was identified. A lack of further suitable research into the organisation did not allow for a detailed exploration of the organisation in terms of the nature of the work, the scientific processes involved, the skills and qualifications of all employees, health and safety considerations or the use of ICT. Information in the portfolio is poorly organised and lacks a coherent structure although it may contain some valid points. The portfolio contains significant errors and/or omissions in the use of technical terms, spelling, punctuation and grammar leading to a lack of clarity. Teacher guidance was often required. * See below</td>
</tr>
<tr>
<td>(1-10 marks)</td>
<td>There was a good attempt to identify research methods. These research methods were, in turn, used to identify a range of organisations and/or businesses that manufacture or process scientific products for sale and provide a scientific service. The initial research was complete but limited by the range of techniques used. A single organisation was selected and studied, and research undertaken in terms of the nature of the work, the scientific processes used, the skills and qualifications of all employees, health and safety considerations and the use of ICT. Although this research was generally complete, it is difficult to make the necessary links between the nature of the work undertaken by the organisation and other aspects of the research. Information in the portfolio shows some organisation and structure and contains some valid evidence. The portfolio contains some errors and/or omissions in the use of technical terms, spelling, punctuation and grammar leading to inconsistency in clarity. Some capacity to work alone has been evident, although teacher guidance was sought. *</td>
</tr>
<tr>
<td>(11-20 marks)</td>
<td></td>
</tr>
<tr>
<td>AO2</td>
<td>The overall impression is that research was undertaken with little regard to the final outcome. Although there is an understanding of health and safety guidelines, it is difficult to see how this was applied to the chosen organisation. There is a vague awareness of commercial, legal and health and safety constraints but these are applied to the organisation inconsistently. The impact of the organisation on the local community was explored; however, there are many inconsistencies and omissions. * See below</td>
</tr>
<tr>
<td>(1-5 marks)</td>
<td>Although the health and safety guidelines were applied to the organisation, the understanding of these guidelines was hampered by poor research into the organisation. A sketchy understanding of how the organisation functions has led to some awareness of the commercial, legal and health and safety constraints under which the chosen organisation operates. How the organisation impacts on the local community was not explored fully/consistently.</td>
</tr>
<tr>
<td>(6-10 marks)</td>
<td></td>
</tr>
</tbody>
</table>

* teacher/assessor evidence required

* Award 0 marks if nothing creditworthy is displayed in the portfolio.
<table>
<thead>
<tr>
<th>Mark Band 3</th>
<th>Mark Band 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AO1</strong></td>
<td>A variety of suitable research methods were identified. These research methods were, in turn, used to identify a range of organisations and/or businesses that manufacture or process scientific products for sale and provide a scientific service. The research used was thorough and consistent. The research into one local organisation considered the nature of the work undertaken, the processes involved, the skills and qualifications of employees, the roles and responsibilities of all scientifically qualified staff, health and safety considerations and the use of ICT. Some of the necessary links are missing between the nature of the work of the organisation and all other aspects of the research. There are slight inaccuracies and some inconsistency. Information in the portfolio is mainly well organised and structured and is supported by valid evidence. The portfolio is expressed with reasonable clarity but has a few minor errors and/or omissions in the use of technical terms, spelling, punctuation and grammar. The final outcome was achieved largely unaided. # (21-30 marks)</td>
</tr>
<tr>
<td><strong>AO2</strong></td>
<td>A thorough understanding of health and safety guidelines was obtained through research, and this understanding was applied correctly and thoroughly to the chosen organisation and its operations. There is a clear understanding of the commercial, legal and health and safety constraints under which the organisation operates. These have been arrived at from a complete understanding of how the chosen organisation works. This understanding was carried through to provide a full consideration of how the organisation impacts on the local community. (16-20 marks)</td>
</tr>
</tbody>
</table>

# teacher/assessor evidence required
AS Unit 2
Energy Transfer Systems

11.1 About this Unit

Energy plays a crucial role in our everyday lives. Energy transfers take place on a variety of scales, from very small-scale transfers to very large-scale global energy transfers.

In this unit you will look at the structure and function of the circulatory and respiratory systems, how these systems can be monitored and investigated and their role in energy transfer in the body. This unit considers some of the ethical issues relating to the monitoring, diagnosis and treatment of circulatory and respiratory illnesses. It also considers more widespread examples of energy transfer and how it can be controlled.

Controlling energy transfers is an important part of modern life. We have to consider our energy usage not only on a small scale but take account of the wider community as our energy usage and wastage impacts around the world.

In this unit you will learn about:

- the structure and function of the circulatory and respiratory systems – including the processes involved in respiration;
- some methods of taking physiological measurements related to the circulatory and respiratory systems, and the uses of these in monitoring health and for diagnosis of illness;
- examples of imaging methods used in monitoring health and in diagnosis, the advantages and disadvantages of using these methods, and which are best suited to particular situations;
- ethical issues relating to the monitoring, diagnosis and treatment of the circulatory and respiratory systems;
- relating information from measurements or monitoring to what is happening in the organs and systems involved;
- some applications of energy transfer both in the body and in wider contexts;
- the meaning of the term efficiency, how to calculate the efficiency of a system and know that there is a fundamental limit to efficiency.

This unit links to other GCE Applied Science units in biology and physics, in particular Unit 8 (Medical Physics) and Unit 14 (The Healthy Body). It also links with other GCE subjects such as biology and physics. This unit will help you prepare for higher education courses in biology and physics or other science-related subjects or for work in a science-based occupation.
In this unit you will be required to complete an external examination of 1½ hours duration. The examination will consist of a series of compulsory short answer, structured questions and will be marked out of 80.

You will be assessed on your knowledge, understanding and skills relating to energy transfer systems.

You should ensure that you have a detailed knowledge and understanding of all the information in Section 11.3.

You should be able to plan and evaluate investigations ensuring that they are valid and reliable. This is for investigations both in the laboratory context, and from the point of view of professionals working in a scientific environment.

You will need to be able to recall, use and manipulate all the formulae contained in this unit, also detailed in Appendix D.

To gain high marks in the examination you should:

- be familiar with all the content described in the unit;
- be able to apply the knowledge you have learned in this unit to familiar and unfamiliar situations;
- ensure that your answers meet the requirements specified in each question;
- avoid irrelevance;
- when necessary, write answers which are logical and coherent paying particular attention to correct spelling, punctuation and grammar.

**The structure and function of the circulatory and respiratory systems**

The human body is organised into cells, tissues and organ systems. They interrelate to enable the human body to function. Healthcare and fitness professionals need to monitor cellular, tissue or organ activity. This information can provide details about how effectively a particular individual is able to perform under different conditions.

You should understand:

- the structure of the heart – including the role of the four chambers, the valves in double circulation and the characteristic features of arteries, veins and capillaries;
- how heart rate is affected by nervous inputs;
- how blood pressure changes with the activity of the body;
- the structure of the lungs, trachea and bronchial tubes, and how breathing movements are brought about by muscles;
- how gases are exchanged between the atmosphere and the blood, through the respiratory surfaces of the lungs;
how pulse rate, breathing rate and tidal volume change in response to changes in carbon dioxide and oxygen levels in the blood;

- how the vital capacity of the lungs may be affected by regular exercise or by lack of exercise;
- homeostatic mechanisms for controlling body temperature;
- how to plan laboratory investigations to investigate the above and evaluate their effectiveness.

**How to find out about physiological status through monitoring**

People who are interested in health and fitness monitor indicators of physiological status. They may do this before, during and after exercise to assess a person’s current level of fitness and if their performance is changing.

In a hospital it may be necessary to monitor indicators such as blood pressure, body temperature or blood sugar level. This may be done to check a person’s state of health, to check how they are recovering from an injury or operation, or to help follow the progress of a clinical condition.

You should be aware of how the following physiological indicators are measured:

- pulse rate and/or heartbeat;
- blood pressure (using a manual or an electronic digital sphygmomanometer);
- breathing rate;
- tidal volume and vital capacity of the lungs (using a simple spirometer, which can also be used to measure the rate of oxygen consumption);
- peak expiratory flow rate (using a peak flow meter).

You should know the average values for the indicators that are regarded as normal for male and female adults at rest, and be able to compare these normal values with real values.

Normal values which will be used for comparison are:

**Breathing:**

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>breathing rate</td>
<td>12–15 breaths per min</td>
</tr>
<tr>
<td>tidal volume</td>
<td>400–500 cm³</td>
</tr>
<tr>
<td>vital capacity (male)</td>
<td>4.8 dm³</td>
</tr>
<tr>
<td>vital capacity (female)</td>
<td>3.1 dm³</td>
</tr>
<tr>
<td>peak flow</td>
<td>400–600 dm³ min⁻¹</td>
</tr>
</tbody>
</table>

**Blood pressure:**

18-year-old male 120/80 mm Hg
20-year-old male 125/80 mm Hg
40-year-old male 135/85 mm Hg

Females usually have slightly lower blood pressure:
20-year-old female 123/80 mm Hg
40-year-old female 133/85 mm Hg

Pulse rate:
typical range of pulse rate is 60–80 beats per minute

In a hospital, an electrocardiogram, spirometer and peak flow meter are used to monitor the activity of the heart and lungs. For each instrument you should be able to:

- recognise a normal trace, or the average value in the case of a peak flow meter, and describe what it shows;
- recognise traces for a normal heartbeat, sinus tachycardia, bradycardia, sinus arrhythmia and ventricular fibrillation;
- describe what such traces show about the probable physiological status of people.

The body generates heat as a result of chemical reactions taking place in it. Energy is constantly lost from the surface of the body through the skin as heat. A small amount of heat is also lost with expired air, urine and faeces. The rate at which heat (energy) is lost from the body depends on conditions such as the temperature of the surroundings, how much skin is exposed and the level of activity of the body.

Normally, body temperature is regulated by homeostatic mechanisms and maintained at a more or less constant value. Variation from this value may indicate a failure of these mechanisms and a probable health problem. However, the body can produce a physiological response to conditions such as fever and will raise the body temperature to aid recovery.

You should be able to explain:
- the significance of the temperature range that a healthy body can withstand and body temperatures that are dangerously high or low.

The range of body temperatures measured in the mouth:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>normal</td>
<td>36.8°C ; range 36.5–37.2°C</td>
</tr>
<tr>
<td>death</td>
<td>below 25°C</td>
</tr>
<tr>
<td>hypothermia</td>
<td>32°C</td>
</tr>
<tr>
<td>fever</td>
<td>above 37.2°C</td>
</tr>
<tr>
<td>heat exhaustion or</td>
<td>likely if above 38°C in absence of infection</td>
</tr>
<tr>
<td>heat stroke</td>
<td></td>
</tr>
<tr>
<td>high temperatures</td>
<td>above 43°C</td>
</tr>
<tr>
<td>that would lead to</td>
<td></td>
</tr>
<tr>
<td>death</td>
<td></td>
</tr>
</tbody>
</table>
how temperature is controlled and regulated by the nervous system, the circulatory system and the skin. You should be able to describe the temperature control mechanisms of sweating, vasodilation, vasoconstriction and shivering;

the circumstances in which particular individuals may be at risk of hypothermia, heat exhaustion or heat stroke.

The process of respiration

You should know:

- that respiration involves chemical reactions that use oxygen;
- the balanced chemical equation for aerobic respiration and be able to identify any waste products produced;
- how respiration can be investigated in the laboratory.

Ethical issues relating to the monitoring, diagnosis and treatment of the circulatory and respiratory systems

You should be aware of, and be able to discuss, some ethical issues relating to monitoring, diagnosis and treatment of circulatory and respiratory systems that healthcare professionals need to consider.

Examples of some ethical issues you should be aware of are:

- treatment of self-inflicted problems;
- whether the cost of treatment should affect treatment options;
- turning off life support systems;
- transplants;
- withholding distressing information from patients;
- using human beings as subjects for investigations and clinical trials.

Imaging methods used in monitoring and diagnosis

Healthcare professionals frequently rely on imaging methods to diagnose illness and monitor the health of the patient. You should be aware of the examples of imaging methods used to diagnose illness and monitor health given below:

- X-rays (including CAT scans);
- ultrasound;
- magnetic resonance imaging (MRI);
- radioactive tracers.

For each of these you should know the advantages and disadvantages of using each method and suggest, with reasons, which methods could be used in particular situations.
Applications of energy transfer

You should know about some applications of energy transfer both inside and outside the body.

You should be able to design, carry out and evaluate investigations related to forces, momentum, power, energy, energy transfer, efficiency and thermal transfer linked to the content given below.

You should:

- know about the role of energy in respiration;
- be able to apply knowledge of energy transfer involving other forms of energy, for example, sound, kinetic, potential, electrical and chemical to a variety of situations;
- use the formulae given below to calculate energy change and comment on the significance of the results obtained in any calculations
  
  potential energy \( (E_p) = \text{mass} \times \text{acceleration} \times \text{height} \)

  due to gravity

  kinetic energy \( (E_k) = \frac{1}{2} \times \text{mass} \times \text{velocity}^2 \)

- explain the effects of friction on effective energy transfer;
- understand how momentum changes in collisions;
- understand the effect of impulse in a collision, how materials and products are manufactured to increase the impact time and reduce the overall effect of the collision;
- compare the energy input and work done in a variety of real-life situations and understand that the work done is equal to the energy transferred;
- understand that power is the rate of transferring energy.

  Power can be calculated using the formula

  \[
  \text{power} \ (P) = \frac{\text{energy transferred} \ (E) \ \text{or work done} \ (w)}{\text{time taken} \ (t)}
  \]

- be able to calculate the cost of using electrical appliances using the formula

  \[
  \text{cost} \ (C) = \text{power} \ (P) \times \text{time} \ (t) \times \text{cost per unit} \ (u)
  \]

  and compare the cost of using a variety of appliances;
- understand the meaning of the term efficiency, how it is calculated and the use and manipulation of the formula

  \[
  \text{efficiency} \ (%) = \frac{\text{useful energy output} \ (E_u)}{\text{total energy input} \ (E_i) \times 100}\%
  \]
You should be able to plan, carry out and evaluate simple experiments relating to the calculation of efficiency. You will need to be aware of the limits to the efficiency of energy transfer and consider the most economical methods of transferring energy:

- know that when designing various machines and heating systems, consideration of the most economical methods of transferring energy will be required;
- know that there is a fundamental limit to the efficiency of some systems – such as heat exchangers and refrigerators – which depends on the limiting temperatures in which they are working;
- know how the rate of energy transfer and temperature of a system can be controlled;
- know and understand how energy is transferred in the three thermal transfer mechanisms – conduction, convection and radiation;
- know which types of materials are good at transferring heat energy by each of these mechanisms and how heat loss through each of these mechanisms can be controlled;
- know which types of materials are poor at transferring heat energy by each of these mechanisms and how heat loss through each mechanism can be controlled;
- be able to apply this knowledge to temperature regulation in the body, in buildings and in the wider environment. A knowledge of $U$-values, as used in the construction industry, is a requirement for this;
- be able to describe how automatic feedback can control the temperature of a system;
- know how electricity is generated from a variety of energy sources – including coal, nuclear power, hydroelectric power, biogas and solar power – and comment of the relative advantages and disadvantages of each;
- know some of the problems, both large and small scale, caused by wasteful energy transfer and be able to suggest some methods of reducing this waste;
- be able to discuss practical methods of reducing wasteful energy transfer and consider the social, environmental and financial consequences of using energy inefficiently.
12.1 About this Unit

Scientists working in analytical laboratories are called analysts; one of the tasks undertaken by analysts is the analysis and identification of chemical and biological substances. This could be, for example, in research for new pharmaceutical products, the quality control of existing products, or in a forensic and/or pathology laboratory. It is important that analysts carry out work precisely and record and interpret results accurately.

It is also important that analysts understand the changes that take place during the reactions that are used in analysis.

In this unit you will learn about:

- how to take and prepare samples for analysis;
- the use of standard procedures to ensure that the results of analysis can be replicated;
- how to conduct qualitative analysis and a volumetric (quantitative) analysis;
- how a chromatographic analysis and colorimetric analysis are conducted;
- how to calculate a molar enthalpy change from experimentation and that energy changes take place during chemical reactions.

This unit links to all other GCE Applied Science units in chemistry, in particular Unit 11 (Controlling Chemical Processes) and Unit 12 (The Actions and Development of Medicines). Through practical investigation there are links with Unit 1 (Investigating Science at Work) and Unit 7 (Planning and Carrying out a Scientific Investigation). It also links with other GCE subjects such as chemistry. This unit will help you to prepare for higher education courses in chemistry or other science subjects with a chemical component, or for work in a chemical or science-based occupation.

12.2 How you will be assessed

You need to produce a portfolio of evidence containing details of a range of analytical exercises in which you show your knowledge of relevant analytical techniques and the scientific principles that underpin them.

Your portfolio of evidence should comprise:

A. a report on four analytical techniques:
   - a qualitative analysis of an unknown inorganic chemical compound
   - an acid/base volumetric (quantitative) analysis
   - an analysis using chromatographic techniques
   - an analysis using colorimetric techniques.
You should:

• explain the uses of each type of analysis;
• give details of how to prepare a sample for each analysis;
• give details of the standard procedures and equipment to be used when carrying out each analysis;
• produce risk assessments for each analysis;
• record observations and measurements accurately for each analysis;
• interpret, explain and evaluate the results obtained for each analysis. This will include conducting any relevant calculations;
• for the qualitative analysis show an awareness of the limitations of this technique;
• explain the underlying scientific principles behind colorimetric and chromatographic techniques.

B. the measurement of the molar enthalpy change of combustion of one reaction including:

• carrying out the reaction following a standard procedure;
• taking appropriate measurements;
• using your results to calculate the molar enthalpy change;
• an explanation of why the energy change has taken place in terms of bond breaking and bond formation;
• an explanation of the use of combustion reactions.

12.3 You need to know, understand and be able to demonstrate

In order to complete the requirements of this unit you will need to know, understand and be able to demonstrate relevant knowledge of the following:

• how to obtain and prepare samples for analysis;
• qualitative chemical analysis;
• volumetric analysis;
• chromatographic techniques;
• colorimetric techniques;
• energy changes that take place when substances react.

How to obtain and prepare samples for analysis

Samples for analysis are obtained from a wide range of sources. For example, in forensic laboratories the analyst may be required to analyse soil, blood or paint samples; in a pharmaceutical research laboratory a sample of a new product will have to be purified before analysis can take place.
For each of the analyses you will undertake you should know:

- how to take a sample for analysis using a relevant sampling technique;
- how to prepare a sample for analysis.

**Qualitative chemical analysis**

Chemical tests are used by analysts to give an indication of the nature of substances that may be present in a sample. For example, a chemical test may be used to determine the presence of a particular metal ion in a sample of water taken from a polluted river. A forensic scientist may use a simple chemical test to identify components in a soil sample taken from a crime scene and compare this with a soil sample taken from a suspect’s shoes. Simple chemical tests can be used to identify a range of molecules.

In your portfolio you will have to show that you are able to:

- explain the uses of qualitative inorganic chemical analysis;
- prepare a sample for analysis.

You will have to produce a report on one qualitative analysis:

- giving details of the standard procedure you used to
  - carry out a chemical test to identify cations
  - carry out a chemical test to identify anions;
- analyse and interpret your results and report accurately the outcomes of your analysis;
- describe the limitations of your qualitative techniques.

**Volumetric analysis**

The titration technique is used in a number of industries. It is a quick, convenient and accurate method of determining the amount of a substance present in certain types of sample – for example, acid in rainwater, ethanoic acid in vinegar, lactic acid in milk and certain types of metal ions in polluted river water.

In your portfolio you will have to produce a report on an acid–base titration analysis and show that you are able to:

- explain how/where volumetric analysis can be used;
- prepare standard solutions for titration using a standard procedure;
- carry out your acid–base titration;
- use given chemical equations for the reactions involved in your titration to explain the scientific principle of the technique and carry out the relevant calculations;
- analyse and interpret your results and report accurately on the outcomes of your analysis.
Chromatographic techniques

Analysts often use chromatography to separate the chemicals in a mixture. This technique can also be used to purify a chemical product or to identify impurities that may be present. It is a powerful technique and is used in, for example, the pharmaceutical industry for the analysis and quality control of drugs as well as in environmental laboratories to measure levels of pollution. Although there are a range of sophisticated gas chromatographic methods, you should be primarily concerned with paper chromatography and thin layer techniques but there are other methods you should be aware of.

In your portfolio you will have to produce a report on a chromatographic analysis and show that you are able to:

- explain the scientific principles of chromatography;
- explain in which situations chromatography will be used;
- separate a mixture of your choice using a simple chromatographic technique;
- process and interpret the results obtained from your chromatographic investigation in terms of $R_f$ values;
- explain the involvement of the mobile and stationary phases in chromatography.

Colorimetric techniques

Analysts use colorimetric techniques to identify coloured solutions and measure their concentration. Colorimetry relies on coloured solutions absorbing light of a particular wavelength. However the technique can also be used to analyse colourless substances if they react with a dye.

In your portfolio you will have to produce a report on a colorimetric analysis and show that you are able to:

- explain the scientific principles of colorimetry;
- explain in which situations colorimetry will be used;
- follow a standard procedure to calibrate and use a colorimeter to determine the concentration of a solution;
- process and interpret your results to determine the concentration of a solution.

Energy changes that take place when substances react

When reactions take place they are accompanied by energy changes. Understanding these energy changes and why they happen helps scientists to control reactions in the laboratory and on a larger industrial scale. It also helps them to make use of accompanying energy changes.
You should be able to:

- explain, in terms of bonds breaking and forming, how energy is produced in combustion reactions;
- produce balanced chemical equations for combustion reactions and appreciate that there are waste products;
- carry out a combustion reaction, following a standard procedure, to determine its molar enthalpy change, including the calculation;
- explain why such reactions are useful.
12.4 Assessment Criteria: Unit 3 – Finding out about Substances

Assessment evidence

You need to produce a portfolio of evidence containing:

A. a report on four analytical techniques;
   - a qualitative analysis of an unknown inorganic chemical compound (AO1, AO3)
   - an acid/base volumetric (quantitative) analysis (AO1, AO2, AO3)
   - an analysis using chromatographic techniques (AO1, AO2, AO3)
   - an analysis using colorimetric techniques. (AO1, AO2, AO3)

B. the measurement of a molar enthalpy change of combustion of one reaction. (AO2, AO3)

<table>
<thead>
<tr>
<th>Mark Band 1</th>
<th>Mark Band 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>AO1</td>
<td></td>
</tr>
<tr>
<td>Knowledge relating to analytical techniques lacks firm foundations in science. This means that details of the uses of each type of analysis are by no means comprehensive and vary across the portfolio. There is some awareness shown of the scientific principles involved in volumetric, colorimetric and chromatographic techniques; however, this is far from complete and not related to the science underpinning each technique. (* See below)</td>
<td>There are details of the uses of each type of analytical technique but these are by no means comprehensive. The understanding of the limitations of the qualitative techniques is fairly detailed. There is a good understanding of the scientific principles relating to volumetric, colorimetric and chromatographic techniques; however, there are inaccuracies and omissions. (3-4 marks)</td>
</tr>
<tr>
<td>(1-2 marks)</td>
<td></td>
</tr>
<tr>
<td>AO2</td>
<td></td>
</tr>
<tr>
<td>Relevant calculations were attempted, but the answers are variable and indicate a lack of understanding of correct units, or the need for accuracy and precision in measurement. In the determination of molar enthalpy change of combustion, the attempt to explain why the change has taken place makes very little reference to bonds. This provides scant opportunity to explain why this type of reaction is useful. (* See below)</td>
<td>Relevant calculations were attempted, but the answers reveal a lack of accuracy and precision in measurement and the recording of results was not consistent. In the determination of molar enthalpy change of combustion, there is an explanation as to why the change has taken place and some reference to bonds is made. However, this offers little scope to explain why this type of reaction is useful. (3-4 marks)</td>
</tr>
<tr>
<td>(1-2 marks)</td>
<td></td>
</tr>
</tbody>
</table>

* Award 0 marks if nothing creditworthy is displayed in the portfolio
<table>
<thead>
<tr>
<th>AO1</th>
<th>Mark Band 3</th>
<th>Mark Band 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The details and uses of each type of analytical technique are generally complete, as are the limitations of the qualitative techniques. There is generally a sound understanding of the scientific principles behind volumetric, colorimetric and chromatographic techniques; however, there are some minor omissions and/or inaccuracies.</td>
<td>A thorough knowledge and understanding of each type of analytical technique and the limitations of the qualitative techniques are demonstrated throughout. The scientific principles behind volumetric, colorimetric and chromatographic techniques are well documented and used to aid understanding.</td>
</tr>
<tr>
<td></td>
<td>(5-6 marks)</td>
<td>(7-8 marks)</td>
</tr>
<tr>
<td>AO2</td>
<td>Relevant calculations are correct; however, there is some inconsistency in the units used or the accuracy and precision of the results obtained. In the determination of molar enthalpy change of combustion, a clear explanation is provided as to why the change happens and there are clear references to bonds breaking and forming, but there are one or two inaccuracies. This understanding links to explanations of why this type of reaction is useful.</td>
<td>The relevant calculations are correct, to an acceptable degree of accuracy and precision and with generally correct units. In the determination of molar enthalpy change of combustion, a comprehensive explanation is provided as to why the change happens and this relates specifically to bonds breaking and forming. This is then clearly linked to an explanation of why this type of reaction is useful.</td>
</tr>
<tr>
<td></td>
<td>(5-6 marks)</td>
<td>(7-8 marks)</td>
</tr>
</tbody>
</table>
### AO3 (i)
There was an inconsistent approach to the investigations and, although all five were attempted, this was not to the same standard and frequent, extensive teacher intervention was needed. 

There are many procedural inaccuracies, with only a cursory use of standard procedures and risk assessment. Observations and measurements, where present, are minimal and incomplete with little regard to the need for precision in conducting the analyses and recording the results.

(* See below)

(1-5 marks)

### AO3 (ii)
Standard procedures and risk assessments, if present, are inconsistently applied across the analyses. Details of how to prepare each sample for analysis lack depth. Observations and measurements are generally incomplete and/or inaccurate and hinder any attempted evaluation of each analysis.

Information in the portfolio is poorly organised and lacks a coherent structure although it may contain some valid points. The portfolio contains significant errors and/or omissions in the use of technical terms, spelling, punctuation and grammar leading to a lack of clarity.

(* See below)

(1-6 marks)

### Mark Band 1
- There was an inconsistent approach to the investigations and, although all five were attempted, this was not to the same standard and frequent, extensive teacher intervention was needed. 
- There are many procedural inaccuracies, with only a cursory use of standard procedures and risk assessment. Observations and measurements, where present, are minimal and incomplete with little regard to the need for precision in conducting the analyses and recording the results.

(1-5 marks)

### Mark Band 2
- Although all five investigations have been attempted, the variability in approach means that the observations and measurements were not recorded across the investigations consistently. There was, on occasion, a need for some teacher intervention/guidance.
- Procedural inaccuracies led to unreliable observations and measurements. Presentation of observations and measurements is neither logical nor clear.

(6-10 marks)

### Mark Band 2
- Standard procedures and risk assessments are generally present; however, they are variable across the analyses and do not allow all to be followed through to conclusion. Details of the preparation of each sample are inconsistent.
- There are some appropriate observations and recorded measurements and these lead, in some cases, to an evaluation.
- Information in the portfolio shows some organisation and structure and contains some valid evidence. The portfolio contains some errors and/or omissions in the use of technical terms, spelling, punctuation and grammar leading to inconsistency in clarity.

(7-12 marks)

# teacher/assessor evidence required
Award 0 marks if nothing creditworthy is displayed in the portfolio.
<table>
<thead>
<tr>
<th>AO3</th>
<th>Mark Band 3</th>
<th>Mark Band 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i)</td>
<td>With minimal teacher involvement all investigations were carried out to a consistently high standard, but there were some minor deviations from standard procedure or risk assessment. # This introduced some inconsistency in the accuracy of observations and measurements, although generally they are recorded logically and presented clearly.</td>
<td>With relative autonomy, all investigations were carried out to a consistently high standard. # The safe and skilful use of equipment following standard procedures and risk assessment is evident. Observations and measurements relating to all investigations were recorded logically and clearly and to an appropriately suitable level of precision.</td>
</tr>
<tr>
<td></td>
<td>(11-15 marks)</td>
<td>(16-20 marks)</td>
</tr>
<tr>
<td>(ii)</td>
<td>Standard procedures, risk assessments and details of the preparation of the samples are detailed suitably; however, there are a few omissions. Observations and measurements are complete and allow for some detailed interpretation and explanation of results for all the investigations. There is evidence that detailed evaluation took place, but this is variable across all the investigations. Information in the portfolio is mainly well organised and structured and is supported by valid evidence. The portfolio is expressed with reasonable clarity but has a few minor errors and/or omissions in the use of technical terms, spelling, punctuation and grammar.</td>
<td>Standard procedures, risk assessments and details of the preparation of the samples are suitably detailed. The clearly documented observations and measurements allowed for intelligent interpretations, explanations and evaluation of results for all investigations. The evaluation is comprehensive and detailed and explains inconsistencies and anomalies in the results obtained. Information in the portfolio is logically organised leading to a coherent structure and is supported by a range of valid evidence. The portfolio is clearly expressed with few minor errors in the use of technical terms, spelling, punctuation and grammar.</td>
</tr>
<tr>
<td></td>
<td>(13-18 marks)</td>
<td>(19-24 marks)</td>
</tr>
</tbody>
</table>

# teacher/assessor evidence required
13.1 About this Unit

The production and retailing of food is a continually expanding industry in the developed world. It employs large numbers of people in agriculture, horticulture, processing, logistics and retailing. The media offers advice and articles concerning the growth of crops (used in food production), food production techniques, food processing and diet. In contrast many other areas of the world have difficulty producing sufficient food to satisfy the demands of their population, which results in disease or famine. The science of food and its production is vital to us all.

An understanding of the importance of balanced diets for different client groups and the different ways in which these diets can be satisfied is essential for those who produce food and those who advise about diet.

In this unit you will learn about:

- different client groups and their dietary needs;
- the agents which can spoil food, and suitable methods of food preservation and food packaging;
- the legal requirements associated with the production and retailing of foods;
- the stages involved in preparing a design brief for a food product that you will produce;
- making and testing a product, including how government agencies, such as the Food Standards Agency, protect the public’s health and consumer interests in relation to food.

This unit links to other GCE Applied Science units, including Unit 5 (Choosing and Using Materials), Unit 7 (Planning and Carrying out a Scientific Investigation) and Unit 14 (The Healthy Body). It also links with other GCE subjects such as biology. This unit will help you to prepare for higher education courses in food technology and food-related subjects as well as those which use science or for work in a science-based occupation. It will also help you to prepare for a career in the food or catering industries.

13.2 How you will be assessed

You need to produce a portfolio of evidence detailing the development and production of a new or modified food product.

Your portfolio of evidence should comprise:

A. a design brief for the product including:
- identifying a specific client group and its dietary requirements;
- demonstrating knowledge of a range of ideas for the
product that suits the chosen client group;

• producing a specification for the product;

• giving details of packaging ideas, including label information and design;

• determining the price of the proposed product to the consumer by considering factors such as cost of raw materials, production costs, transport costs, marketing costs and profit;

• comparing the cost of the proposed product with a similar product(s).

B. a summary of the production and testing of the product by:

• using data and observations collected from experiments undertaken in relation to food spoilage, applying these to the production of the product and to the design brief;

• using data and observations collected from experiments in relation to food preservation and applying these to the production and packaging of the product;

• detailing how you made the product and how this related to the original specification;

• detailing current health and safety regulations which should be adhered to;

• stating any health and safety practices followed in the production;

• evaluating if the product fulfils current legislation relating to labelling requirements;

• considering the role of government agencies, such as the Food Standards Agency, and the types of testing they may undertake;

• identifying any modifications you would make in producing your product.

13.3 You need to know, understand and be able to demonstrate

In order to complete the requirements of this unit you will need to know, understand and be able to demonstrate relevant knowledge of the following:

• the type of diet required for different client groups;

• the causes of food spoilage and methods of food preservation;

• the packaging of products;

• the labelling of products;

• legislation relating to the management of hygiene in the food industry;

• how to prepare a design brief for a new product;

• making the product;
• testing the product by government agencies.

The type of diet required for different client groups

You should be aware that there is a range of different client groups for different products. You should be able to identify the characteristics of a number of different client groups which include, among other things, age, gender, ethnic group and religion. You should also be aware that other factors such as work patterns, social habits, fashion, special dietary requirements and socio-economic factors will affect a particular client group and this will, in turn, affect their choice of product.

You should have an understanding of the functions and main sources of the following components of foods in the human diet:

• carbohydrates;
• proteins;
• fats;
• minerals – iron, calcium and phosphorous;
• vitamins – A, D, E, K, B and C;
• water;
• roughage.

You should be able to target the product you produce to a particular client group you have identified, bearing in mind its specific dietary requirements.

The causes of food spoilage and methods of food preservation

One of the legal requirements of food packaging is that it states a sell-by date and use-by date. In order for these to be determined it is important to understand the common causes of food spoilage and the methods that can be used to preserve food.

You should be able to use your knowledge of agents that spoil food to plan and conduct a range of simple laboratory experiments to show how food is spoilt by:

• microbes and the action of the toxins produced by them;
• the action of enzymes;
• the action of oxygen causing, for example, fats to become rancid.

You will need to be aware that food will spoil at different rates and conduct some simple experiments which show:

• the spoilage rates of foods kept under the same external conditions;
• the external factors that will affect the spoilage rate of particular foods.
You should be able to demonstrate that you can relate your findings from your experimental work directly to your product.

You should be aware of the scientific principles underlying methods of food preservation. You should have practical experience of the following food preservation methods:

- temperature control, including freezing, chilling, blanching, sterilising and pasteurising;
- the control of water content by drying, sugaring and salting;
- control of pH;
- the effects and action of antioxidants, antifungal and antibacterial agents.

You should have an understanding of how the following food preservation methods are used in the food industry and the background science that supports each method:

- sealing – including vacuum packing, modified atmosphere packaging, bottling and canning;
- irradiation – including the use of gamma rays for sterilising sealed food products and to prevent greening and subsequent sprouting of some vegetables.

You should be able to demonstrate that you can relate your findings from your experimental work directly to your product.

**The packaging of products**

The packaging of food products has two main functions:

- to protect the product while in transit and on the shelf;
- to attract consumers to the product and provide information relating to its contents.

When a manufacturer decides on the packaging for a product they will consider the following:

- economics;
- practicality;
- environmental concerns;
- presentation.

You should have an awareness of a variety of different types of packaging – including glass, plastic, foil and cardboard – and an awareness of the economic and practical reasons for each type of packaging.

In designing the packaging for your product you should be aware not only of the design of the package but other considerations including size, shape and material.
The labelling of products

It is a legal requirement that all packaged food products are correctly labelled. The label of the food product must contain:

- a full ingredients list, arranged in descending percentage composition;
- nutritional information that relates specifically to the product.

The labelling of a food product will allow consumers of the product to make an informed decision about their purchase. You should produce a label for the product which fulfils current legal requirements. In order to do this you will need to research the current legal requirements for the labelling of food products.

Legislation relating to the management of hygiene in the food industry

Employers and employees have certain responsibilities relating to the management of hygiene in the food production industry.

You should be aware of the management of hygiene systems in the food industry and the control of potential hazards. You should understand current legislation in relation to this and be aware of the manufacturer’s responsibilities, as well as the responsibilities of individual employees, in relation to hygiene systems in the workplace.

How to prepare a design brief for a new product

When deciding on a new product, a manufacturer will produce a design brief which will follow the format below:

- an idea is generated for a new product – the idea will be the result of a variety of factors and will include the needs of a specific client group;
- the suitability of the product for the specified client group is established;
- a specification for the product is produced, to include
  - a list of ingredients with exact quantities, appreciating the need for, and importance of, scaling up quantities for industrial production
  - the method of preparation – including a process flow diagram indicating the equipment required
  - the hygiene practices to be observed and any Hazard Analysis Critical Control Point (HACCP) procedures required;
  - the quantitative nutritional content and how this meets any claims made for the product
  - the shelf-life of the final product;
- packaging ideas including design, shape, size and materials to be used.
You should be able to produce a comprehensive design brief for the product. As well as the factors given above you should:

- determine the price of a new product to the consumer by considering factors such as cost of raw materials, cost of production, transport costs, marketing and profit;
- compare the price, shelf-life and packaging of similar products and be able to suggest why a new proposed product would appeal to your chosen consumer group.

Making the product

New products are normally made in small batches as this will allow for the specification to be tested and any changes made to the product before manufacture. In making your product you will need to:

- decide where the product will be made – for example, a school laboratory or the food technology department in your centre;
- use appropriate equipment to measure and record the ingredients used;
- meet appropriate hygiene requirements.

Testing the product by government agencies

When making a product, a manufacturer should test it to ensure that it remains of a consistently high quality. Government agencies will also carry out testing of products. The Food Standards Agency is an independent food safety watchdog set up in 2000 to protect the public’s health and consumer interests in relation to food.

You should be aware that sampling tests may be carried out by government agencies to assess:

- the chemical and biological contaminants in food products caused by migration from materials and articles in contact with the food;
- additive and nutrient content – does the product agree with the label?
- food authenticity – does the product agree with the label?
- pesticide residues in food.

You should be able to explain:

- why it is necessary to conduct such sampling tests;
- how the tests would be conducted in relation to your product;
- how you have produced your product to ensure that it meets the requirements of government agencies.

You should be able to demonstrate an appreciation that modifications to the design brief and the production of your product may be required based on your knowledge of any relevant testing by government agencies while making your product.
### 13.4 Assessment Criteria: Unit 4 – Food Science and Technology

#### Assessment evidence

**You need to produce** a portfolio of evidence containing:

A. a design brief for the product; (AO1, AO2)

B. a summary of the production and testing of the product. (AO3)

<table>
<thead>
<tr>
<th>Mark Band 1</th>
<th>Mark Band 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AO1</strong></td>
<td>A simplistic design brief for the product was produced. A product was suggested but with limited reference to the client group at which it is targeted or its dietary needs. Some research was undertaken into the method of preparation of the product and the legal requirements for labelling but this is unfocused and incomplete. (* See below)</td>
</tr>
<tr>
<td>(1-3 marks)</td>
<td>A detailed design brief for the product was produced. The portfolio shows knowledge of the diet of the targeted client group, and this shows some links with the initial design brief and suggestions for the product. The research into the method of preparation and legal requirements for labelling lacked depth and required teacher input. #</td>
</tr>
<tr>
<td><strong>AO2</strong></td>
<td>A vague understanding of the science behind agents which spoil food and food preservation methods is evident; however, this was not applied correctly in forming the design brief. Calculations, where evident, were rudimentary and predominantly focused on one factor and not the total costs. Extensive teacher assistance was required to relate these to the design brief. # (* See below)</td>
</tr>
<tr>
<td>(1-2 marks)</td>
<td>Knowledge and understanding of the science behind the agents which spoil food and food preservation methods are evident but it was not appropriately integrated into the production of the design brief. Straightforward calculations were attempted successfully and then related to certain aspects of the design brief, albeit with teacher assistance. # The calculations do not necessarily consider the total costs of production but do consider some of the relevant factors.</td>
</tr>
<tr>
<td>(3-4 marks)</td>
<td></td>
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</tbody>
</table>

# teacher/assessor evidence required

* Award 0 marks if nothing creditworthy is displayed in the portfolio
### Mark Band 3

**AO1**
A comprehensive design brief for the product was produced. It is not always fully supported by scientific theory. Realistic ideas for a product were generated, supported by research into the target client group and their specific dietary requirements. Research was undertaken into the method of preparation and the legal requirements for the labelling of products and this has generally been applied throughout with minimal teacher input.

(7-9 marks)

**AO2**
In producing the design brief, knowledge and understanding of the science behind food spoilage and food preservation methods were applied in an appropriate and consistent manner. Calculations considered the total costs of producing the product, by incorporating most of the relevant factors. Calculations were attempted independently; however, there were some inaccuracies and/or omissions which were corrected with teacher intervention.

(5-6 marks)

# teacher/assessor evidence required

### Mark Band 4

**AO1**
The comprehensive design brief produced for the product details fully the procedures to be followed, and direct links are forged to the appropriate scientific theory. The specific dietary needs of the target client group were clearly identified and this information was used in a methodical way to produce a realistic design brief. Research into the method of preparation and legal requirements for the labelling of food products was conducted with relative autonomy and was systematic and comprehensive.

(10-12 marks)

**AO2**
Knowledge and understanding of food spoilage and food preservation methods were applied consistently and appropriately in the production of the design brief. Calculations relevant to the design brief were completed independently with a high degree of precision. The cost is realistic and related to the total cost of production incorporating all relevant factors.

(7-8 marks)
<table>
<thead>
<tr>
<th><strong>AO3 (i)</strong></th>
<th><strong>Mark Band 1</strong></th>
<th><strong>Mark Band 2</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiments relating to the causes of food spoilage and methods of food preservation were undertaken but with little regard to the product and with extensive and frequent teacher intervention required in order that the experiments were completed. # Unfamiliarity with, and lack of skill in, the use of the equipment is evident. Thus the results obtained are inaccurate, imprecise and of limited use. An attempt was made to produce the product; however, extensive teacher intervention was necessary to ensure that relevant health and safety procedures were adhered to. (* See below)</td>
<td>Experimental work into the agents which spoil food and the methods of food preservation was undertaken with some regard to the product. There was, on occasion, the need for some teacher intervention/guidance. # The results obtained show that some skill and precision was used with equipment and in the collection of data and observations; however, this was inconsistent across the experiments. A product has been produced and an awareness of health and safety procedures relating to the production of the product is evident; however, without teacher intervention these would not have been put into practice in producing the product. (* See below)</td>
<td>(1-6 marks)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>AO3 (ii)</strong></th>
<th><strong>Mark Band 1</strong></th>
<th><strong>Mark Band 2</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>The observations and data obtained from experiments on agents that spoil food and food preservation methods are sparse. There are very limited links between these experiments and the design brief and it is not possible to make the necessary scientific links to the shelf-life considerations of the design brief. There is little knowledge shown of the purpose of testing by government agencies, or any tests they may undertake. There is little attempt to suggest modifications to the product. Information in the portfolio is poorly organised and lacks a coherent structure although it may contain some valid points. The portfolio contains significant errors and/or omissions in the use of technical terms, spelling, punctuation and grammar leading to a lack of clarity. (* See below)</td>
<td>The observations and data obtained from experiments conducted into agents which spoil foods and food preservation methods are incomplete and, on the whole, poorly presented. There is a tentative link between the nature of the experiments and the design brief; however, the incomplete results will mean that shelf-life considerations are unrealistic and are generally unsupported by experimental data. There is some knowledge shown of the purpose of testing by government agencies and of the tests they may undertake. An attempt was made to suggest some modifications but these are not wholly linked to the results of any tests. Information in the portfolio shows some organisation and structure and contains some valid evidence. The portfolio contains some errors and/or omissions in the use of technical terms, spelling, punctuation and grammar leading to inconsistency in clarity.</td>
<td>(1-4 marks)</td>
</tr>
</tbody>
</table>

# teacher/assessor evidence required

Award 0 marks if nothing creditworthy is displayed in the portfolio.
### AO3 (i)

<table>
<thead>
<tr>
<th>Mark Band 3</th>
<th>Mark Band 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>With minimal teacher involvement, experiments into the agents that spoil food and food preservation methods were undertaken successfully. # The generally skilful use of equipment yielded correct and generally precise experimental results; however, there are small omissions. In conducting the experiments an awareness of the design brief was shown and results were produced with this in mind. Health and safety procedures were generally correctly applied.</td>
<td>With relative autonomy, suitable experiments were conducted on the agents that spoil food and food preservation methods. The safe and skilful way in which these experiments were undertaken means that the comprehensive results obtained are both precise and reliable. # In producing the product, health and safety procedures were strictly adhered to.</td>
</tr>
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</table>

(13-18 marks)

### AO3 (ii)

<table>
<thead>
<tr>
<th>Mark Band 3</th>
<th>Mark Band 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observations and data obtained from experiments conducted on agents that spoil food and food preservation methods are well presented and generally complete with only a few omissions. A shelf-life, based on scientific understanding, for the product was suggested as part of the design brief; however, this is a little unrealistic given the nature of the data used. There is a good understanding of the role of government agencies and the requirements for the testing of products, and tests are suggested that might be undertaken on the product. However, these are not thorough or wholly related to the product. Modifications to the product were suggested and these are based on the results of the tests undertaken. Information in the portfolio is mainly well organised and structured and is supported by valid evidence. The portfolio is expressed with reasonable clarity but has a few minor errors and/or omissions in the use of technical terms, spelling, punctuation and grammar.</td>
<td>Comprehensive observations and extensive data gained from the experiments on food spoilage and food preservation are presented clearly and logically. Shelf-life considerations, as part of the design brief, are realistic and have a foundation in science. There is a real understanding of the need for testing and a consideration of the types of tests that government agencies undertake, and these are related specifically to the product. Appropriate modifications were suggested and these are clearly linked to the results of the tests undertaken. Information in the portfolio is logically organised leading to a coherent structure and is supported by a range of valid evidence. The portfolio is clearly expressed with few minor errors in the use of technical terms, spelling, punctuation and grammar.</td>
</tr>
</tbody>
</table>

(9-12 marks) (13-16 marks)

# teacher/assessor evidence required
14

AS Unit 5
Choosing and Using Materials

14.1 About this Unit

The study of types of materials and their properties is central to the way science is used in many industrial situations, from making small items – such as contact lenses and pens – through to larger artefacts – such as domestic appliances and cars – to large structures – such as trains and bridges. You only have to look around your immediate environment to see the multitude of objects made from different materials. One thing they have in common is that the materials selected will have properties best suited to the use the object has been put to.

In this unit you will learn about:

- the different properties of materials such as metals, polymers and ceramics;
- how scientists define the properties of a material and compare values for different materials;
- how to measure some of the properties of a material and investigate how they allow the material to be put to a particular use;
- why different materials behave in different ways;
- how the internal structure of a material influences the way it behaves;
- ways in which properties of a material can be modified by altering the structure of the material.

This unit links to other GCE Applied Science units in chemistry, in particular Unit 3 (Finding out About Substances), Unit 11 (Controlling Chemical Processes) and Unit 13 (Colour Chemistry). Through practical work and the need for risk assessment, this unit also links with Unit 1 (Investigating Science at Work). It also links to other GCE subjects such as chemistry. This unit will help you to prepare for higher education courses in chemistry or other science-related subjects such as materials science or for work in a science-based occupation.

14.2 How you will be assessed

In this unit you will be required to complete an external examination of 1½ hours duration. The examination will consist of a series of compulsory short answer questions and will be marked out of 80. The examination may also contain a comprehension exercise.

You will be assessed on your knowledge, understanding and skills relating to choosing and using materials.

You should ensure that you have a detailed knowledge and understanding of all of the information in Section 14.3.
You should be able to plan and evaluate investigations ensuring that they are both valid and reliable. This is for investigations in the laboratory context, and also from the point of view of professionals working in a scientific environment.

You will need to be able to recall, use and manipulate all the formulae contained in this unit, also detailed in Appendix D.

To gain high marks in the examination you should:

- be familiar with all the content described in the unit;
- be able to apply the knowledge you have learned in this unit to familiar and unfamiliar situations;
- ensure that your answers meet the requirements specified in each question;
- avoid irrelevance;
- when necessary, write answers which are logical and coherent paying particular attention to correct spelling, punctuation and grammar.

14.3 You need to know, understand and be able to demonstrate

Identifying the purposes for which materials are needed

When considering which materials to use for a specific project, designers will choose a material based on its particular properties. The specific properties of the material must be considered in order that the design can be translated successfully. Materials scientists will need to know the significance of the properties of a material and how the material behaves under different conditions.

You should know about the properties of materials, including:

- the meaning and scientific definitions of the following mechanical properties: stiffness, brittleness, ductility, elasticity, the Young modulus, plasticity, ultimate tensile strength;
- the meaning of the terms stress and strain and be able to calculate these using the formula

\[
\text{stress (}\sigma\text{)} = \frac{\text{force (} F \text{)}}{\text{cross-sectional area (} A \text{)}}
\]

\[
\text{strain} = \frac{\text{change in length}}{\text{original length}}
\]

- the meaning of the term density and be able to calculate its value using the formula

\[
\text{density (}\rho\text{)} = \frac{\text{mass (} m \text{)}}{\text{volume (} v \text{)}}
\]

you should be able to compare a calculated value of density with known values;
• the scientific definitions of electrical conductivity and thermal conductivity;
• the scientific definition of thermal expansivity;
• the meaning of the term resistance to chemicals.

You should be able to:

• identify different examples of materials with each mechanical property listed above;
• state why the value of each mechanical property is relevant to the use to which the material is to be put, and compare given values for each mechanical property;
• explain the meaning and relevance of the terms stiffness, brittleness, ductility, malleability, elasticity, the Young modulus, plasticity, ultimate tensile strength, stress, strain, density, electrical conductivity, thermal conductivity and thermal expansion.

Relating the physical properties of materials to their structure

Materials behave as they do because of their structure; the way their atoms and molecules fit together. Materials scientists consider how materials behave at the atomic level in order to assess the suitability of a material for a specific project.

You should understand how physical properties relate to:

• the microscopic structure of crystalline, polymeric and amorphous materials;
• the structure of composite materials;
• strong bonding between particles (ionic, covalent and metallic);
• weak bonding between particles.

The different classes of materials

Materials can be grouped into classes according to their composition.

You should know:

• the basic categories of materials – metals, ceramics, glasses, polymers and a group of combined materials known as composites.

You should be able to:

• give examples of uses of each of these basic categories of materials and be able to offer and justify a range of common uses of these materials in different situations – such as construction, domestic goods, industrial plant, medical applications and sports equipment;
• investigate how the properties of the categories of materials influence their use.
Justifying the use of a particular material

You should be able to justify the use of a material in an artefact or a given situation in terms of properties such as stiffness, brittleness, ductility, elasticity, plasticity, ultimate tensile strength, stress, strain, Young modulus, density, electrical conductivity, thermal conductivity, resistance to chemicals and thermal expansion.

Designers take a broader view of the choice of materials, and need to consider other factors as well as their physical properties. This takes into account other influences.

You should know:

- the ease with which the material can be used in constructing the artefact under consideration;
- the environmental factors affecting the making and use of a range of materials;
- the conditions of use of materials;
- the costs involved when choosing a particular material;
- the availability of the material selected;
- aspects of disposal or recycling of materials used in artefacts.

Methods for measuring physical properties

Manufacturers of materials need to be aware of methods for measuring physical properties. These could be used to test new materials or as a quality control check in a factory.

You will need to be aware of simple laboratory experiments to measure the values of physical properties. You will need to be able to measure the following physical properties for a range of materials – including metals, ceramics, glass, polymers and composites:

- a mechanical property;
- density;
- electrical conductivity;
- thermal conductivity;
- resistance to chemicals;
- thermal expansion/contraction.

You will need to be aware of experiments that test the physical properties of materials. The specific experiments you should be aware of are:

- the determination of Hooke’s law and how to relate the relevant physical properties of the material (elasticity, elastic limit, permanent deformation, plasticity, break point) to the molecular structure of the material;
• how to use a tensile tester or Searle’s apparatus to calculate the stiffness of a material. The results obtained can then be used to determine the Young modulus of a material using the formula

\[
\text{Young modulus (} E \text{)} = \frac{\text{stress}}{\text{strain}}
\]

You will need to be able to use this formula to calculate a value for the Young modulus of a material. You will then need to compare this value to given values and relate this to particular uses of a material.

You should show an awareness that in a commercial environment these experiments will often be done quite differently than in a school laboratory, sometimes on a much larger scale and often more rigorously.

**Explaining the changes in the physical properties of modified materials in terms of their structure**

Manufacturers can alter the properties of a material by subjecting it to a range of techniques. These techniques will affect the material at the atomic level which will, in turn, affect the physical properties of the material.

You should be aware of the various techniques used to alter the properties of materials. You should know that:

• alloying or heat treating (annealing and quenching) metals may affect their atomic lattice structures and grain structures;
• tempering, thermal toughening, sintering and annealing glass affects its mechanical strength;
• cold drawing of polymers may affect cross-linking and the arrangement of molecules;
• changing the components in composite materials, or changing the proportion of these components, affects their physical properties.
15.1 About this Unit

Preparative or synthetic chemists employed in science-based industries are sometimes required to prepare, purify and analyse compounds in the laboratory. These chemists play a significant part in identifying and synthesising new compounds that might be of benefit to society – for example, pharmaceuticals and agrochemicals. They also find improved ways of making products on a large scale and developing products on a small scale, including using advances in modern technology and maintaining quality in production techniques.

In this unit you will learn about:

- the wide range and number of organic compounds formed by carbon;
- how to describe organic compounds;
- how to recognise a range of aliphatic compounds, their functional groups, structural formula and shape;
- recognising examples of a range of chemical reactions and writing balanced equations;
- how to make and purify organic compounds;
- how to determine theoretical and actual percentage yield.

This unit links to other GCE Applied Science units in chemistry, in particular Unit 3 (Finding out about Substances) and Unit 11 (Controlling Chemical Processes). Through practical investigation and the need for risk assessment, this unit also links with Unit 1 (Investigating Science at Work). It also links with other GCE subjects such as biology and chemistry. This unit will help you to prepare for higher education courses in biology and chemistry or other science-related subjects with a biology/chemistry component or for work in a science-based occupation.

15.2 How you will be assessed

You need to produce a portfolio of evidence which gives an account of organic compounds and a report into the preparation and determination of a laboratory preparation of two pure organic compounds.

Your portfolio of evidence should comprise:

A. an account of a range of organic compounds including:
   - an explanation of why carbon forms such a huge range of compounds;
   - an explanation of structural isomerism and stereoisomerism;
   - an explanation of the term aliphatic and identification of common compounds, functional groups, structural formulae, bonding and shape;
   - the use of spectroscopic techniques to identify organic
compounds;
• examples of the main types of reactions (redox, hydrolysis, esterification and condensation polymerisation). This will include writing balanced chemical equations and identifying reagents.

B. a report of a laboratory preparation and determination of purity of two organic compounds including:
• details of the method for the preparation of each organic compound – the method should differ for each organic compound;
• producing risk assessments;
• carrying out the laboratory preparation and purification of the two organic compounds;
• recording observations and measurements, and processing the data obtained;
• calculating the actual and theoretical percentage yield of each organic compound;
• checking the quality of each organic compound by determining its melting point and boiling point;
• suggesting and explaining any modifications you would make to the product and/or method used in order to ensure a better quality and/or higher yield of the product;
• explaining the types of reactions taking place and the structure of the reactants and products;
• research into how one spectroscopic technique (infrared, mass spectrometry or NMR) would be used in an industrial laboratory to determine the purity of one of your chosen organic compounds.

15.3 You need to know, understand and be able to demonstrate

In order to complete the requirements of this unit you will need to know, understand and be able to demonstrate relevant knowledge of the following:
• organic compounds and functional groups;
• types of chemical reaction;
• the use of spectroscopic techniques (infrared, mass spectrometry or NMR) in identifying organic compounds;
• how to make and purify organic compounds;
• how to determine yield and purity.

Organic compounds and functional groups

Many of the materials we use today are made by chemical synthesis. They can be classified as organic or inorganic, although some compounds do not fit neatly into either category – for example, organometallic compounds. Most of the new compounds made
today are organic, based on the element carbon, and there is a vast industry based on the synthesis of these new compounds. To be effective, synthetic chemists must know about two important concepts that underpin their work – functional groups and the shapes of molecules.

In order to produce an account of organic compounds you should be able to:

- explain why carbon forms such a huge range of compounds;
- explain the importance of the characteristic reactions of functional groups;
- recognise and name aliphatic organic compounds with the functional groups:
  - alkene: \( \text{C} = \text{C} \)
  - alcohol: \( -\text{OH} \)
  - carboxylic acid: \( -\text{COOH} \)
  - amine: \( -\text{NH}_2 \)
  - ester: \( -\text{COOR} \)
  - amide: \( -\text{CONHR} \)
  - aldehyde: \( -\text{RCHO} \)
  - ketone: \( -\text{RCOR} \);
- draw structural formulae for organic compounds containing the functional groups listed above and describe their three-dimensional shapes;
- identify which bonds allow rotation in a molecule and the effect this has on its three-dimensional shape;
- explain structural isomerism and stereoisomerism;
- explain how spectroscopic techniques may be used to identify organic compounds.

**Types of chemical reaction**

Each functional group has its characteristic reactions. Synthetic chemists use their understanding of how chemical changes take place (reaction mechanisms) to devise efficient synthetic routes for the preparation of organic compounds.

In order to give details of the main types of chemical reaction you should be able to:

- recognise and give examples of the following types of reactions:
  - redox
  - hydrolysis (as a substitution reaction)
  - esterification
  - condensation polymerisation, for example, in making nylon;
- write appropriate balanced chemical equations for reactions of the types listed above;
- identify possible reagents that can be used to bring about the reaction types listed.
The use of spectroscopic techniques (infrared, mass spectrometry or NMR) in identifying organic compounds

You should be aware that, in an industrial laboratory, spectroscopic analysis can be used to provide a fingerprint of evidence of the purity or nature of a substance. You should understand how one type of spectroscopy (infrared, mass spectrometry or NMR) could be used to determine the purity of one of your organic compounds. You should be able to explain the science behind the spectroscopic technique you have chosen and the benefits of using that technique.

How to make and purify organic compounds

To make organic compounds in the laboratory and determine their purity, scientists must be confident about handling different types of substances and using equipment. Standard procedures are generally used both to ensure a consistency of approach and to allow experiments to be replicated.

The preparation of a compound in the laboratory is often the first stage in the design of an industrial process for its manufacture. Different routes can be tried, using different starting materials and varying the reaction conditions, to see which give good yields and products of highest purity. There are many techniques that can be used to prepare and purify compounds in the laboratory.

In order to prepare and purify two organic compounds you should be able to:

- research and follow standard procedures to prepare and purify both organic compounds;
- carry out risk assessments;
- use laboratory equipment safely – including assembling and using glassware and selecting and using equipment for heating, cooling and mixing reaction mixtures as appropriate;
- handle substances safely – this will include transferring substances (solid, liquid or gas) with minimum loss of material;
- carry out the preparations safely and within any constraints imposed;
- separate mixtures using an appropriate technique – such as precipitation, crystallisation, filtration, distillation and/or solvent extraction;
- purify products using an appropriate method – such as distillation or recrystallisation.

How to determine yield and purity

A compound must often be made to a required purity and the products of chemical reactions must be assessed to determine their purity.
Once you have completed the preparation of your two pure organic compounds you should be able to:

- determine the theoretical and actual percentage yield;
- measure melting points and boiling points;
- suggest and explain any modifications you would make to the product and/or method used in order to ensure a better quality and/or higher yield of the product.
15.4 Assessment Criteria: Unit 6 – Synthesising Organic Compounds

Assessment evidence

You need to produce a portfolio of evidence containing:

A. an account of a range of organic compounds; (AO1)
B. a report of a laboratory preparation and determination of purity of two organic compounds. (AO1, AO2, AO3)

<table>
<thead>
<tr>
<th>Mark Band 1</th>
<th>Mark Band 2</th>
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<tbody>
<tr>
<td>AO1</td>
<td>Drawing on some relevant background knowledge, supported by limited research, a simplistic account of organic compounds was produced. The account is primarily based around the range of organic compounds; however, there is an attempt to describe the structure, shape, functional groups and the main types of reaction, and the use of spectroscopic techniques, this was hampered by omissions and inaccuracies. Through research, a method of preparation for each organic compound was identified; however, this was generally incomplete. (* See below)</td>
</tr>
<tr>
<td>AO2</td>
<td>There was an unsuccessful attempt to provide balanced equations. The resulting calculations relating to the theoretical and actual percentage yield were attempted but with little success. The explanations of the types of reactions taking place, and the structure of the reactants and products are evident, although incomplete, and does not relate specifically to the two organic compounds. (* See below)</td>
</tr>
</tbody>
</table>

* Award 0 marks if nothing creditworthy is displayed in the portfolio
<table>
<thead>
<tr>
<th>AO1</th>
<th>Mark Band 3</th>
<th>Mark Band 4</th>
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<tbody>
<tr>
<td>Research and background knowledge were used to provide a detailed account of organic compounds. The account of the range of organic compounds is complete and is supported by scientific knowledge of shape, structure, functional groups, main types of reactions and the use of spectroscopic techniques; however, there are slight inaccuracies. Through research, a method of preparation for each organic compound has been identified; however, there are slight omissions and/or inaccuracies.</td>
<td>Through research and background knowledge, a full account of organic compounds was produced. The account is comprehensive with no significant omissions and this is supported by scientific knowledge relating to shape, structure, functional groups, main types of reactions and the use of spectroscopic techniques. Through research, a comprehensive method of preparation of each organic compound was identified.</td>
<td>(7-9 marks)</td>
</tr>
<tr>
<td>AO2</td>
<td>Balanced equations and the resulting calculations relating to the theoretical and actual percentage yield of each organic compound were successfully attempted. However, some slight inaccuracies in either the processing of the data or the use of units are evident. The explanations into the types of reactions taking place, and the structure of the reactants and the products are thorough and are linked to the two organic compounds; however, there are slight inaccuracies and/or omissions.</td>
<td>Balanced equations and the resulting calculations relating to the theoretical and actual percentage yield were complete and correct in almost every respect. The explanations of the types of reactions taking place, and the structure of the reactants and the products are thorough, complete and clearly linked to the two organic compounds.</td>
</tr>
<tr>
<td>AO3 (i)</td>
<td>With extensive and frequent teacher involvement, the preparation and purification of both organic compounds was attempted but the approach lacks consistency. Standard procedures and risk assessment were used, although there were many inaccuracies in both. Equipment was used with little skill. Precision in results is inconsistent and observations and measurements, where present, are minimal and incomplete. The measurements of melting point and boiling point were attempted but with little success. (* See below)</td>
<td>With some teacher intervention/guidance, both organic compounds were prepared and purification was attempted; however, an inconsistent approach means that observations and measurements recorded are of a variable standard. The use of equipment was acceptable but there was, on occasion, the need for some teacher intervention/guidance. This, together with some procedural inaccuracy, means that observations and measurements were not wholly reliable, nor were they recorded logically or presented clearly. The measurements of melting points and boiling points were attempted with dubious success. (1-6 marks)</td>
</tr>
<tr>
<td>AO3 (ii)</td>
<td>The observations and data obtained from the experiment on the preparation and determination of purity of the two organic compounds are sparse. It is difficult to see how this data links to calculation of theoretical/actual percentage yield. There are few suggestions made with regard to the product and/or the method used; however, if present, these are unworkable or indeed do not improve the yield or the purity of the product. Through research, a vague awareness of a relevant spectroscopic technique was shown; however, this does not specifically relate to one of the organic compounds made. There was no real explanation relating to either the science behind the spectroscopic technique used or the benefits of using it. Information in the portfolio is poorly organised and lacks a coherent structure although it may contain some valid points. The portfolio contains significant errors and/or omissions in the use of technical terms, spelling, punctuation and grammar leading to a lack of clarity. (* See below)</td>
<td>The observations and data obtained from the experiments on the preparation and determination of purity of the two organic compounds are generally incomplete. It is clear that observations and measurements were made with a view to calculating the theoretical/actual percentage yield. Some suggestions were made with regard to the product and/or the method used to improve the quality or yield of the product; however, the explanations given do not have firm foundations in science. Research provided an awareness of a suitable spectroscopic technique which could be used and there was an attempt to link this to one of the organic compounds made; however, this was not completely successful. There was an attempt to explain the scientific principles behind the spectroscopic technique chosen and the benefits of using it. Information in the portfolio shows some organisation and structure and contains some valid evidence. The portfolio contains some errors and/or omissions in the use of technical terms, spelling, punctuation and grammar leading to inconsistency in clarity. (1-4 marks)</td>
</tr>
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</table>

* Award 0 marks if nothing creditworthy is displayed in the portfolio.
### Mark Band 3

**AO3 (i)**

With minimal teacher involvement, both organic compounds were prepared and purified to a consistently high standard with the skilful use of equipment being evident. However, there were some deviations from the standard procedures or risk assessments used. The overall effect of this is some inconsistency in the observations and accuracy of measurements recorded. The measurement of melting point or boiling point was complete but with slight inaccuracies.

(13-18 marks)

**AO3 (ii)**

The observations and data obtained from the experiments on the preparation and determination of purity of the two organic compounds are generally complete with few omissions. It is clear that observations and measurements were made with a view to calculating the theoretical/actual percentage yield. Detailed and workable suggestions were made describing modifications which could be made to either the product and/or the method to ensure better quality and/or higher yield of the product; however, there are some slight omissions or scientific inaccuracies. Comprehensive research was carried out into a suitable spectroscopic technique which could be used and this was been linked to one of the organic compounds produced; however, there were some slight omissions or scientific inaccuracies. There is a detailed explanation of the science behind the chosen spectroscopic technique, together with the benefits of using it. Information in the portfolio is mainly well organised and structured and is supported by valid evidence. The portfolio is expressed with reasonable clarity but has a few minor errors and/or omissions in the use of technical terms, spelling, punctuation and grammar.

(9-12 marks)

# teacher/assessor evidence required

### Mark Band 4

**AO3 (i)**

With relative autonomy, both organic compounds were prepared and purified. Standard procedures and risk assessment were applied to a consistently high standard and both preparations were conducted safely and skilfully. Comprehensive observations were recorded and measurements are precise. The measurements of melting point and boiling point are accurate and complete.

(19-24 marks)

**AO3 (ii)**

Comprehensive observations and extensive data were obtained from the experiments on the preparation and determination of purity of the two organic compounds and these are clearly and logically presented. It is clear that all observations and measurements were made in relation to the calculation of the theoretical/actual percentage yield. Detailed and workable suggestions were made describing modifications which could be made to either the product and/or the method to ensure better quality and/or higher yield of the product. Thorough research was carried out into a suitable spectroscopic technique which could be used and this was successfully linked to one of the organic compounds produced. There is a thorough explanation of the science behind the chosen spectroscopic technique, together with the benefits of using it. Information in the portfolio is logically organised leading to a coherent structure and is supported by a range of valid evidence. The portfolio is clearly expressed with few minor errors in the use of technical terms, spelling, punctuation and grammar.

(13-16 marks)
16.1 About this Unit

Many industries employ scientists who are involved in investigation or research. This unit provides an opportunity to use the knowledge and skills you have gained in the other units of this specification to undertake research and investigative work of your own.

In this unit you will learn about:

- the stages involved in planning a practical investigation;
- how to conduct a practical investigation;
- how to record, process, evaluate and draw conclusions from the data obtained from the practical investigation;
- presenting your practical investigation to a client.

This unit links to all other GCE Applied Science units. It also links with other GCE subjects through the preparation of the practical investigation. In this unit you will be required to bring together knowledge, skills and understanding from different areas of the specification to fulfil the formal requirement for synoptic assessment within this specification. This unit will help you to prepare for higher education courses which use scientific skills and for work in science-based occupations.

16.2 How you will be assessed

You need to produce a portfolio of evidence which shows that you can plan and conduct an investigation and present your findings in a suitable way for a chosen client.

Your portfolio of evidence should comprise:

A. a research outline, using knowledge and understanding of a topic in this specification, of one practical investigation you wish to conduct including:

- the identification of a chosen client;
- the identification of the practical investigation;
- a research outline including objectives;
- details of health and safety and environmental regulations and preparation of suitable risk assessments;
- a statement of, and use of, valid secondary sources of information.

B. a report, including a plan, detailing how you undertook the practical investigation and the results you obtained including:
• details of trials undertaken to ensure that the technique, or procedure used, will provide the necessary data for the practical investigation. At this point you will need to describe any modifications to your original plan;

• recording all data appropriately. You should ensure that quantitative data is obtained accurately and recorded to a suitable level of precision;

• noting anomalous results and suggesting reasons for these;

• appropriate manipulation of the data;

• processing of relevant calculations;

• evaluating the investigation. This involves reviewing your results against your original aims and making any suggestions for improvement.

C. the presentation of your findings in a suitable way for the chosen client, including:

• identifying the client for whom the investigation was targeted together with the aims of the investigation;

• using a suitable method to present your findings including the correct use of scientific terminology.

16.3 You need to know, understand and be able to demonstrate

In order to complete the requirements of this unit you will need to know, understand and be able to demonstrate knowledge of the following:

• how to plan an investigation;

• how to carry out the investigation;

• recording and processing the data obtained;

• evaluating and drawing conclusions from the investigation;

• presenting the outcomes of the investigation.

How to plan an investigation

When undertaking investigations, scientists will have a clear purpose to their work and will conduct the investigation adhering to a planned schedule.

You should be able to:

• state for whom your investigation is intended;

• establish the purpose of the investigation and set objectives which are realistic and achievable;

• give details of suitable practical techniques which will allow you to obtain primary data. This could result from using standard procedures or adapting standard procedures to suit the requirements of your
investigation;

• identify apparatus required to carry out the investigation;

• identify any constraints and prepare appropriate risk assessments;

• locate, and use, secondary sources of information, checking their validity and selecting relevant information.

How to carry out the investigation

Having devised a plan for an investigation and carried out the necessary background work, you should set about collecting primary data (qualitative and quantitative) from direct observation and measurement.

For your investigation you should:

• carry out trials, where necessary, to check that specific techniques or procedures will provide the data you require;

• check data as it is obtained to decide if the original plan needs to be modified;

• use the chosen techniques or procedures to obtain data accurately, reliably and to appropriate levels of precision;

• comply with health and safety and environmental regulations;

• follow standard procedures and/or any modified procedures.

Recording and processing the data obtained

You should record your observations and measurements in the most appropriate way to allow you to obtain the information you require from them.

You should be able to:

• record qualitative data in an appropriate format;

• record quantitative data accurately in an appropriate format, to a suitable level of accuracy and with a consideration of correct units;

• recognise that some data collected may be anomalous and suggest reasons for this;

• carry out relevant calculations and use a variety of suitable methods for presenting quantitative data;

• select and use appropriate methods to manipulate the data.
Evaluating and drawing conclusions from the investigation

Having completed your investigation and processed the data collected, you will then have to consider your work against the purposes and objectives originally set.

You should:
• evaluate your results and identify any sources of error;
• use your data to draw conclusions that are valid and relevant to the purpose and objectives of the investigation;
• make any recommendations for improvements to your investigation.

Presenting the outcomes of the investigation

Your findings should be presented in an appropriate manner. This could include a formal presentation, a poster, a series of leaflets, a support book for students or colleagues working in science, or a video but it should reflect the client’s needs. You should feel free to explore a variety of presentation methods and select the most appropriate to your investigation.

You should:
• clearly identify the intended client(s) for whom the report is intended;
• summarise the aims of the practical investigation;
• present your findings clearly and concisely;
• use appropriately the correct scientific terminology related to the requirements of your chosen client;
• combine text and images to create an effective presentation.
### Assessment evidence

**You need to produce** a portfolio of evidence containing:

- A. a research outline, using knowledge and understanding of a topic within this specification, of one practical investigation you wish to conduct; (AO1, AO3)
- B. a report, including a plan, detailing how you undertook the practical investigation and the results you obtained; (AO2, AO3)
- C. the presentation of your findings in a suitable way for the chosen client. (AO3)

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<tr>
<td><strong>AO1</strong></td>
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<tr>
<td>A client and investigation were identified and the research outline produced was, at best, sketchy, and it is difficult to see how this links to knowledge gained from the specification. Objectives, where stated, were not realistic or integral to the research outline. There was little relevant research into health and safety issues and an explanation of the necessity for such regulations. There is little evidence of any use of secondary sources. (* See below)</td>
<td>A client and suitable investigation were suggested with links to area(s) of the specification. The research outline lacked some depth of knowledge and understanding. The stated objectives were realistic but were not integral to the research outline. The research into health and safety issues allowed for some description into why they were necessary, but omissions/errors did not allow for an explanation of their necessity. These issues suggested did not go beyond an unscientific/common sense approach. There is some evidence of the use of secondary sources but these have not been validated. Relevant information was extracted, though this was not wholly linked to the objectives in the outline. (* See below)</td>
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<td>(1-2 marks)</td>
<td>(3-4 marks)</td>
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| **AO2**                                                                   |                                                                            |
| There is, at best, a tenuous grasp of the area of study. The application of the science in relation to the topic under the investigation was weak with a poor comprehension of scientific principles. Without considerable assistance it is unlikely that the scientific principles and information gained from any secondary sources would have been applied in a viable methodology.# Any calculations provided had little relevance and were simplistic. (* See below) | The grasp of the chosen area of study means that application of relevant principles and concepts was not developed. Much teacher assistance was required when considering the scientific principles of the secondary sources of information. # Calculations were attempted successfully and were relevant, though the more difficult ones required teacher assistance. |
| (1-3 marks)                                                               | (4-6 marks)                                                                |

* Award 0 marks if nothing creditworthy is displayed in the portfolio.
# teacher/assessor evidence required
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<th>Mark Band 3</th>
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<tr>
<td>AO1</td>
<td>A client and suitable investigation were suggested with good links to area(s) of the specification. The research outline was thorough with one or two slight omissions/inaccuracies. Objectives were clear and realistic. Research into health and safety allowed for a full description of them; however, the necessity for them was not fully explained. These issues were considered in a scientific manner. Secondary sources were used and these are linked to the objectives in the outline. There was an attempt to check, validate and extract relevant information from secondary sources. (5-6 marks)</td>
<td>A client was identified and a realistic investigation was suggested with appropriate links to area(s) of the specification. The research outline was well thought out and complete in all respects with clear, realistic and achievable objectives. Research into health and safety issues allowed for a full description of them together with suitable explanations of why they are necessary. This description and explanation was complete and based on scientific understanding. There was extensive use of secondary sources and this research is clearly linked to the outline. Secondary sources of information were checked thoroughly and validated and only relevant information was used in the outline. (7-8 marks)</td>
</tr>
<tr>
<td>AO2</td>
<td>The relationship between the area of study in the specification and the investigation is clear. The ability to sift through secondary sources of information and use the relevant information is also evident. The work was characterised by a greater level of autonomy and little consultation was needed with the teacher to make progress towards application. Calculations were independently attempted; however, there were some inaccuracies. # (7-9 marks)</td>
<td>Acting almost completely autonomously, there was a high level of understanding of the chosen area and the pre-selected sources of secondary information. A real grasp of how relevant principles can be used and applied to the investigation is clear in the portfolio. Relevant calculations were completed independently and carried out with a high degree of precision. # (10-12 marks)</td>
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# teacher/assessor evidence required
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<th>AO3 (i)</th>
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<tr>
<td>There is little evidence of any trials ahead of the investigation. The documented procedures were not followed accurately and did not allow meaningful results to be obtained without teacher intervention. # Equipment was not used safely, nor skilfully, and was manipulated with little regard to the need for precision. There was a need for extensive and frequent teacher intervention to ensure that progress was made. # Observations and measurements were minimal and incomplete. (* See below)</td>
<td>There are some documented trials, though their findings are not related clearly to the investigation. Documented procedural inaccuracies or the inability to follow a standard procedure produced inconsistent results. Inexperience in the use of equipment and the need for some teacher intervention/guidance led to generally imprecise results. # Observations and measurements were not wholly reliable or presented logically and clearly.</td>
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<td>(1-4 marks)</td>
<td>(5-8 marks)</td>
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<th>AO3 (ii)</th>
<th>Mark Band 1</th>
<th>Mark Band 2</th>
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<tbody>
<tr>
<td>An outline plan has been produced. This includes some explanation of the investigation but will not go into specific detail as to the nature of the experiments to be undertaken. There is no detail regarding trial experiments. Some standard procedures were detailed but with little regard to how they should be modified to fit into the investigation. There was little attempt at any risk assessment. The report contains major errors and/or omissions. Evaluation of the methodology and/or equipment was sparse. Poor presentation of the facts to the client means they would be unlikely to see how the conclusions reached have a scientific basis. Information in the portfolio is poorly organised and lacks a coherent structure although it may contain some valid points. The portfolio contains significant errors and/or omissions in the use of technical terms, spelling, punctuation and grammar leading to a lack of clarity. (* See below)</td>
<td>A plan has been produced which includes an explanation of the investigation and contains some details as to the experiments required. Trial experiments were detailed but will be of little use in informing the plan. Standard procedures were identified which could be used in the investigation; the need to modify the standard procedures was understood but this was not fully carried out. A risk assessment was suggested, though this was relatively simple and lacking in scientific depth. The report has some slight errors and/or omissions. Evaluation of the methodology and/or equipment is evident but without proper accuracy or appropriateness. Presentation of data to the client lacks coherence and they would struggle to draw meaningful conclusions. Information in the portfolio shows some organisation and structure and contains some valid evidence. The portfolio contains some errors and/or omissions in the use of technical terms, spelling, punctuation and grammar leading to inconsistency in clarity.</td>
<td></td>
</tr>
<tr>
<td>(1-6 marks)</td>
<td>(7-12 marks)</td>
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</tbody>
</table>

* Award 0 marks if nothing creditworthy is displayed in the portfolio.

# teacher/assessor evidence required
<table>
<thead>
<tr>
<th>AO3 (i)</th>
<th>Mark Band 3</th>
<th>Mark Band 4</th>
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<tr>
<td>The trials undertaken were appropriate and relevant to the investigation. Although generally complete, there are inconsistencies in the approach across the investigation. With minimal teacher involvement, equipment was used competently and safely. This led to observations and measurements which are generally correct and precise, although not always presented in a completely logical way.</td>
<td>Extensive trials were undertaken and their scientific findings were clearly linked to the investigation. With relative autonomy the investigation was completed to a consistently high standard with the use of equipment being both safe and skilful. There was a strict emphasis on both standard procedure and risk assessment. Observations and measurements were complete and precise and presented in a thoroughly logical way.</td>
<td>(9-12 marks)</td>
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<tr>
<th>AO3 (ii)</th>
<th>Mark Band 3</th>
<th>Mark Band 4</th>
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<tr>
<td>A plan has been produced. The plan includes a detailed explanation of the investigation, the nature of the experiments to be undertaken and details of standard procedures; however the results of the trial experiments do not fully explain how these standard procedures need to be modified to suit the investigation, though these were not wholly linked to the plan. A scientific approach to the risk assessment was adopted and this was clear, though perhaps missing some salient points. The report produced has few errors or omissions. Evaluation of the methodology and/or equipment is reasoned and justified. The presentation meets the needs of the client and allows the client to draw some conclusions. Information in the portfolio is mainly well organised and structured and is supported by valid evidence. The portfolio is expressed with reasonable clarity but has a few minor errors and/or omissions in the use of technical terms, spelling, punctuation and grammar.</td>
<td>A comprehensive plan has been produced. The plan includes a detailed explanation of the investigation, the nature of experiments to be undertaken and details of standard procedures and how these would need to be modified to fit the needs of the investigation. There was a full and complete risk assessment with firm foundations in science. The presentation to the client allows meaningful conclusions to be drawn. The method of presentation used conveys all the relevant information and is suitable for the specific needs of the client. Evaluation of the methodology and/or equipment is complete, comprehensive and consistent. The report produced has few significant errors and no significant omissions. Information in the portfolio is logically organised leading to a coherent structure and is supported by a range of valid evidence. The portfolio is clearly expressed with few minor errors in the use of technical terms, spelling, punctuation and grammar.</td>
<td>(13-18 marks)</td>
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# teacher/assessor evidence required
A2 Unit 8

Medical Physics

17.1 About this Unit

This unit will enable you to discover how physics forms the basis of the technology which can be used in the diagnosis and treatment of illness. It considers the principles involved in a range of equipment used for diagnosis and treatment, and shows how these principles can be used to produce the modern healthcare technology that is often taken for granted. The unit covers the use of X-rays, radioisotopes, ultrasound, optical fibres and lasers in modern medicine, and discusses the effectiveness of each technique in diagnosing and/or treating particular complaints.

In this unit you will learn about:

- the principles of physics involved in a range of modern healthcare machines;
- which instruments and techniques are used to diagnose and treat particular illnesses;
- the most appropriate use of individual diagnostic tools;
- the types and uses of radiation;
- the medical uses of radiation;
- the hazards associated with radiation and the precautions to be taken when using it.

This unit links to all other GCE Applied Science units in physics and biology, in particular Unit 2 (Energy Transfer Systems) and Unit 10 (Physics of Performance Effects). It also links with other GCE subjects such as physics. This unit will help you to prepare for higher education courses in physics or other science-related subjects with a physics component, or for work in a science-based occupation. This unit will be particularly useful as a foundation for further study in areas relating to medical physics.

17.2 How you will be assessed

In this unit you will be required to complete an external examination of 1½ hours duration. The examination will consist of a series of compulsory short answer, structured questions and will be marked out of 80.

You will be assessed on your knowledge, understanding and skills relating to medical physics.

There are two opportunities in the examination for the assessment of QWC.

You should ensure that you have a detailed knowledge and understanding of all the information in Section 17.3.

You should be able to plan and evaluate investigations ensuring that they are valid and reliable. This is for investigations both in the
laboratory context, and from the point of view of professionals working in a scientific environment.

You need to be able to recall, use and manipulate all the formulae contained in this unit, also detailed in Appendix D.

To gain high marks in the examination you should:

- be familiar with all the content described in the unit;
- be able to apply the knowledge you have learned in this unit to familiar and unfamiliar situations;
- ensure that your answers meet the requirements specified in each question;
- avoid irrelevance;
- when necessary, write answers which are logical and coherent paying particular attention to correct spelling, punctuation and grammar.

17.3 You need to know, understand and be able to demonstrate

How physiological measurements are indicators of health

Healthcare professionals use a variety of techniques to assess and monitor the health of patients.

You should learn how to measure the following:

- body temperature;
- blood pressure;
- heart activity;
- brain activity.

For body temperature measurements you should know about commonly used thermometers (liquid-in-glass clinical thermometers and thermistor thermometers) in terms of how they work and the advantages and disadvantages of each type of thermometer for measuring and monitoring core body temperature. You should also be able to evaluate the choice of thermometer and blood pressure monitor to perform a specified function.

You should know the following and be able to apply this knowledge to a range of appropriate medical situations:

- the value of normal core body temperature and the range of core temperatures over which the body can survive, noting the effects on the body as the temperature moves from normal towards the lower and upper limits of this range. This should include the symptoms of hyperthermia and hypothermia;
- the range of body temperatures measured in the mouth;

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<thead>
<tr>
<th>State</th>
<th>Temperature</th>
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<tr>
<td>normal</td>
<td>36.8 °C</td>
</tr>
<tr>
<td>death</td>
<td>below 25 °C</td>
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<tr>
<td>range</td>
<td>36.5–37.2 °C</td>
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</table>
hypothermia 32°C
fever above 37.2°C
heat exhaustion or likely if above 38°C in absence of infection
heat stroke high temperatures that would lead to death above 43°C

- the structure of a sphygmomanometer, how it works, how it is used and why blood pressure readings are taken at the upper arm;
- the terms *systolic* pressure and *diastolic* pressure, and be able to explain them and describe how the person using a sphygmomanometer can record these values of blood pressure;
- the difference between invasive and non-invasive methods of measuring blood pressure, and comment on the advantages and disadvantages of each evaluating their use in a variety of situations;
- the normal values of blood pressure for healthy young adult males (125/80 mm Hg) and healthy young adult females (123/80 mm Hg) and be able to explain what each figure represents and relates to;
- that an electrocardiogram (ECG) monitors heart activity, be able to recognise a normal ECG trace and describe how this trace changes during heart attack, sinus tachycardia, bradycardia and ventricular fibrillation. You should be able to explain why patients need to be relaxed and still while an ECG trace is being taken;
- that an electroencephalogram (EEG) monitors electrical activity of the brain. You should be able to draw typical traces for alpha, beta, delta and theta waves and know when each of these types of wave is produced;
- that EEGs are used to diagnose brain disorders, research sleep, monitor the effects of anaesthetics and provide evidence of brain death.

The use of diagnostic techniques

Healthcare professionals now have a wide range of sophisticated tools to assist them in diagnosis. Such tools make use of a wide range of scientific principles and allow healthcare professionals to be more accurate in their diagnosis.

You should know:
- how X-rays, radioactivity (alpha (α) particles, beta (β) particles and gamma (γ) rays), ultrasound, magnetic fields (MRI), thermography and endoscopy (using optical fibres) are used to diagnose a variety of conditions;
- the advantages and disadvantages of using each of the above;
• the type(s) of diagnostic tool(s) are most suitable for diagnosing specific problems.

**Thermography and its uses**

Detection of infrared radiation emitted from the body is a useful non-invasive method of investigating possible illness.

You should:

• know how a thermograph is produced;
• know some situations where thermography is a good diagnostic tool and the advantages and disadvantages of using thermography;
• be able to evaluate the appropriate use of thermography for diagnosis in a variety of situations.

**The use of X-rays**

The use of X-rays to investigate inside the body without the need for surgery was one of the earliest of the modern diagnostic techniques. The dangers of X-rays were discovered some time after their original discovery and early use. Modern equipment, techniques and safety precautions have reduced the risk to patients and those who use X-rays.

You should know:

• that X-rays are high frequency electromagnetic waves;
• the dangers of using X-rays and how the extent of damage caused depends on the part of the body exposed, the dose received, the rate at which it is received, and the importance of using the lowest effective dose;
• the difference between stochastic and non-stochastic effects, the difference between hereditary and somatic effects and be familiar with the sievert (Sv) as the unit of dose equivalent;
• the precautions taken by radiographers when using X-rays to protect both themselves and the patient;
• how X-rays are produced – including the basic structure of an X-ray tube;
• how X-ray images are formed (exposure of photographic film) and the meaning of the terms *attenuation* and *contrast*;
• how contrast media can be used to enhance X-ray images;
• what CAT scans are, how they produce images and how they differ from standard X-rays;
• how CAT scans are similar to, and different from, MRI scans;
• some situations where X-rays are a good diagnostic technique and, by considering the different attenuation
effects of different tissues, be able to explain why X-rays are suitable for diagnosing some conditions but not others;

• be able to evaluate the use of X-rays and CAT scans in specified situations.

Radiation, its uses and dangers

Radiation can be used for both diagnosis and treatment. Healthcare professionals need to consider the use to which radiation is to be put before deciding on the most appropriate type of radiation to use, the dosage and how it is to be applied.

You should know:

• that there are three types of radioactivity – alpha (α) particles, beta (β) particles and gamma (γ) rays;
• the different penetration powers of each of the three types of radioactivity and how these can be measured in the laboratory;
• the relative dangers of each type of radioactivity and the importance of using the lowest effective dose when using radioisotopes for diagnosis;
• that radioactive decay is random;
• the concept of half-life and how it is measured – including graphical methods to represent radioactive decay and to calculate half-life, and methods to ensure that data is valid and reliable;
• how radioisotopes can be used for diagnosis and the factors affecting the choice of radioisotope – including explaining why radioisotopes used as tracers should ideally emit only gamma radiation;
• why certain radioisotopes – for example technetium-99 and iodine-131 – are commonly used. You should be aware of properties such as ease of manufacture, half-life, cost, type of radiation emitted and organ affinity;
• the precautions taken by radiographers and medical physicists when using radioisotopes and the scientific reasons for these precautions;
• how to detect radioactivity – including Geiger counters, gamma cameras, rectilinear scanners and film badges;
• why, in the body, radioisotopes have an effective half-life \( T_e \) which is shorter than their physical half-life \( T_p \), affected by their biological half-life \( T_b \) and how these are calculated by the use and manipulation of the formula

\[
\frac{1}{T_e} = \frac{1}{T_p} + \frac{1}{T_b}
\]

• how to plan, carry out and evaluate experiments related to radioactivity.
The uses of ultrasound

Ultrasound is a relatively modern technique for examining the inside of the human body without the need for surgery. It is mainly a diagnostic technique rather than a treatment.

You should know:

- what ultrasound is and how ultrasound images are produced;
- how ultrasound is used for diagnosis;
- in which situations ultrasound is a good diagnostic tool and in which it is unsuitable, and be able to evaluate the use of ultrasound in specified circumstances;
- how to describe ultrasonic waves in terms of velocity, frequency and wavelength. You should be able to use and manipulate the formula

$$v = f \times \lambda$$

- how and why the speed of ultrasonic waves is different in different materials;
- how ultrasound is absorbed, attenuated and reflected differently by different materials depending on their value of acoustic impedance ($Z$) and how to use the formula

$$\alpha = \left( \frac{Z_2 - Z_1}{Z_2 + Z_1} \right)^2$$

to calculate the intensity reflection coefficient, $\alpha$, between two media;
- how to link the clarity and contrast of the ultrasound image formed and the need to use a gel as a coupling agent.

Lasers and fibre optics in medicine

We normally think of fibre optics as being used in mass communications, but their use in healthcare diagnosis is now well established.

You should know:

- how light, with particular reference to lasers, is transmitted along optical fibres;
- how optical fibres are used in diagnosis;
- situations where optical fibres are a suitable diagnostic tool;
- the advantages and disadvantages of using optical fibres for diagnosis compared with other diagnostic methods;
- how to calculate refractive index ($n$) and critical angle ($c$) using the formulae
refractive index, \( n = \frac{\sin i}{\sin r} \sin c = \frac{1}{n} \)
and the significance of the values obtained;

- the principles behind cladding optical fibres;
- how to plan, carry out and evaluate investigations involving refractive index and total internal reflection.

**Magnetic resonance imaging (MRI)**

The use of MRI is becoming increasingly common as a diagnostic technique.

You should know:
- how MRI images are formed;
- about situations where MRI imaging is an appropriate technique and be able to evaluate the use of MRI in specified circumstances;
- the similarities and differences between MRI and CAT scans.

**How radioisotopes, ultrasound and light are used in therapy**

You should know:
- that radioisotopes, ultrasound and light are used in the treatment of various illnesses, and the advantages and disadvantages of each type of therapy;
- which type(s) of therapy would be most suitable for treating particular medical complaints;
- how ultrasound can be used for therapy – including medical complaints commonly treated with ultrasound (gall stones and kidney stones) – and the advantages and disadvantages of ultrasound as therapy compared with other methods for specific medical complaints;
- how lasers can be used as surgical instruments, both alone and in conjunction with optical fibres;
- how optical fibres can be used in conjunction with miniature surgical equipment and/or lasers in keyhole surgery;
- the advantages and disadvantages of using lasers in surgery compared with traditional methods;
- the advantages and disadvantages of using keyhole surgery compared with traditional surgical methods;
- the dangers involved in using lasers in surgery and the precautions that need to be taken when they are in use;
- the factors affecting the choice of radioisotope for treatment of a particular medical complaint;
- the types of complaints normally treated with radiotherapy and the isotopes commonly used to treat
specific tumours
- cobalt-60 for general therapy
- iridium-192 for breast cancer implants
- iodine-131 for thyroid cancer;

• that the choice of radioisotope can depend on organ affinity, and be able to explain why the radioisotopes used inside the body for therapy are normally emitters of beta radiation;

• the factors to be taken into consideration when planning the treatment of a specified condition;

• how to evaluate the choice of specific therapeutic methods in the treatment of specified conditions.
18.1 About this Unit

Playing sports well depends not only on the skill and fitness of the player but also on the body being correctly prepared to achieve optimum performance and to avoid injury. This unit will enable you to find out about how science is involved in sport.

In this unit you will learn about:

- how to take measurements which relate to assessing a person’s health and fitness;
- achieving optimum sporting performance for health and fitness; the importance of diet and how some substances can have a negative effect on health and fitness;
- sports injuries, their causes, immediate treatment and prevention;
- occupations that are involved with the application of science to sport.

This unit links to all other GCE Applied Science units, including Unit 2 (Energy Transfer Systems), Unit 4 (Food, Science and Technology) and Unit 14 (The Healthy Body). Through practical investigation this unit links with Unit 7 (Planning and Carrying out a Scientific Investigation). It also links with other GCE subjects such as physics and biology. This unit will help you to prepare for higher education courses which use physics, biology and sports-related disciplines, for work in a science-based occupation, and as a useful introduction to basic first aid techniques.

18.2 How you will be assessed

You need to produce a portfolio of evidence which shows the links between exercise, sport, injury and the human body.

Your portfolio of evidence should comprise:

A. a personal health and fitness programme to prepare yourself, or another person, for participation in a particular sport over a four-week period by:

- identifying a particular person and a particular sport;
- carrying out appropriate research into the person and sport and linking this research to the aspect to be improved;
- identifying in your programme
  - the person, particular sport and the proposed level of participation in the sport
  - initial and final measurements that you will need to take in order to, at the end of the four-week period, assess the overall effectiveness of the programme
  - the effects of diet – including the role of macronutrients and
micronutrients in promoting good health and preparing the body for activity

- an explanation of the effects that harmful drugs (alcohol, tobacco, steroids and other drugs) can have a health and fitness

- specific details of the programme to be followed including details of relevant equipment to be used

- the specified outcomes you would wish to achieve and how these relate to the programme you have devised

- how you will monitor the level of participation in the programme;

• providing quantitative experimental data (initial and final measurements) to assess the specified outcomes over the four-week period of the programme;

• evaluating the programme at the end of the four-week period in terms of the specified outcomes including relating these to the initial and final measurements that you have taken.

B. a case study of the first aid treatment which has been administered to a chosen athlete (real or imaginary) as a result of an injury sustained while participating in a sport by:

• stating a particular individual and a chosen sport (real or imaginary);

• stating the nature of the injury or condition which needed to be treated;

• describing the cause of the injury or condition;

• describing the nature of the first aid treatment;

• discussing how/whether the injury or condition could have been prevented.

C. a report into an occupation involving sports science by:

• outlining what the job entails;

• considering the scientific knowledge that has to be applied in the occupation;

• considering the need for any relevant qualifications.

18.3 You need to know, understand and be able to demonstrate

In order to complete the requirements of this unit, you will need to know, understand and be able to demonstrate relevant knowledge of the following:

• health and fitness;

• sports injuries and conditions;

• first aid techniques;

• prevention of sporting injuries and conditions;
• occupations involving the application of science to sport.

Health and fitness

In connection with sporting activities you will learn how to take measurements of weight, external body measurements, flexibility, stamina, breathing rate, strength, resting pulse rate, recovery time, vital capacity, blood pressure and actual performance (times, speeds, distances, coordination). You will learn about the importance of diet in maintaining health and the effects of harmful substances on health and fitness.

In your portfolio you will have to be able to:

• identify which aspect of health and fitness you wish to improve;
• devise and implement a suitable four-week programme to improve the stated aspect of health and fitness;
• take relevant measurements at the start and the end of the health and fitness programme;
• explain the significance of these measurements;
• interpret these measurements in relation to particular cases;
• explain the effects of diet in promoting health. This will include the role of macronutrients and micronutrients in promoting good health and preparing the body for exercise or sporting activity;
• explain the effects of alcohol, tobacco and other harmful drugs (including steroids) on health and fitness.

These measurements are important in terms of your fitness programme in order for you to:

• state which aspects of fitness you are aiming to improve;
• assess your (or another person’s) health, fitness and performance at the start of a fitness/training programme;
• assess your (or another person’s) health, fitness and performance at the end of a fitness/training programme;
• use the data obtained to evaluate the effectiveness of the programme.

Sports injuries and conditions

You should be aware of the most common sports injuries and conditions caused by sporting activities, including:

• fractures;
• concussion;
• bleeding;
• joint injuries;
• skin damage;
• muscle injuries;
• tendon and ligament injuries;
• dehydration;
• hyperthermia and hypothermia.

In your portfolio, you will need to produce a case study on a sporting injury or condition of your choice. In doing so, you should consider:

• what the injury or condition is;
• how it was caused.

First aid techniques

There are many first aid techniques used to deal with a range of sporting injuries and conditions from muscle injuries in professional athletes to cardio-pulmonary resuscitation (CPR) in unfit and unprepared participants undertaking strenuous exercise. You should have an awareness of the basic principles of first aid and emergency procedures, including:

• D - danger
  R - response
  A - airway
  B - breathing
  C - circulation;
• resuscitation;
• the recovery position;
• R - rest
  I - ice
  C - compression
  E - elevation;
• artificial respiration;
• CPR.

In your case study on a sporting injury or condition you should consider:

• how the injury or condition should be treated immediately through any first aid technique;
• the reason for the choice of first aid technique.

Prevention of sport injuries and conditions

You should be able to explain the importance of the following in preventing the injury or condition:

• obeying the rules of sport;
• wearing suitable clothing for participation in sport;
• using the correct equipment when participating in sport;
• warming up and cooling down;
• participating at the correct level to minimise the risk of injury.

In your case study on a sporting injury or condition of your choice you should consider:

• how/whether it could have been prevented.

**Occupations involving the application of science to sport**

You will learn in general terms about a range of occupations that are either directly or indirectly involved when applying science to sport.

You will be aware of the science underpinning the work in the particular occupation you have chosen including:

• improvements in performance of athletes (dieticians, coaches, personal trainers);
• the production of sporting equipment and clothing (designers, materials technologists, aerodynamics engineers; mechanical engineers);
• the treatment of injury (physiotherapists, osteopaths, chiropractors).

In your portfolio, you will write a report about a chosen occupation involved in sports science. In doing so, your report should consider:

• the nature of the work involved;
• how the job is linked to sport;
• the scientific knowledge required in doing the work;
• the qualifications necessary for following your chosen sports related occupation.
### 18.4 Assessment Criteria: Unit 9 – Sports Science

#### Assessment evidence

**You need to produce** a portfolio of evidence containing:

A. a personal health and fitness programme to prepare yourself, or another person, for participation in a particular sport over a four-week period; (AO1, AO2, AO3)

B. a case study of the first aid treatment which has been administered to a chosen athlete (real or imaginary) as a result of an injury sustained while participating in a sport; (AO1, AO2)

C. a report into an occupation involving sports science. (AO1)

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<th>Mark Band 1</th>
<th>Mark Band 2</th>
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<tr>
<td><strong>AO1</strong></td>
<td><strong>AO1</strong></td>
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<tr>
<td>The case study into the injury lacks any real depth of knowledge and understanding. Research into the person, particular sport and the chosen occupation was generally limited and what has been produced is incomplete. Ideas and concepts are expressed throughout the portfolio using non-specialist language, but are adequate to convey meaning. (* See below)</td>
<td>The case study into the injury shows some appropriate knowledge of the injury and how first aid could be applied. Research into the person, particular sport and the chosen occupation showed some depth of knowledge and understanding and detail but has some inaccuracies. Scientific terminology is used infrequently but meaning is generally clear.</td>
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<td>(1-2 marks)</td>
<td>(3-4 marks)</td>
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<tr>
<th><strong>AO2</strong></th>
<th><strong>AO2</strong></th>
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<tr>
<td>Straightforward calculations related to the level of fitness at the start and end of the four-week programme were attempted with variable success. There is little evidence that knowledge gained from the unit was applied to either the health and fitness programme or to the discussion of how the injury or condition sustained could have been prevented and how this could have been achieved. The portfolio contains much irrelevant material and does not go beyond the presentation of a series of unconnected facts. (* See below)</td>
<td>Relevant straightforward calculations related to the level of fitness at the start and end of the four-week programme were generally attempted correctly. There is some evidence that knowledge gained from the unit was applied to either the health and fitness programme or to the discussion of how the injury or condition sustained could have been prevented and how this could have been achieved. The portfolio is firmly rooted in the familiar and the demonstration of knowledge is limited to the well known and tried and tested.</td>
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<td>(1-3 marks)</td>
<td>(4-6 marks)</td>
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* Award 0 marks if nothing creditworthy is displayed in the portfolio.
| Mark Band 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Mark Band 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|---|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| AO1 | The detailed case study also contains slight inaccuracies in terms of knowledge and understanding. Research into the person, particular sport and chosen occupation was good in terms of depth and details but there are a few inaccuracies. Suitable scientific terminology is usually used to correctly convey meaning with precision.                                                                                   | Using comprehensive knowledge of biology from the unit, a four-week health and fitness programme was devised which relates specifically to the chosen aspect to be improved. The case study is thorough and complete and appropriate knowledge from the unit was applied consistently well. Research into the person, particular sport and chosen occupation was extensive in depth, sound in knowledge and understanding, with no inaccuracies and there is suitable scientific terminology used to enhance meaning. |
|    | (5-6 marks)                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | (7-8 marks)                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| AO2 | Relevant calculations related to the level of fitness at the start and end of the four-week programme were generally attempted successfully with only one or two minor omissions and/or inaccuracies. There is evidence that knowledge gained from the unit was applied to the health and fitness programme and to the discussion of how the injury or condition sustained could have been prevented and how this could have been achieved. There is a clear relationship between the particular sport and the appropriate training regime suggested. | All calculations related to the level of fitness at the start and end of the four-week programme were correct in all respects. The knowledge gained from the unit was applied to the health and fitness programme and to the discussion of how the injury or condition sustained could have been prevented and how this could have been achieved. Wise choices were made such that, for example, relevant material was produced regarding the relationship between the particular sport and the appropriate training regime which supports it. |
|    | (5-9 marks)                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | (10-12 marks)                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| AO3 (i) | With extensive and frequent teacher intervention, some measurements for use in the health and fitness programme were taken but they were imprecise and there was little continuity between the initial and final measurements. #
The measurements were fairly basic and did not really go beyond measuring the main factors pertinent to any programme. Although some initial measurements were taken there was little correlation between these measurements and the aim of the fitness programme. With the programme complete, some final measurements were taken but these were limited and not directly linked to the original measurements at the start of the programme. 
(* See below) |
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| Mark Band 2 | Initial and final measurements for use in the health and fitness programme were recorded with some precision but there was, on occasion, the need for some teacher intervention or guidance. #
A few measurements were taken and these enabled the performance to be measured. The understanding of why specific measurements need to be taken, in line with the aims of the programme, was evident. However, these did not relate significantly to the overall effectiveness of the programme. |
| (7-12 marks) |

| AO3 (ii) | A fitness programme was suggested but it did not have a true foundation based in science. The fitness programme was, at best, sketchy and did not target a specific area for improvement. The measurements taken did not allow for an evaluation of the programme based on the factual information presented. The evaluation of the programme is merely a statement without any real attempt at justification.
Information in the portfolio is poorly organised and lacks a coherent structure although it may contain some valid points. The portfolio contains significant errors and/or omissions in the use of technical terms, spelling, punctuation and grammar leading to a lack of clarity. |
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| Mark Band 2 | A fitness programme was produced which has its basis in science but largely failed to target a specific area for improvement. The fitness programme was implemented. However, due to the inconsistency in the approach to taking measurements, it proved to be of very limited use in evaluating the fitness programme against the initial aims. There was some attempt to link the measurements to support how successful the programme was.
Information in the portfolio shows some organisation and structure and contains some valid evidence. The portfolio contains some errors and/or omissions in the use of technical terms, spelling, punctuation and grammar leading to inconsistency in clarity. |
| (5-8 marks) |

* Award 0 marks if nothing creditworthy is displayed in the portfolio.
# teacher/assessor evidence required
### AO3

<table>
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<th>Mark Band 3</th>
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<tr>
<td><strong>(i)</strong> With minimal teacher involvement, initial and final measurements in relation to the health and fitness programme were taken and recorded with precision, though there are some inconsistencies in how they are linked or related. # There was an understanding of which measurements needed to be taken and an understanding of the required science beyond the aims of the programme. Measurements to assess starting/finishing condition of the participant were generally linked and complete.</td>
<td>With relative autonomy, relevant measurements for the health and fitness programme were recorded to a high level of precision and were presented logically and clearly. # With the aim of the fitness programme clearly in mind, specific initial measurements were taken precisely and recorded to a high level of accuracy. There was a real understanding of the science behind why the measurements were taken and these were linked to the aims of the programme.</td>
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<td><em>(13-18 marks)</em></td>
<td><em>(19-24 marks)</em></td>
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| AO3 | A fitness programme was produced which targeted a specific aspect to be improved. The fitness programme has its foundations in science but there are a few omissions which will affect the overall performance of the programme. There was an attempt at evaluation at the end of the programme, though this was not wholly linked to the original aims. There was supporting evidence that the programme was been monitored over the period. Information in the portfolio is mainly well organised and structured and is supported by valid evidence. The portfolio is expressed with reasonable clarity but has a few minor errors and/or omissions in the use of technical terms, spelling, punctuation and grammar. | The aim of the fitness programme was clearly stated and a specific area of fitness targeted. The fitness programme had realistic objectives, was comprehensive and complete and covered the specific period. The evaluation of the programme had insight and was well reasoned using previously recorded data to justify the effectiveness of the programme. The programme was rigorously implemented and monitored over the period. Information in the portfolio is logically organised leading to a coherent structure and is supported by a range of valid evidence. The portfolio is clearly expressed with few minor errors in the use of technical terms, spelling, punctuation and grammar. |
| **(ii)** | *(9-12 marks)* | *(13-16 marks)* |

# teacher/assessor evidence required
19

A2 Unit 10

Physics of Performance Effects

19.1 About this Unit

The staging of a performance can rely heavily on the use of light and sound to produce the dramatic effects required.

In this unit you will find out about the properties of sound and the ways in which sound systems can be used in conjunction with a venue to ensure that the sound produced is of an optimum quality. You will also find out about the properties of light and how lighting effects can be used to enhance a performance. You will have the opportunity to design a sound system for a particular venue, a lighting set-up for a performance of your choice and evaluate the lighting and sound set-ups used in a performance you have attended.

In this unit you will learn about:

• the nature of sound, how this is applied to a sound system and sound control system to tailor the sound to meet the needs of a venue;

• the nature of light, how this can be applied to a lighting set-up and control system and how this can be applied to suit a particular performance;

• describing and evaluating the sound system and lighting set-ups used in a performance you have attended. This will include how to calculate the cost of a lighting set-up for the performance.

This unit links to other GCE Applied Science units in physics, in particular Unit 8 (Medical Physics). Through practical investigation this unit also links with Unit 7 (Planning and Carrying out a Scientific Investigation). It also links with other GCE subjects such as physics. This unit will help you to prepare for higher education courses in physics, or other science-related subjects with a physics component, or for work in a science-based occupation.

19.2 How you will be assessed

You need to produce a portfolio of evidence which considers how light and sound can be used in a performance and the science behind the design of a lighting and sound system in a performance you attended.

Your portfolio of evidence should comprise:

A. a design for a sound system and appropriate control system for a venue you have chosen including:

• details of the venue you have chosen;

• the use of the correct scientific terminology to explain the characteristics of sound;
• the results obtained from conducting relevant experiments in relation to the speed of sound, reflection, refraction, diffraction, resonance, interference, superposition and absorption of sound to show how sound behaves in your chosen venue;

• details of the type/arrangement of microphones and loudspeakers to be used and the function of each component part of the system;

• details of how the shape of a performance area, position of the performers/audience and materials, as part of the set, used in the performance affect the quality of the sound in the venue;

• details of how the control system is used.

B. a design for a lighting set-up and control system for a performance, or part of a performance, of your choice including:

• the use of correct scientific terminology to explain the characteristics of light;

• details of experiments you have conducted into reflection, refraction and colour;

• how a variety of lighting effects could be incorporated into the lighting set-up;

• how the control system is used.

C. a description and evaluation of a sound and lighting system used in a performance you have attended including:

• specific details of the lighting and sound systems used. You should use correct scientific terminology and scientific principles in your description and evaluation;

• specific details of how lighting and sound effects are used in the performance and the scientific principles behind these effects; this will include the use of correct scientific terminology;

• a calculation of the total cost of the lighting for the complete performance.

19.3 You need to know, understand and be able to demonstrate

In order to complete the requirements of this unit you will need to know, understand and be able to demonstrate relevant knowledge of the following:

• the nature of sound and its application to sound systems;

• sound control systems;

• the nature of light and its application to lighting systems;

• lighting control systems;

• evaluating a performance.
The nature of sound and its application to sound systems

A venue can have dramatic effects on the quality of the sound produced in a performance. A sound system, in conjunction with other factors, can be used to enhance the quality of sound in a chosen venue.

The sound system you design should be tailored to a specific venue. Prior to undertaking your design you should be aware of the general properties of sound waves. You should have an understanding of how sound travels (as a longitudinal wave) and the relationship between the frequency and pitch, and the amplitude and volume of a sound. This will help you when designing your sound system. You should know, and show an understanding of, the following:

- the speed of sound in the venue. You should conduct an experiment to determine the speed of sound in your chosen venue. You should have an awareness of factors such as temperature, pressure and humidity and how they will affect the speed of sound and how this may impact on your chosen venue;
- reflection, refraction and diffraction. You should conduct appropriate experiments to show how sound is reflected, refracted and diffracted and relate these to your chosen venue;
- resonance and the principle behind it. You should conduct an experiment to show how resonance relates to the venue you have chosen;
- the principles of constructive and destructive interference and how they may affect the sound in your chosen venue;
- the absorption of sound. You should conduct experiments which show that different types of surfaces are good absorbers of sound and how these findings will be used to affect the sound within your chosen venue;
- the reflection of sound. You should conduct experiments which show that different types of surfaces are good reflectors of sound and how this will affect your chosen venue.

Once you have conducted your experiments in relation to your chosen venue (speed of sound, reflection, refraction, diffraction, resonance, interference, superposition and how surfaces reflect and absorb sound) you should then consider how the sound is to be transferred from the stage to the auditorium. You should be aware that the quality of the sound received could depend on the position of the listener in the auditorium and you should take the necessary steps to ensure that the sound quality received by the listener is as consistent as possible throughout the auditorium. In order to achieve this you will need to consider how the following factors can affect sound quality during a performance:

- the type and quality of equipment used;
the number and type of microphones and loudspeakers used;
the positioning of loudspeakers and microphones;
the shape of the performance area;
the position of the audience;
the position of the performers;
the materials used in the performance area.

**Sound control systems**

You should be aware that sound in a venue can be controlled by a sound control system. In relation to your design for a sound system you should be able to explain:

- how a sound control system operates;
- how sound levels can be adjusted and controlled;
- the characteristics of an effective control system;
- the type of control system used (digital or analogue) in your chosen venue;
- the meaning of the term *feedback* and how it can be incorporated into a control system.

**The nature of light and its application to lighting systems**

In order to produce a suitable lighting set-up you should have an understanding of:

- how light travels. You should understand that this will have a fundamental effect on the positioning of the lights used as part of your lighting set-up;
- the intensity of light. You should demonstrate your understanding of the relationship between the amplitude of a light wave and the intensity of the light received.

In order to support your design for the lighting system for the performance you should be aware of some of the general properties of light including:

- the relationship between the distance from a light source and the intensity of the light received

\[
\text{intensity } (I) \propto \frac{1}{\text{distance from source}^2 (d^2)}
\]

and relate this directly to the lighting used in the performance;

- the reflection of light by plane, convex and concave surfaces. You should conduct appropriate experiments concerned with the reflection of light related to your design and where necessary use the formula

\[
\text{angle of incidence } (i) = \text{angle of reflection } (r)
\]
• the refraction of light by prisms, convex and concave lenses. You should conduct experiments appropriate to your design which are concerned with the refraction of light and, where appropriate, use and manipulate the formula

\[ n = \frac{\sin i}{\sin r} \quad \text{or} \quad n = \frac{c_1}{c_2} \]

(where \( c_1 \) and \( c_2 \) are the speed of which light travels in the two media);

• the relationship between the frequency of a light wave and the colour of the light and where appropriate use, and manipulate, the mathematical relationship

\[ \text{velocity (v)} = \text{frequency (f)} \times \text{wavelength (}\lambda) \]

and carry out relevant calculations in relation to your design;

• the three primary colours of light and how they combine to produce secondary colours and white light, and how this could be used in the performance;

• the relationship between primary colours and their associated complementary secondary colours;

• the production of a spectrum by the use of a white light source and a prism and where appropriate incorporate this into your design;

• an explanation of the use of colour filters. You will need to explain how the filters are used to produce different coloured lights and their effects on the colour of the light transmitted. Where appropriate you should conduct appropriate experiments, the findings of which will support your design for the lighting set-up;

• reflection and absorption of light to colour objects. You should understand that surfaces can be made to appear different colours through being exposed to different coloured lights. Where appropriate you should conduct specific experiments which relate to the performance and explain how these will be incorporated into your design;

• a description of appropriate lighting effects – for example, silhouettes, shadows, lightning flashes, optical illusions and how they would be used in the performance;

• how lighting aids operate and examples of what each could be used for in relation to your lighting set-up. These could include footlights, floodlights, stroboscopes, dimmer boards, dimmer racks, slide projectors, data projectors, colour wheels, mirror balls and lasers.
Lighting control systems

You should be aware that light in an auditorium can be controlled by a lighting control system. In relation to your design for a lighting system you should be able to explain:

- how light levels can be adjusted and controlled;
- how to produce a system to control light;
- the characteristics of an effective control system;
- the difference between analogue and digital electronic systems in terms of signal type, attenuation and interference.

Evaluating a performance

When describing and evaluating a performance you should be able to use the knowledge and understanding gained in this unit to:

- describe the sound system. You should be able to explain, using the correct scientific terminology and scientific principles, why the number and location of the microphones and loudspeakers has been selected for the performance, how the venue has been adapted for the performance and if the sound quality is consistent throughout the venue;

- describe the lighting set-up. You should be able to explain, using correct scientific terminology and scientific principles, why the lighting set-up has been selected for the performance. You should be able to relate this to factors such as the intensity of the light in the performance area, the use of colour and the science behind any lighting effects used.

As part of the evaluation of the performance you should consider the cost of lighting the performance. You should consider the number and power of the lights used as well as the duration of the performance.

In order to calculate the cost of a lighting set-up and lighting effects used in a performance you may need to use and manipulate the following equations:

\[
power (P) = current (I) \times voltage (V) \\
voltage (V) = current (I) \times resistance (R) \\
cost (C) = power (P) \times time (t) \times cost per unit (u)
\]
19.4 Assessment Criteria: Unit 10 – Physics of Performance Effects

Assessment evidence

You need to produce a portfolio of evidence containing:

A. a design for a sound system and appropriate control system for a venue you have chosen; (AO1, AO2, AO3)
B. a design for a lighting set-up and control system for a performance, or part of a performance, of your choice; (AO1, AO2, AO3)
C. a description and evaluation of a sound and lighting system used in a performance you have attended. (AO1, AO2)

Mark Band 1

AO1 The portfolio shows limited knowledge and understanding of sound and light. Scientific ideas are seldom used to describe either sound waves or light waves. The description of the sound and lighting system used in the performance attended moves little beyond descriptive phrases and has limited foundation in science. (* See below) (1-2 marks)

AO2 There was some rudimentary knowledge displayed but there was little application of this to the tasks required. The importance of the type and arrangement of equipment and how the venue and control system affected the quality of the sound did not move beyond the presentation of facts. This was also the case for the lighting effects and the control system. The evaluation of the performance did not move beyond the presentation of descriptive phrases. The details of how the lighting and sound effects were used in the performance attended have no foundations in science. There was a failure to move beyond the presentation of facts learned in the unit. There was little evidence of the use of quantitative physical relationships in preparatory research. There was little attempt at relevant calculations relating to the speed of sound, intensity of light and the cost of the lighting arrangement in the performance attended. (* See below) (1-3 marks)

Mark Band 2

AO1 The portfolio shows evidence of some knowledge of sound and light. Some scientific ideas are used in the description of sound waves and light waves. The description of the sound and lighting system used in the performance attended has some foundations in science. (3-4 marks)

AO2 There was some attempt at applying knowledge but it was limited to the straightforward and well known. For the sound system there was a limited understanding of the importance of the type and arrangement of equipment and how the venue and control system affected the sound quality. The lighting effects and control system used showed only limited scientific knowledge. The evaluation of the performance was descriptive and contained some details of how lighting and sound effects were used in the performance attended. These details had some foundation in science. There was some use of quantitative physical relationships in the preparatory research. There were attempts at some relevant calculations relating to the speed of sound, intensity of light and the cost of the lighting arrangement in the performance attended but there were some inaccuracies. (4-6 marks)

* Award 0 marks if nothing creditworthy is displayed in the portfolio.
### Mark Band 3

**AO1**

The portfolio displays evidence of knowledge and understanding of sound and light. Scientific ideas are used reasonably well to describe sound waves and light waves and this continues through to the description of the sound and lighting systems used in the performance attended.

(5-6 marks)

**AO2**

Application of the knowledge of the unit appropriate to the tasks is evident. The type and arrangement of equipment and how the venue and control system affected the sound quality are related to the science underpinning them, as are lighting effects and control systems used in the lighting design. A thorough evaluation of the performance was produced, including details of the lighting and sound effects used in the performance attended. These had firm foundations in science. There is significant evidence of the appropriate use of quantitative physical relationships in the preparatory research. The application of relevant calculations to the speed of sound, intensity of light and the cost of the lighting arrangement in the performance attended were usually successfully performed.

(7-9 marks)

### Mark Band 4

**AO1**

Through the portfolio, clear and thorough knowledge and real understanding of sound and light is demonstrated. Correct scientific ideas are used throughout to describe sound waves and light waves. This continues through to the description of the sound and lighting system used in the performance attended.

(7-8 marks)

**AO2**

Knowledge from the unit was fully applied in an appropriate manner across all the tasks. The knowledge gained was used to produce succinct designs for both the sound system (arrangement of equipment/venue and control systems) and the lighting set-up (lighting effects/control systems). A comprehensive evaluation of the performance was produced including details of the lighting and sound effects used in the performance attended. These details were presented in such a way that it is clear to see the science behind them. There was substantial evidence of the appropriate use of quantitative physical relationships in the preparatory research. Relevant calculations in relation to the speed of sound, intensity of light and the cost of the lighting arrangement in the performance attended were performed to a high degree of accuracy.

(10-12 marks)
<table>
<thead>
<tr>
<th>AO3 (i)</th>
<th>Mark Band 1</th>
<th>Mark Band 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>There was a variable approach to the experiments in relation to sound and light. Equipment was used with little skill or regard for precision; this is reflected in the minimal number of results obtained and the need for extensive and frequent teacher intervention. # Experimental results were incomplete and presented in a way which was of little use in informing the final design. (* See below) (1-4 marks)</td>
<td>Although a majority of experiments were conducted in relation to light and sound, there was, on occasion, the need for some teacher intervention/guidance. # There was a degree of variability in the results obtained and this resulted from inexperience in the use of the equipment. # The final results obtained were of some use in informing the final design. (5-8 marks)</td>
<td></td>
</tr>
<tr>
<td>AO3 (ii)</td>
<td>Designs for the lighting and sound system were produced but had limited scientific support and there was inconsistency across both designs. Experimental results obtained in relation to sound and light experiments were generally incomplete or inaccurate. Information in the portfolio is poorly organised and lacks a coherent structure although it may contain some valid points. The portfolio contains significant errors and/or omissions in the use of technical terms, spelling, punctuation and grammar leading to a lack of clarity. (* See below) (1-6 marks)</td>
<td>There was evidence of some background science which was used to support the design of the sound and lighting set-up. The designs are by no means comprehensive. Experimental results obtained in relation to sound and light experiments, where recorded, were generally appropriate to the designs. Information in the portfolio shows some organisation and structure and contains some valid evidence. The portfolio contains some errors and/or omissions in the use of technical terms, spelling, punctuation and grammar leading to inconsistency in clarity. (7-12 marks)</td>
</tr>
</tbody>
</table>

* Award 0 marks if nothing creditworthy is displayed in the portfolio.
# teacher/assessor evidence required
<table>
<thead>
<tr>
<th>AO3</th>
<th>Mark Band 3</th>
<th>Mark Band 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i)</td>
<td>With minimal teacher involvement, all experiments were carried out to a high standard. There was some variability in</td>
<td>With relative autonomy, all the experiments conducted into light and sound were carried out to a high standard. The</td>
</tr>
<tr>
<td></td>
<td>the results obtained from the experiments into sound and light. Equipment was used skilfully and safely in general.</td>
<td>results obtained were of a consistently accurate standard. Equipment was used safely and skilfully to collect data to</td>
</tr>
<tr>
<td></td>
<td>However, there were some minor issues in relation to the precision of the results. Data was presented clearly and logically</td>
<td>a high level of precision. Data was presented clearly and logically and is relevant to the designs produced.</td>
</tr>
<tr>
<td></td>
<td>and has links into the designs produced.</td>
<td>(9-12 marks)</td>
</tr>
<tr>
<td></td>
<td>(9-12 marks)</td>
<td>(13-16 marks)</td>
</tr>
<tr>
<td>(ii)</td>
<td>Detailed designs for both the lighting and sound systems were produced and were supported by appropriate scientific</td>
<td>Using plans and concepts with a firm foundation in science, comprehensive designs for both the lighting and sound</td>
</tr>
<tr>
<td></td>
<td>knowledge gained from experiments. Appropriate experimental results were obtained and were recorded adequately.</td>
<td>system were produced. Results from the experiments conducted in relation to sound and light were fully documented and</td>
</tr>
<tr>
<td></td>
<td>Information in the portfolio is mainly well organised and structured and is supported by valid evidence. The portfolio</td>
<td>recorded to a high level of precision. Information in the portfolio is logically organised leading to a coherent</td>
</tr>
<tr>
<td></td>
<td>is expressed with reasonable clarity but has a few minor errors and/or omissions in the use of technical terms,</td>
<td>structure and is supported by a range of valid evidence. The portfolio is clearly expressed with few minor errors in the</td>
</tr>
<tr>
<td></td>
<td>spelling, punctuation and grammar.</td>
<td>use of technical terms, spelling, punctuation and grammar.</td>
</tr>
<tr>
<td></td>
<td>(13-18 marks)</td>
<td>(19-24 marks)</td>
</tr>
</tbody>
</table>

# teacher/assessor evidence required
20.1 About this Unit

Chemists work with other scientists, engineers and technologists to convert materials that occur naturally into useful substances ranging from medicines to explosives and plastics. Some are manufactured on a huge scale, for example sulphuric acid, others in very small quantities, for example specialist drugs. The manufacture of chemical compounds is important; it makes a major contribution to the UK economy. Effective and efficient manufacture of compounds depends on understanding chemical change and on the ability of scientists and technologists to control chemical processes.

This unit will enable you to find out about industrial processes used to manufacture compounds. You will gain an understanding of chemical changes, the factors that affect them and how they may be controlled.

In this unit you will learn about:

- the industrial manufacture of chemical compounds;
- the effect of reaction conditions on chemical change;
- how to investigate chemical change in the laboratory.

Your study of industrial manufacture could be integrated with other units, for example Unit 1 (Investigating Science at Work). This unit links to other GCE Applied Science units in chemistry, in particular Unit 3 (Finding out about Substances), Unit 6 (Synthesising Organic Compounds) and Unit 13 (Colour Chemistry). It also links with other GCE subjects such as chemistry. This unit will help you to prepare for higher education courses in chemistry or other science-related subjects with a chemistry component or for work in a science-based occupation.

20.2 How you will be assessed

In this unit you will be required to complete an external examination of 1½ hours duration. The examination will consist of a series of compulsory short answer, structured questions and will be marked out of 80.

You will be assessed on your knowledge, understanding and skills relating to controlling chemical processes.

There are two opportunities in the examination for the assessment of QWC.

You should ensure that you have a detailed knowledge and understanding of all the information in Section 20.3.

You should be able to plan and evaluate investigations ensuring that they are valid and reliable. This is for investigations in the laboratory context, and from the point of view of professionals working in a scientific environment.
You will need to be able to recall, use and manipulate all the formulae contained in this unit, also detailed in Appendix D.

To gain high marks in the examination you should:
- be familiar with all the content described in the unit;
- be able to apply the knowledge you have learned in this unit to familiar and unfamiliar situations;
- ensure that your answers meet the requirements specified in each question;
- avoid irrelevance;
- when necessary, write answers which are logical and coherent paying particular attention to correct spelling, punctuation and grammar.

20.3 **You need to know, understand and be able to demonstrate**

**The industrial manufacture of chemical compounds**

The chemical industry manufactures vast numbers of compounds for a range of purposes. Many more factors have to be taken into account when a compound is made in industry than when it is made in the laboratory. Economic considerations mean that compounds need to be manufactured as cheaply as possible, while maintaining appropriate levels of health and safety and protection of the environment.

You should understand the factors that an organisation takes into account when considering manufacturing chemical compounds. These include:

- continuous and batch processes;
- the design of industrial reaction vessels (batch and continuous);
- identifying the factors to be monitored and controlled (kept constant or altered as necessary) to ensure safe and economic control of industrial processes;
- comparing the conditions used in manufacture with those which give maximum yield and/or rate;
- identifying the capital, direct and indirect costs of producing a compound;
- estimating the total costs of production and determining the selling price;
- identifying the economic reasons for the differences between industrial and laboratory conditions for a reaction.

The factors above need to be considered in respect to the production of:
- agrochemicals;
• chloralkalis;
• petrochemicals.

With reference to a range of other industrial chemical extraction and manufacturing processes.

Calculating quantities of substances

Scientists need to be able to measure quantities of substances. This is because they want to calculate the amounts of reactants that are required to make a particular amount of a compound, to determine the actual yield of a product or use chemical analysis to determine purity.

You should understand and be able to carry out calculations including:
• using the chemical formula and relative atomic masses to calculate the molar mass of a substance;
• calculating the amount of substance (moles) from its quantity (mass or volume) and vice versa;
• writing balanced equations to describe chemical reactions (including the use of half equations and oxidation numbers);
• using balanced equations to calculate required quantities of reactants and theoretical yields of products;
• calculating percentage yield from experimental data and theoretical yield.

Reaction conditions

Many laboratory preparations are carried out between 0 and 100°C at atmospheric pressure. More extreme reaction conditions are necessary when compounds are manufactured industrially using equipment which may be designed specifically for industrial production. However, new compounds are usually prepared in the laboratory first. The preparation is then scaled up and piloted in plant conditions to learn more about the process; manufacture is then begun. Sometimes a different route is chosen for industrial manufacture because of environmental and economic factors. Data from laboratory and pilot plant investigations is used to predict the effect of conditions on a reaction and to help in the design of the industrial process.

You should know the factors that affect chemical reactions and understand how these factors affect the reactions.

You should be able to:
• use your knowledge of chemical equilibrium (including application of Le Chatelier’s principle) to explain changes in yield as conditions are varied;
• use your understanding of chemical kinetics to explain changes in rate as conditions are varied;
- select appropriate laboratory conditions for a reaction to give a good yield at a reasonable rate using your knowledge of enthalpy changes;
- identify changes to laboratory conditions that may be needed for industrial manufacture;
- predict the effects of changes in conditions on temperature, changes that must be managed (including possible uses for the heat released in exothermic reactions) and on the yield and rate when a process is scaled up for industrial manufacture.

To understand how reaction conditions affect reactions you should understand:

- chemical equilibrium
  - reversible processes and equilibrium
  - at equilibrium the rates of the forward and reverse reactions are equal
  - equilibrium constant
  - qualitative effect of changes in reactant and product concentration on the position of equilibrium
  - qualitative effects of changing the temperature and the total pressure to a reaction vessel (including those used on an industrial scale) on the position of equilibrium;

- rate of reaction
  - qualitative effects of concentration, temperature and pressure changes (including those used on an industrial scale) and the effect of particle size (although relatively unusual on an industrial scale)
  - catalysts and their effect
  - reaction profiles, collision theory, activation energy
  - the effect of a change of temperature on energy distribution (Maxwell–Boltzmann distribution curves)
  - use of energy distribution curves to explain the effect of a change in temperature and the use of a catalyst
  - rate equations
  - order of reaction (zero, first, second) and the rate constant
  - determining order of reaction and rate equation from data on initial rates;

- enthalpy changes
  - exothermic and endothermic reactions
  - bond breaking and bond forming in chemical reactions
  - bond enthalpies and their relationship to the enthalpy change for a reaction
- molar enthalpy change
- enthalpies of combustion and formation
- calculations involved in enthalpy changes
- including a knowledge and understanding of Hess’s law.

**Laboratory investigations**

Most compounds are prepared for the first time in a laboratory on a small scale so that energy changes, equilibria and reaction rates can be studied. Data collected in these investigations increases scientists’ understanding of the process and helps them design an effective and efficient industrial process.

For a range of chemical reactions you should be able to:

- identify the factors that control the rate of a reaction;
- identify the factors and conditions that influence the position of equilibrium;
- calculate the equilibrium constant for a reaction from the equilibrium concentrations of reactants and products;
- select analytical methods to measure the changes in concentrations of reactants and/or products during a reaction;
- calculate the rate of a reaction from a graph of concentration against time;
- measure temperature changes in a reaction that go to completion, correcting if necessary for cooling;
- calculate the molar enthalpy change for a reaction including the use and manipulation of the equation

\[ Q = mc\Delta T \]

- carry out risk assessment when necessary;
- comply with relevant health and safety and environmental regulations.

Give essential experimental details and show how the results would be used in determining:

- enthalpy change of combustion;
- enthalpy change of a reaction;
- rate of reaction;
- order with respect to a reaction.
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A2 Unit 12
The Actions and Development of Medicines

21.1 About this Unit

The role of the pharmaceutical industry is critical in our modern world. It develops new products and improves existing ones in order to promote and advance healthcare. However, not only do medicines help society but they also introduce hazards. In this unit you will study the problems associated with developing new medicines and how they must be controlled to avoid such problems as antibiotic resistant organisms.

You will have the opportunity to consider the role of medicines and their importance in everyday life. Scientists and technicians employed in the pharmaceutical industry use their knowledge and understanding to develop and trial different medicines. You will consider how different medicines are developed and trialled by the pharmaceutical industry and how medicines are synthesised from chemical and/or natural sources.

In this unit you will learn about:

- the different categories of medicines;
- the actions of medicines, the site of action, formulation and how they can be administered;
- how medicines are developed for production on a commercial scale;
- how medicines are tested and the ethical issues relating to the development of new medicines;
- the role of the manufacturer and the regulatory authorities;
- how to analyse the properties of medicines through quantitative analysis and bioassay.

This unit links to all other GCE Applied Science units in particular Unit 3 (Finding out about Substances), Unit 6 (Synthesising Organic Compounds) and Unit 13 (Colour Chemistry). Through practical investigation this unit also links to Unit 1 (Investigating Science at Work) and Unit 7 (Planning and Carrying out a Scientific Investigation). It also links with other GCE subjects such as chemistry. This unit will help you to prepare for higher education courses in chemistry and related subjects which use science, and for work in a science-based occupation.

21.2 How you will be assessed

You need to produce a portfolio of evidence which considers the actions and development of two different medicines. You need to conduct a quantitative analysis and a bioassay for each medicine.
Your portfolio of evidence should comprise:

A. a report on the development and application of two different medicines of your choice by:
   - identifying the category in which each of the two medicines belong. You must use a different category for each;
   - describing the factors which affect the action of each medicine;
   - describing the type of formulation and the method of administration of each medicine to be used;
   - identifying the site in the body where the action takes place;
   - describing how each medicine is prepared for clinical trials;
   - describing the development and testing process each medicine will go through before a licence is issued;
   - a summary of ethical issues in relation to the development of each medicine;
   - describing the roles and responsibilities of manufacturers of each medicine;
   - describing the roles and responsibilities of the UK regulatory authority.

B. a report on the quantitative analysis of two chosen medicines including:
   - researching a suitable method(s) for the quantitative analysis, including appropriate background scientific principles;
   - a list of information sources;
   - describing the practical procedures to be used;
   - selecting appropriate equipment and using it safely;
   - detailing carrying out the analysis;
   - carrying out risk assessment(s);
   - evaluating the method(s) used.

C. a report on the bioassay of two chosen medicines including:
   - researching a suitable method(s) for the bioassay including appropriate background scientific principles;
   - a list of information sources;
   - describing the practical procedures to be used;
   - selecting and using safely, appropriate equipment;
   - detailing carrying out the bioassay;
   - carrying out risk assessment(s);
   - evaluating the method(s) used.
In order to complete the requirements of this unit you will need to know, understand and be able to demonstrate relevant knowledge of the following:

- the different categories of medicines and their action;
- the development of a medicine;
- methods of analysing medicines.

**The different categories of medicines and their actions**

The range of illnesses and physiological disorders which are diagnosed mirror the vast range of medicines devised to treat them.

In your portfolio you will write a report on the development and application of two different medicines. It is important to understand the application of your chosen medicines to particular medical conditions, their general and specific modes of actions, and the importance of their routes of administration to optimise their effectiveness.

In your report you should:

- categorise each medicine – for example antibiotic, antiviral (compound), analgesic, anaesthetic, anti-inflammatory agent, vaccine, antiseptic, vitamin supplement. Your two chosen medicines must come from different categories;
- give details of the different factors which affect the action of the medicine – including molecular structure, functional groups, method of elimination from the body, either through excretion or metabolism;
- give details of the site in the body where the action of each medicine take place – for example organs, cell membranes, muscles, microorganisms, blood system or nervous system;
- explain the different route(s) by which the medicine can be administered – for example oral, rectal, nasal, inhalation, injection and transdermal patches;
- consider the various types of formulation used for medicines – for example syrups, tablets, creams, injections – and select the most suitable for the two medicines you have chosen.

**The development of a medicine**

The development of a new medicine can cost millions of pounds. It is important that the activities of the pharmaceutical industry are controlled, tested and are open to scrutiny from both the medical profession and the public.

You should investigate, interpret and evaluate the performance criteria laid out when a new medicine is developed, trialled and introduced for prescribing.
For your report on the development and application of your two chosen medicines you should understand, for each different medicine:

- the development testing process through which a new medicine is put before being licensed for use – including, where appropriate, in-vitro and in-vivo preclinical testing, clinical testing, blind trials, use of placebos, any side effects and the effects of being used in combination with other medicines;

- the ethical issues relating to the development of a new medicine – for example testing on animals, clinical trials, patient consent and safety guidelines;

- the roles and responsibilities of the manufacturer – including guidance for use of the medicines, quality assurance and the efficacy of the medicines, issue of licences;

- the roles and responsibilities of the UK regulatory authorities for medicines – for example Licensing Authorities, Committee on Safety of Medicines and Medicines Control Agency.

**Methods of analysing medicines**

Doctors and patients depend on the highly regulated standards which control the pharmaceutical industry. Sound, predictable standards (quality and quantity of medicine) need to be maintained and proper evaluation of the safety and the effects of the medicine need to be monitored. To do this effectively there needs to be accurate and reliable methods for chemical assay and bioassay.

For each of your chosen medicines you will need to carry out a quantitative analysis and a bioassay.

You will need to:

- research and provide details of a suitable method(s) to be used in the quantitative analysis and a suitable method(s) to be used in the bioassay. This will include details of the underlying scientific principles to be used;

- describe in detail the practical procedures in the quantitative analysis and the practical procedures used in the bioassay – including an explanation of the scientific principles involved;

- select appropriate apparatus for both the quantitative analysis and bioassay;

- carry out a risk assessment for the quantitative analysis and bioassay and complete the procedures in a safe manner;

- evaluate the method used in the quantitative analysis and bioassay.
21.4 Assessment Criteria: Unit 12 – The Actions and Development of Medicines

Assessment evidence

You need to produce a portfolio containing:

A. a report on the development and application of two different medicines of your choice; (AO1, AO2)
B. a report on the quantitative analysis of two medicines; (AO1, AO3)
C. a report on the bioassay of two medicines. (AO1, AO3)

<table>
<thead>
<tr>
<th>Mark Band 1</th>
<th>Mark Band 2</th>
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<tbody>
<tr>
<td><strong>AO1</strong></td>
<td></td>
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<tr>
<td>The report displays little evidence of knowledge and understanding. There is an identification of the categories to which each medicine belongs, but there is little supporting evidence to outline why. There is little consideration of the factors affecting the action of each medicine, and a lack of knowledge displayed in identifying where the action takes place in the body or, indeed, the clinical trials which take place. The considerations of the formulation and method of administration are simplistic, lacking any scientific supporting evidence. There was little research undertaken into suitable method(s) for either the quantitative analyses or the bioassays. The research was based around the methods to be used and did not consider alternative methods or suitability of the method outlined. It is not supported by background scientific principles. (* See below)</td>
<td>There is a suitable report on the development and application of two different medicines and this displays some appropriate knowledge and understanding. There is an understanding of the actions of each of the two medicines. There are considerations of formulations and methods of administration but these are not developed in scientific terms. There is some knowledge displayed relating to clinical trials undertaken. Knowledge is not displayed consistently across the report. There is some knowledge evident of regulatory bodies, but this is not well developed. The research into suitable method(s) for either the quantitative analyses or the bioassays displays some understanding of the scientific principles required, though this is not consistently displayed. From the research undertaken a suitable method was chosen but without justification and this is not generally supported in the reports by full consideration of other methods. (1-2 marks)</td>
</tr>
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</table>

| **AO2** |             |
| There is little application of the knowledge and understanding gained in the unit. There is a minimal description of the development and testing process for each medicine. The ethical issues raised are simplistic and are not based on scientific knowledge. Any discussion of roles and responsibilities for manufacturers of the chosen medicines is not supported by scientific reasoning and is muddled and confused. (* See below) | There is some attempt to apply the knowledge and understanding to the chosen medicines, though this application is inconsistent across the report. There is a description of the development and testing of the medicines, though this is not well balanced or supported by the application of scientific understanding. There is some consideration of ethical issues, though these are not wholly based on scientific reasoning. There is some treatment of the roles and responsibilities of manufacturers, though this lacks the scientific understanding to develop the report further. (3-4 marks) |

* Award 0 marks if nothing creditworthy is displayed in the portfolio.
<table>
<thead>
<tr>
<th>AO1</th>
<th>Mark Band 3</th>
<th>Mark Band 4</th>
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<tbody>
<tr>
<td>The report on the development and application of two different medicines displays some sound appropriate knowledge and understanding. There is an understanding of the actions of each of the medicines, outlining clearly the site in the body where the action takes place. There is a good description of the clinical trials undertaken. The references to formulations and methods of administration are supported by scientific evidence. Some inaccuracies are evident and the report lacks a depth of scientific understanding. An understanding of the roles and responsibilities of the regulatory bodies is evident. The research into suitable method(s) for either quantitative analyses or the bioassays comes from a variety of sources and there is a justification of the final method chosen. There is a sound understanding of the scientific principles behind the analyses and bioassays.</td>
<td>There is a full, clear and accurate report on development and application of two different medicines. There is a clear scientific understanding of the actions of each of the medicines and a full description of the clinical trials that are undertaken is given. There is scientific consideration of various formulations and methods of administration and a scientific understanding of the roles and responsibilities of the regulatory bodies is evident. The comprehensive research into suitable method(s) for either quantitative analyses or the bioassays comes from a variety of sources and there is justification and an evaluation of the method used. The methods chosen are fully justified and there is a clear understanding displayed of the background scientific principles.</td>
<td>(5-6 marks)</td>
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<tr>
<td>AO2</td>
<td>The description of the development and testing of the medicines is supported by an appropriate application of scientific understanding and this is balanced across both medicines. The consideration of ethical issues is supported by some scientific evidence, rather than unsupported statements. The roles and responsibilities of manufacturers were approached in a scientific manner, if perhaps lacking depth of treatment. There are inaccuracies evident in the supporting scientific arguments throughout the report.</td>
<td>Scientific knowledge is fully applied and understanding is evident in an appropriate manner across the report. Knowledge is fully related to considerations of the development and testing of both medicines. The consideration of ethical issues and the roles and responsibilities of manufacturers in the report are wholly based on scientific principles and understanding.</td>
</tr>
<tr>
<td>AO3</td>
<td>Mark Band 1</td>
<td>Mark Band 2</td>
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<td>----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>(i)</td>
<td>Unfamiliarity with, and lack of skill in, use of the equipment is evident, and there was the need for extensive and frequent teacher assistance in order for progress to be made. The results obtained in the analyses are inaccurate, imprecise and of limited use. The observations obtained from the bioassays are generally incomplete. It is possible that one of the tasks was undertaken more successfully than the other. (* See below)</td>
<td>The results obtained show that some skill and precision was used when using the equipment, though there was, on occasions, a need for some teacher intervention/guidance. The results obtained from the analyses are mainly accurate but there are some omissions and/or inaccuracies. The bioassayss were undertaken such that simple observations could be made.</td>
</tr>
<tr>
<td></td>
<td>(1-4 marks)</td>
<td>(5-8 marks)</td>
</tr>
<tr>
<td>(ii)</td>
<td>There are methods suggested for both the quantitative analyses and the bioassays, though their suitability is questionable. There is little attempt to justify or evaluate the method selected. There was little attempt at risk assessments and only passing references to health and safety practices. There was limited opportunity for any evaluation of the analyses and the bioassays due to the results and observations obtained. Information in the portfolio is poorly organised and lacks a coherent structure although it may contain some valid points. The portfolio contains significant errors and/or omissions in the use of technical terms, spelling, punctuation and grammar leading to a lack of clarity. (* See below)</td>
<td>Appropriate methods were suggested for the tasks. There was some attempt to justify or evaluate the method selected. There was an attempt at a plan which outlines the practical procedures to be adopted and there is evidence of some risk assessments being considered, though these are based on a common sense approach rather than scientific reasoning. There was some evaluation and an attempt was made to consider the data and observations. The evaluation was limited by the lack of supporting scientific evidence, inaccuracies and a lack of knowledge. Information in the portfolio shows some organisation and structure and contains some valid evidence. The portfolio contains some errors and/or omissions in the use of technical terms, spelling, punctuation and grammar leading to inconsistency in clarity.</td>
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<td></td>
<td>(1-6 marks)</td>
<td>(7-12 marks)</td>
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* Award 0 marks if nothing creditworthy is displayed in the portfolio.

# teacher/assessor evidence required
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<th>Mark Band 3</th>
<th>Mark Band 4</th>
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<tbody>
<tr>
<td><strong>AO3 (i)</strong></td>
<td>The tasks were undertaken with minimal teacher involvement. #</td>
<td>With relative autonomy, experimental work has been undertaken in a safe and skilful way and this meant that the comprehensive results obtained are both precise and reliable.#</td>
</tr>
<tr>
<td></td>
<td>The generally skilful use of equipment yielded correct and generally precise experimental results; however, some inaccuracies were evident. The results obtained from the analyses were precise with few omissions or inaccuracies. Accurate observations from the bioassays were made.</td>
<td>The results obtained from the analyses were complete and accurate. The bioassays were completed so that full and comprehensive observations were available for evaluation.</td>
</tr>
<tr>
<td></td>
<td>(9-12 marks)</td>
<td>(13-16 marks)</td>
</tr>
<tr>
<td><strong>AO3 (ii)</strong></td>
<td>The methods obtained through research were full and detailed with only a few omissions. There was an attempt to justify the method used in each case and to evaluate its success. A plan was outlined which states the practical procedures to follow and the equipment to use. The risk assessments were extensive if, in areas, lacking the scientific justifications. There was an evaluation of the procedure, the recorded data and observations and this displays a scientific understanding, though there are some shortcomings in the arguments presented. Information in the portfolio is mainly well organised and structured and is supported by valid evidence. The portfolio is expressed with reasonable clarity but has a few minor errors and/or omissions in the use of technical terms, spelling, punctuation and grammar.</td>
<td>The methods obtained through research were comprehensive and complete. The methods were fully justified and evaluated. An extensive plan was presented fully outlining the procedures to be adopted and the equipment to be used. A full scientific risk assessment was recorded. The evaluation of the procedure of the recorded data and the observations in the bioassays was comprehensive and complete. The work displays a thorough knowledge and understanding of the scientific principles assessed in the tasks. Information in the portfolio is logically organised leading to a coherent structure and is supported by a range of valid evidence. The portfolio is clearly expressed with few minor errors in the use of technical terms, spelling, punctuation and grammar.</td>
</tr>
<tr>
<td></td>
<td>(13-18 marks)</td>
<td>(19-24 marks)</td>
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# teacher/assessor evidence required
22.1 About this Unit

The textile and paint industries play a major role in modern society. These industries have to respond to the demands of manufacturers, fashion designers and customers for new dyes and pigments. These dyes and pigments must be aesthetically pleasing, chemically stable and not constitute a health risk to the consumer. Scientists and technicians in the dyeing and paint industries use their knowledge and understanding to design and develop an ever-increasing range of dyes and pigments that are used in a wide range of materials including clothing, furnishings, printing and paints.

In this unit you will learn about:

- why dyes and pigments have a colour;
- the extraction of a natural (plant) dye and the preparation of a synthetic dye;
- the application of dyes to fabric – including the underlying science;
- the use of coloured pigments and other ingredients in an oil-based paint.

This unit links to all other GCE Applied Science units, in particular Unit 3 (Finding out about Substances), Unit 6 (Synthesising Organic Compounds), Unit 11 (Controlling Chemical Processes) and Unit 12 (The Actions and Development of Medicines). Through practical investigations this unit also links with Unit 1 (Investigating Science at Work). It also links with other GCE subjects such as chemistry. This unit will help you to prepare for higher education courses in chemistry, biochemical sciences or other science-related subjects with a chemical component, or for work in a chemical or science-based occupation.

22.2 How you will be assessed

You will need to produce a portfolio of evidence detailing the extraction and application of a natural (plant) dye and the preparation and application of a synthetic dye. You should also include evidence detailing the use of organic pigments in an oil-based paint.

Your portfolio of evidence should comprise:

A. A report detailing the extraction of a natural (plant) dye together with details of its application to three different fabrics including:

- identifying your chosen dye and researching a method for its extraction;
- detailing the type of dye and the method used to make it, the scientific principles underlying the process together with the apparatus used and any appropriate risk assessments;
• applying your dye to three chosen fabrics. You should describe the structure of the fabric, the bonding between the dye and fabric, the apparatus and method used and an evaluation, for each fabric, of the dye’s suitability;

• scaling up of the extraction from a laboratory extraction to an industrial scale by the use of relevant calculations.

B. a report detailing the preparation of a synthetic dye together with details of its application to three different fabrics including:

• identifying your chosen dye and researching a method for its extraction;

• detailing the type of dye and the method used to make it, the scientific principles underlying the process together with the apparatus used and any appropriate risk assessments;

• applying your dye to three chosen fabrics, describing the structure of the fabric, the bonding between the dye and fabric, the apparatus and method used and an evaluation, for each fabric, of the dye’s suitability;

• scaling up the preparation from a laboratory preparation to an industrial scale by the use of relevant calculations.

C. a report on the preparation of an oil-based paint and testing its hiding power in which you:

• prepare an oil-based paint and test its hiding power;

• identify, and explain, how the colour for the paint is achieved using titanium (IV) oxide and transition metal compounds;

• explain the role of the following ingredients in the paint
  - solvents
  - thinners
  - resins
  - catalysts;

• explain the concept of hiding power in relation to the paint.

22.3 You need to know, understand and be able to demonstrate

In order to complete the requirements of this unit you will need to know, understand and be able to demonstrate relevant knowledge of the following:

• the origin of colour in dyes and pigments;

• the extraction of natural (plant) dye and preparation of a synthetic dye;

• application of dyes to fabric;

• scaling up a laboratory preparation to industrial manufacture;

• the use of coloured pigments in oil-based paints.
The origin of colour in dyes and pigments

Dyes and pigments have colour because of their components. Dyes and pigments have a wide variety of uses. Dyes are organic molecules that contain a functional group that gives rise to the compound being coloured. For your portfolio you are required to produce a natural (plant) dye and a synthetic dye.

For each dye you should be able to:

- identify the functional groups that give rise to colour – for example azo group, alkene group, carbonyl group and conjugated systems.

Most coloured pigments used in oil-based paints are transition metal compounds. For your report about an oil-based paint you should:

- explain why transition metal compounds are coloured.

The extraction of a natural (plant) dye and preparation of a synthetic dye

When carrying out the extraction of the natural (plant) dye and the small-scale preparation of a synthetic dye you will need to:

- research a method for the extraction of the natural (plant) dye and a different method for the preparation of the synthetic dye;
- describe in detail the practical procedures involved – including an explanation of the underlying scientific principles involved;
- carry out a risk assessment for each procedure;
- select and use appropriate apparatus for each product;
- complete each procedure in a safe manner;
- evaluate the method used.

Application of dyes to fabric

There is a large range of types of dyes. The application of a dye to a fabric depends on the structure of the dye and the structure of the fabric. Dyes are water soluble and are used in solution. The fabric is soaked in the solution and the dye becomes attached to the fabric. The forces of attraction between the dye and the fabric depend on the structure and bonding in the fibre and the dye. It is important that the dye is fast (does not wash out), is chemically stable and is unaffected by light.

For each of the two dyes that you have prepared, you should:

- identify the type of dye – for example basic dye, vat dye, acid dye, fibre reactive dye, direct dye or disperse dye;
- give details of the bonding and structure of the dye – for example azo dye, anthroquinone, sulphonic dye, cationic dye or anionic dye.

For each of the three fabrics you choose to apply each dye to, you should:

- give details of the bonding and structure of the fabric;
• give details of the type of bonding between the dye and the fabric and how this relates to the structure of both the dye and the fabric;
• describe the method used in testing the application of the dye;
• evaluate the suitability of the application of each dye to each fabric.

Scaling up a laboratory preparation to industrial manufacture

The laboratory process of extracting a natural (plant) dye and preparing a synthetic dye will need to be scaled up if the dye is to be manufactured industrially. You will need to understand the factors that must be considered in commercial manufacture, including the following:
• costs of the raw materials for each dye;
• the percentage yield;
• size of reaction vessels;
• energy costs relating to the manufacture of each dye.

The use of coloured pigments in oil-based paints

Pigments are used mainly in paints and printing inks, but they are also used in textiles. Pigments are insoluble and are used in the form of a suspension.

For your report on the preparation and testing of the hiding power of an oil-based paint, you will need to have an understanding of the following:
• the use of titanium(IV) oxide as the major pigment in paints;
• the addition of coloured transition metal compounds to an oil-based paint;
• oil-based paints contain a vehicle which is a resin dissolved in a hydrocarbon solvent;
• catalysts, which speed up the drying process of the oil-based paint;
• the concept of hiding power.
22.4  Assessment Criteria: Unit 13 – Colour Chemistry

Assessment evidence

You need to produce a portfolio of evidence containing:

A.  ia report detailing the extraction of a natural (plant) dye together with details of its application to three different fabrics; (AO1, AO2, AO3)

B.  a report detailing the preparation of a synthetic dye together with details of its application to three different fabrics; (AO1, AO2, AO3)

C.  a report on the preparation of an oil-based paint and testing its hiding power. (AO1, AO3)

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<tr>
<td>AO1</td>
<td>There was some evidence of limited research to identify a method of extracting a natural (plant) dye and preparing a synthetic dye. This presented an incomplete summary of the techniques to be used which bore scant relevance to the underlying science. The report on the preparation of an oil-based paint shows limited knowledge relating to colour, ingredients and the concept of hiding power. The report is tentatively linked to the product. Any scientific knowledge relating to the type of dye, bonding and the structure of dyes and fabrics is not specifically related to the dyes produced or the fabrics used. (* See below)</td>
<td>There was evidence of research to identify a method of extracting a natural (plant) dye and preparing a synthetic dye. This presented an incomplete summary of the techniques to be used; however, the summary had a foundation in science. In producing the report on the preparation of an oil-based paint there is generally correct knowledge displayed relating to colour, ingredients and the concept of hiding power. This is linked to the product. Scientific knowledge relating to the type of dye, bonding and the structure of dyes and fabrics is generally correct and is related, although tentatively, to the dyes produced and the fabrics used.</td>
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<td></td>
<td>(1-2 marks)</td>
<td>(3-4 marks)</td>
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<tr>
<td>AO2</td>
<td>Calculations in relation to the scaling up for commercial manufacture (cost, percentage yield and size of reaction vessels) were attempted for both dyes but with limited success. (* See below)</td>
<td>Calculations in relation to the scaling up for commercial manufacture (cost, percentage yield and size of reaction vessels) were attempted for both dyes with variable success.</td>
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<tr>
<td></td>
<td>(1-3 marks)</td>
<td>(4-6 marks)</td>
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* Award 0 marks if nothing creditworthy is displayed in the portfolio.
# Unit 13 – Colour Chemistry

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<thead>
<tr>
<th><strong>AO1</strong></th>
<th><strong>Mark Band 3</strong></th>
<th><strong>Mark Band 4</strong></th>
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<tbody>
<tr>
<td>Research to identify a method of extracting a natural (plant) dye and preparing a synthetic dye was complete. This presented a summary of suitable methods with firm foundations in science. In producing the report on the preparation of an oil-based paint, there is generally correct knowledge displayed relating to colour, ingredients and the concept of hiding power, and has been applied to the product with few omissions and/or inaccuracies. Scientific knowledge relating to the type of dye, bonding and structure of dyes and fabrics is generally complete with few omissions. This is linked to the dyes produced and fabrics used.</td>
<td>Thorough research has produced comprehensive and workable methods of extracting a natural (plant) dye and preparing a synthetic dye. These are firmly rooted in science. Knowledge of how colour is achieved in oil-based paints, as well as the ingredients and the concept of hiding power, is comprehensive, clearly evident and correctly applied to the oil-based paint. Scientific knowledge relating to the type of dye, bonding and structure of dyes and fabrics is comprehensive and is specifically related to the dyes produced and fabrics used.</td>
<td>(5-6 marks)</td>
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<thead>
<tr>
<th><strong>AO2</strong></th>
<th><strong>Mark Band 3</strong></th>
<th><strong>Mark Band 4</strong></th>
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<tbody>
<tr>
<td>Calculations in relation to the scaling up for commercial manufacture (cost, percentage yield and size of reaction vessels) were attempted consistently well for both dyes with only one or two slight omissions and/or inaccuracies.</td>
<td>Calculations in relation to the scaling up for commercial manufacture (cost, percentage yield and size of reaction vessels) were complete for both dyes and are accurate in all respects.</td>
<td>(7-9 marks)</td>
</tr>
<tr>
<td>AO3 (i)</td>
<td>With extensive teacher involvement, both dyes were produced and the hiding power of the oil-based paint was tested but there was inconsistency in approach. # A method (obtained from research) and risk assessments were used, although there were many inaccuracies in the procedure followed. Unfamiliarity with, and a lack of skill in, the use of equipment was evident. # Both dyes were applied to three fabrics but observations, which relate to the suitability of each dye, were minimal and incomplete. (* See below)</td>
<td></td>
</tr>
<tr>
<td>AO3 (ii)</td>
<td>Initial plans into a method of extracting a natural (plant) dye, preparing a synthetic dye and preparing the oil-based paint were not comprehensive, generally incomplete and produced unworkable methods. The observations obtained from the experiment into the application of the two dyes, the preparation of and the testing of the hiding power of an oil-based paint were, at best, sparse. There was little attempt to evaluate the method of preparation of each dye, or the suitability of each dye in relation to the three fabrics. Information in the portfolio is poorly organised and lacks a coherent structure although it may contain some valid points. The portfolio contains significant errors and/or omissions in the use of technical terms, spelling, punctuation and grammar leading to a lack of clarity. (* See below)</td>
<td></td>
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</table>

**Mark Band 1**

| 1-6 marks |

**Mark Band 2**

| 7-12 marks |

* Award 0 marks if nothing creditworthy is displayed in the portfolio. # teacher/assessor evidence required
<table>
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<tr>
<th>AO3</th>
<th>Mark Band 3</th>
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<tr>
<td>(i)</td>
<td>With minimal teacher involvement, both dyes were made to a consistently high standard, adhering to the method (obtained from research) and the fully documented standard procedures. The hiding power of oil-based paint was also tested. However, there were some deviations from the method researched or risk assessment. Equipment was used skilfully; however, its use lacked some precision. Both dyes were applied to three fabrics and detailed observations relating to the suitability of each dye were recorded. (13-18 marks)</td>
<td>With relative autonomy, both dyes were made successfully and the hiding power of oil-based paint was tested. The method (obtained from research) and risk assessment were applied to a consistently high standard and both preparations were conducted safely and skilfully. Both dyes were applied to three fabrics and comprehensive observations relating to the suitability of each dye were recorded. (19-24 marks)</td>
</tr>
<tr>
<td>(ii)</td>
<td>Initial plans into a method of extracting a natural (plant) dye, preparing a synthetic dye and preparing the oil-based paint were detailed and complete with only a few omissions. The observations obtained from the application of the two dyes, the preparation and the testing of the hiding power of an oil-based paint were generally complete with only a few omissions. Modifications to the method of preparation of each dye were suggested and this was supported by the detailed evaluation of the suitability of each dye to the three chosen fabrics. Information in the portfolio is mainly well organised and structured and is supported by valid evidence. The portfolio is expressed with reasonable clarity but has a few minor errors and/or omissions in the use of technical terms, spelling, punctuation and grammar. (9-12 marks)</td>
<td>Initial plans into a method of extracting a natural (plant) dye, preparing a synthetic dye and preparing the oil-based paint were comprehensive with no error and yielded workable methods. Full and detailed observations were obtained from the application of the two dyes, the preparation and the testing of the hiding power of an oil-based paint and these were presented clearly and logically. Appropriate modifications to the method of preparation of the dyes were suggested. There was a comprehensive evaluation of the suitability of each dye to the three fabrics and this supports the modifications suggested. Information in the portfolio is logically organised leading to a coherent structure and is supported by a range of valid evidence. The portfolio is clearly expressed with few minor errors in the use of technical terms, spelling, punctuation and grammar. (13-16 marks)</td>
</tr>
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# teacher/assessor evidence required
23

A2 Unit 14
The Healthy Body

23.1 About this Unit

A healthy body can enable a person to achieve realistic biological performance of activities of daily living – for example walking, feeding and dressing. A healthy body can also allow the realisation of sporting goals.

Those working in healthcare professions may be called on to take a number of measurements of the functions of human biological systems. These measurements can assist with diagnosis of disease, improvement of performance in sport, or recovery from illness or injury. In this unit you will consider some health and fitness measurements used to monitor the activity of the body.

Healthcare workers may also give advice about diet. You will investigate what is considered to be a healthy diet for different groups – for example children, the elderly and athletes. You will also look at how the digestive system works. You will find out about some of the chemical reactions that are needed to sustain life in the cells of the body. Many of these reactions require an input of energy.

In this unit you will learn about:

- the cardiovascular and pulmonary systems as part of the respiratory process in obtaining ATP from food;
- why the respiratory process is so important to the functioning of all cells in the body;
- the application of physiological measurements in one of the following:
  - dietary management in hospitals and in the community – for example Health Action Zones
  - health and fitness management in a sporting context – for example football, swimming, athletics, hockey, netball and basketball
  - fitness screening and management in sport centres and swimming pools – for example induction screening for new clients; GP referrals of patients recovering from heart attacks;
- how monitoring the cardiovascular and pulmonary systems, and analysis of blood samples provides healthcare workers and sport scientists with information about a person’s state of health and/or fitness;
- how sports physiologists can investigate the ways in which the body responds biochemically to different exercise regimes – for example sprinting and long distance running;
• how cells obtain energy from respiration and how this process is linked to the activity of the body as a whole;
• the structure and function of the digestive system and the components of a balanced diet;
• some of the substances carried by the blood and how the levels of these substances vary and are regulated.

This unit links to other GCE Applied Science units in biology, especially Unit 2 (Energy Transfer Systems) and Unit 4 (Food Science and Technology). It also links with other GCE subjects such as biology. This unit will help to prepare you for higher education courses that include work involving human biology or sport science. It could also prepare you for work in healthcare – for example as a nurse, physiotherapist or dietician – or in leisure areas and sports.

### 23.2 How you will be assessed

In this unit you will be required to complete an external examination of 1½ hours duration. The examination will consist of a series of compulsory short answer, structured questions and will be marked out of 80.

You will be assessed on your knowledge, understanding and skills relating to the healthy body.

There are two opportunities in the examination for the assessment of QWC.

You should ensure that you have a detailed knowledge and understanding of all the information in Section 23.3.

You should be able to plan and evaluate investigations ensuring that they are valid and reliable. This is for investigations in the laboratory context, and from the point of view of professionals working in a scientific environment.

You must show that you know about four different indicators of physiological status for at least two individuals of different age, gender and lifestyle,

This knowledge and understanding will enable you to answer the questions in the external examination.

To gain high marks in the examination you should:
• be familiar with all the content described in the unit;
• be able to apply the knowledge you have learned in this unit to familiar and unfamiliar situations;
• ensure that your answers meet the requirements specified in each question;
• avoid irrelevance;
• when necessary, write answers which are logical and coherent paying particular attention to correct spelling, punctuation and grammar.
How basic homeostatic mechanisms maintain a healthy body

The human body is organised into cells, tissues and organ systems. They interrelate with each other to enable the body to function. Cellular, tissue or organ activity can be monitored to provide information about how effectively any particular individual is able to perform under different conditions.

You should know:

- the function of the component parts which make up the cardiovascular system – how these parts function individually and how the system functions as a whole. You should be aware of common defects of the heart and apply your knowledge of the structure of the heart to these defects;

- the function of the component parts which make up the pulmonary system – how these parts function individually and how the system functions as a whole;

- about homeostatic mechanisms and how they function as detection/correction systems – for example in the control of blood sugar concentration or the concentration of carbon dioxide in the blood;

- the role of hormones in body function;

- the source, role and regulation of antidiuretic hormone (ADH) secreted by the hypothalamus and how it regulates blood volume and changes blood pressure;

- the source, role and regulation of insulin and glucagon in regulation of blood glucose concentration;

- the source, role and control of thyroxine;

- the homeostatic mechanisms involved in regulation of sodium – for example the source, role and control of aldosterone;

- that blood is an aqueous electrolyte mixture containing sodium ions and chloride ions;

- why sodium ions and chloride ions are important to the healthy functioning of the body;

- how these ions are obtained by the body and how they can be lost from the body;

- the consequences of sodium chloride (salt) deficiency in the short term and the long term;

- circumstances in which certain people may be at risk of losing too much salt;

- why excess salt in the diet might create health problems.
Cellular respiration

This is the process that enables every living cell to obtain energy for its activities. Biochemists can analyse the rates of cellular respiration in samples of tissues; this is usually done in a specialised laboratory. Sport physiologists can determine whether an individual is respiring aerobically or anaerobically using non-invasive methods (indirect calorimetry) – for example the collection of exhaled gases and analysis of these in a gas analyser. This information can be used to calculate the basal metabolic rate (BMR) of an athlete at rest. The same method can be used to calculate metabolic rates while exercising. The information about metabolic rate can be used to ensure that energy expenditure meets energy inputs. The BMR can also be determined by whole body (direct) calorimetry.

You should know:

- the balanced symbol equation for aerobic respiration;
- that during cellular respiration adenosine triphosphate (ATP) is produced by phosphorylation by the addition of a phosphate group to a molecule of adenosine diphosphate (ADP);
- that ATP can be used to release energy for cell activity;
- that the first part of the breakdown of glucose takes place in the cytoplasm of the cell. Following this, aerobic respiration takes place in structures called mitochondria;
- that cells can metabolise carbohydrates, fats and proteins to make ATP.

You should be able to:

- describe, in outline, the stages in the respiration of glucose that result in the production of ATP. These stages are known as glycolysis, the Krebs cycle (the citric acid cycle or tricarboxylic acid cycle or the TCA cycle) and the electron transport system;
- state and compare the amount of ATP that can be produced from aerobic and anaerobic pathways;
- understand where fat (lipids) and protein can enter glycolysis, the Krebs cycle and the electron transport system;
- define what is meant by BMR and explain how it can be determined in a laboratory by direct or indirect methods;
- explain the differences in BMR for males and females, and for different age groups of both genders using secondary data;
- explain methods of monitoring the respiratory system (breathing rate and volumes).
How to monitor concentrations of substances in the blood

Cells in the body can only function properly in a suitable environment. This environment is provided by the tissue fluid which bathes the cells. Since tissue fluid is derived from blood, the levels of various substances in the blood are critical.

**Blood pH**

You should know:

- the normal pH range for blood (7.35–7.45) and why pH values for arterial and venous blood are different;
- how blood is buffered to maintain pH within safe limits;
- some of the causes and effects of blood becoming too acidic or too alkaline;
- the diseases or conditions in which acidic or alkaline blood conditions can arise – for example diabetic acidosis.

**Oxygen saturation**

The majority of oxygen is carried by the molecule haemoglobin. When haemoglobin carries eight oxygen atoms (i.e. Four O\textsubscript{2} molecules) it is said to be fully saturated. Doctors, nurses and physiotherapists monitor the oxygen saturation levels of patients with respiratory diseases, or when people are in intensive care. Reduced oxygen levels will interfere with the ability of cells to respire properly and a consequence of this is that cells may die.

You should know:

- how oxygen is transported on haemoglobin, and the effect of blood pH and temperature on oxygen transport – for example the Bohr effect on the oxygen dissociation curve;
- oxygen saturation is written as SaO\textsubscript{2} %;
- a machine called a pulse oximeter is used to measure oxygen saturation. It is a non-invasive method;
- the normal range of oxygen saturation levels is 95–99%;
- people with diseases such as emphysema or cystic fibrosis may have reduced oxygen saturation levels.

**Blood glucose**

Brain cells depend on direct supplies of glucose from the blood, so brain cells are starved of energy if glucose levels fall too low. Excess glucose is normally removed from the blood and converted to glycogen or fat for storage. Our body constantly monitors our blood glucose level internally. However, in certain situations it is necessary for individuals to manage directly their own blood glucose level – for example people with diabetes. Diabetics need to be very careful in relation to their diet and their use of insulin. They need to monitor their blood glucose concentration regularly and ensure that this stays within safe limits.
You should know:

• about the body’s normal system for regulating blood glucose levels – for example the cells and organs involved;

• how blood glucose is regulated by the antagonistic action of insulin and glucagon with particular reference to diabetes;

• about situations in which blood glucose levels need to be monitored;

• the normal range of values for blood glucose concentration (fasting glucose level is 3.5–7.5 mmol/litre);

• why the presence of glucose in the urine can be an indicator that regulatory mechanisms are not working properly;

• how a simple glucose test can be carried out on urine samples in a healthcare setting – for example dipstick tests;

• how a glucose tolerance test can be used to monitor how glucose is handled in the blood, and how it can be used to assist diagnosis of diabetes.

How a healthy diet helps to maintain a healthy body

Dieticians work in the health service or with professional sports teams – for example cycling teams, football teams and athletes. In the health service, dieticians may advise people who are very obese, or have diabetes, on the best way to achieve better health through their diet. Sports teams employ dieticians whose job it is to ensure that team members receive adequate and appropriate nutrition to achieve maximum sporting performance.

You should know:

• the principles of the composition of a healthy diet for an average person – including the proportions of different food groups;

• the energy needs for different groups of individuals – including babies, infants, teenagers, pregnant women, adults and the elderly;

• the nutritional needs for different individuals – including babies, infants, teenagers, pregnant women, adults and the elderly;

• how and why a diet may need to be modified to suit the needs of specialist groups – for example diabetics, the obese and elite athletes.
Monitoring the levels of cholesterol, vitamins and minerals in the body

Hospitals have specialist doctors, nurses and dieticians who advise individuals about the risks of cardiovascular or bone problems and the need for suitable levels of micronutrients – such as cholesterol and calcium – in their blood and how the levels can be managed. The testing of these micronutrients is usually carried out by biochemists in medical analytical laboratories using specialised equipment. Nutritional advice is given to help maintain health or reduce the likelihood of health problems developing in the future. Several companies produce low-fat spreads which may impact on blood cholesterol, and may be used as part of a healthy diet and lifestyle to help reduce the intake of saturated fats. Some spreads and yoghurts are also manufactured which can actually reduce the levels of cholesterol in the blood. Many breakfast cereals are supplemented with vitamins and minerals.

You should know:

- the source, regulation and use of the following blood components: cholesterol, vitamins B, C, D and E and the minerals iron, sodium and calcium;
- the normal levels of total cholesterol in the blood (fasting total cholesterol should be 4.0–6.5 mmol/litre);
- how the level of cholesterol can be measured in a healthcare setting – for example the dipstick test and cholesterol meter;
- the health effects of continually high or low cholesterol;
- the normal levels of vitamin B, C, D and E in the blood and how these are detected;
- the effects of deficiencies of vitamin B, C, D and E in terms of disease, and ways that these deficiencies can be addressed;
- the effects of excess vitamin B, D and E;
- the normal levels of iron, sodium and calcium in the blood and how these are detected – for example iron levels can be determined indirectly by looking at haematocrit (packed cell volume) or by detecting haemoglobin levels in the blood;
- the effects of deficiencies of iron, sodium and calcium in terms of disease and the ways these deficiencies may be addressed.

The structure and function of the digestive system

The ability of the body to absorb nutrients in an available form depends on healthy functioning of the digestive system. Dentists and dental hygienists help people to maintain good dental health by advising on cleaning routines for teeth and gums. Radiographers
can image the contents and structures of the digestive system using radio-opaque materials. Surgeons can look inside the digestive tract using endoscopes. It is important for these healthcare workers to know what the normal structure and function of the digestive system looks like in order to be able to diagnose disease.

You should know:

- the function of teeth, the tongue and saliva;
- about chemical and mechanical digestion in the mouth;
- how the mouth keeps itself clean and how good dental hygiene can be maintained;
- the structure and mechanical action of the different regions of the digestive system;
- the role of acid, mucus and enzymes in the stomach;
- the role of enzymes in the digestion of proteins, carbohydrates and fats;
- how enzymes regulate and facilitate digestion of the components of foods, and that they are specific in their action and in the conditions under which they can operate;
- about the digestion of fats and the control of pH in the small intestine by the action of bile and bile salts;
- about the control of the sequence of digestive activity from ingestion to egestion by hormones – for example gastrin;
- how the structure of the gut is designed to meet its function of absorption;
- how the intestine monitors and controls the levels of fluid in it to facilitate digestion and prevent excessive water loss;
- about the role of the digestive system in water intake and balance.
24

A2 Unit 15

The Role of the Pathology Service

24.1 About this Unit

The pathology service is crucial as it provides diagnostic services to family doctors and hospital departments. It is a varied discipline, ranging from the study of biochemicals, body tissues and bodily fluids to microbes and antibiotics.

This unit is about the operation of the departments which make up the pathology service in a large hospital. You need to be aware of the range of samples that are analysed/investigated and how these samples are tracked, analysed and how the results are reported. The unit considers the importance of health and safety practices which should be adhered to by people working in these departments.

In this unit you will learn about:

- the role of the biochemistry, haematology, microbiology and histopathology departments, and the types of tests undertaken in each department;
- the stages involved in the processing of specimens and the importance of health and safety principles;
- the knowledge and skills required by people working in the biochemistry and microbiology departments;
- how to conduct a microbiological analysis and either a chromatographic or electrophoresis analysis.

This unit links to other GCE Applied Science units in biology and chemistry, in particular Unit 2 (Energy Transfer Systems), Unit 3 (Finding out about Substances) and Unit 14 (The Healthy Body). It also links with other GCE subjects such as biology. This unit will help you to prepare for higher education courses in biology or other science-related subjects with a biology component or for work in a science-based occupation. This unit is particularly useful if you wish to study vocational or higher education courses in areas such as nursing or medical laboratory science.

24.2 How you will be assessed

You will need to produce a portfolio of evidence which considers the work undertaken by the following departments in the pathology service – biochemistry, haematology, microbiology and histopathology. You will then undertake a microbiological analysis, and either a chromatographic or electrophoresis analysis.

Your portfolio of evidence should comprise:

A. a report on the work of the following departments in the pathology service – biochemistry, haematology, microbiology and histopathology, including:

- an overview of the role of each department;
• the types of specimens tested by each department – for example urine, faeces, blood, sputum, cerebrospinal fluids, serum and tissues;

• details of the stages involved in the processing of specimens – for example the sending and receipt of specimens, recording, sorting, storage, testing, noting of results, interpretation of results, dissemination of results, use of computers and the Data Protection Act;

• the importance of health and safety principles relating to, for example, avoidance of contamination (self, others, environment, specimens), sterility (equipment, medium, work environment), training, work procedures (testing, maintenance of equipment, cleaning of equipment), hazard analysis, risk assessment, safe handling of specimens and safe disposal;

• the role of legislation in maintaining health and safety principles;

• details of the knowledge and skills used by people employed in the biochemistry and microbiology departments of the pathology service.

B. a report of:
- a microbiological analysis,
- and either a chromatographic or electrophoresis analysis that you have undertaken, which includes:

• details of the standard procedure followed;

• details of the risk assessments undertaken;

• how health and safety principles were adhered to including, where appropriate, avoidance of contamination, sterility, work procedures, safe handling and disposal of specimens;

• a record of qualitative observations and quantitative measurements;

• an interpretation, explanation and evaluation of the results obtained;

• an evaluation of the procedure you followed in each case. This should include comparing how each procedure was undertaken in a school/college laboratory and how it would have been undertaken in a hospital department.

24.3 You need to know, understand and be able to demonstrate

In order to complete the requirements of this unit you will need to know, understand and be able to demonstrate relevant knowledge of the following:

• the role of the biochemistry department;

• the role of the haematology department;
• the role of the microbiology department;
• the role of the histopathology department;
• working in the biochemistry and microbiology departments.

**The role of the biochemistry department**

The role of the biochemistry department is to provide analytical chemical tests which help in the diagnosis of disease in patients and, where appropriate, to act as an advisory service to support treatment of patients.

The biochemistry department undertakes the measurement of important biological chemicals in the body. Knowledge of sugar analysis in diabetes, cholesterol and amino acids detection are examples of its work.

You should learn about:

• the role of the biochemistry department;
• the types of specimens tested;
• the nature of the work undertaken in the department including common types of tests performed – for example testing for glucose in blood and urine, sodium and potassium in blood and estimating blood cholesterol;
• the principles involved in the use of either thin layer chromatography or electrophoresis. You should be able to use these principles to conduct either a chromatographic or electrophoresis analysis.

You should understand the stages involved in processing specimens – for example the sending and receipt of specimens, recording, sorting, storage, testing, noting of results, interpretation of results, dissemination of results, use of computers and the Data Protection Act.

You should also be aware of:

• the importance of health and safety principles in relation to the testing of glucose in blood and urine, sodium and potassium in blood and the estimation of blood cholesterol;
• the importance of health and safety principles in relation to thin layer chromatography or electrophoresis;
• the role of legislation in maintaining health and safety principles;
• the knowledge and skills used by those working in the biochemistry department and be able to link these directly to either the chromatographic or electrophoresis analysis you will undertake.

**The role of the haematology department**

The role of the haematology department is to diagnose blood-related diseases such as leukaemia and to check blood for patients
undergoing surgery, by cross-matching of blood.

The laboratory within this department must be able to measure the number of cellular constituents of blood such as enzymes, haemoglobin and antibodies, to identify abnormalities in haemoglobin and to cross-match blood.

You should learn about:

- the role of the haematology department;
- the types of specimens tested;
- the nature of the work undertaken in the department – including the preparation of blood smears and the identification of various types of cells such as red blood cells, neutrophils, eosinophils and platelets.

You should understand the stages involved in processing specimens – for example the sending and receipt of specimens, recording, sorting, storage, testing, noting of results, interpretation of results, dissemination of results, use of computers and the Data Protection Act.

You should also be aware of:

- the importance of health and safety principles in relation to the handling of blood and blood products;
- the role of legislation in maintaining health and safety principles.

**The role of the microbiology department**

The role of the microbiology department is to monitor infectious diseases in hospitals and the community. It provides a diagnostic service to primary healthcare workers and monitors microbial public health diseases in the community.

The microbiology department provides a diagnostic service for infectious diseases (bacterial, viral, fungal and parasitic). It assists in the control of infections by undertaking antibiotic assays, cross-infection surveys and by monitoring antibiotic resistance.

You should learn about:

- the role of the microbiology department;
- the types of specimens tested;
- the nature of the work undertaken in the department – including the Grams staining technique to distinguish between Gram-positive and Gram-negative bacteria, investigating the effectiveness of antiseptics and antibiotics on microbes using the dilution plate technique and the ELISA technique.

You should understand the stages involved in processing specimens – for example the sending and receipt of specimens, recording, sorting, storage, testing, noting of results,
interpretation of results, dissemination of results, use of computers and the Data Protection Act.

You should also be aware of:

• the importance of health and safety principles in relation to the tests undertaken;

• the role of legislation in maintaining health and safety principles;

• the knowledge and skills used by those working in the microbiology department and be able to link these directly to your microbiological analysis.

The role of the histopathology department

The role of the histopathology department is to diagnose the causes of death. It participates in the diagnosis of disease from tissue.

You should learn about:

• the role of the histopathology department;

• the type of specimens tested;

• the nature of the work undertaken in the department. This will include the identification of various types of cells such as blood, heart, muscle, artery, vein, kidney and liver;

• how to prepare tissue samples for microscope slides and how to recognise atheroma and emphysema from prepared microscope slides.

You should understand the stages involved in processing specimens – for example the sending and receipt of specimens, recording, sorting, storage, testing, noting of results, interpretation of results, dissemination of results, use of computers and the Data Protection Act.

You should also be aware of:

• the importance of health and safety principles in relation to the tests undertaken;

• the role of legislation in maintaining health and safety principles.

Working in the biochemistry and microbiology departments

In considering the roles of the biochemistry and microbiology departments you should have an understanding of the knowledge and skills of people, both qualified and unqualified, who work in these departments. You should understand how their knowledge and skills are used as part of their daily work.

You will undertake:

• a microbiology analysis of your choice;

• either a chromatographic or electrophoresis analysis of your choice.
In conducting these analyses you should adopt the role of a scientist in the appropriate department. You should:

- work skilfully and safely, using documented standard procedures;
- produce risk assessments;
- work within any health and safety constraints that may apply.

You will need to:

- consider both qualitative observations and quantitative data from your analyses and draw conclusions in relation to the data collected;
- record appropriate qualitative observations and quantitative measurements;
- interpret, explain and evaluate the results obtained and observations made.

You should compare how you undertake each analysis in your school/college laboratory with how it would have been undertaken in an appropriate hospital department. You should include:

- details of the apparatus and procedure you have used;
- details of the apparatus and procedure which would be used in a hospital department;
- a summary of the similarities and differences in the apparatus used and the procedure followed, and how these will affect the final results.
### Assessment Criteria: Unit 15 - The Role of the Pathology Service

**Assessment evidence**

**You need to produce** a portfolio of evidence containing:

A. a report on the work of the following departments in the pathology service – biochemistry, haematology, microbiology and histopathology; (AO1, AO2)

B. a report of:
   - a microbiological analysis, (AO3)
   - either a chromatographic or electrophoresis analysis that you have undertaken. (AO3)

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<thead>
<tr>
<th>Mark Band 1</th>
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<tr>
<td><strong>AO1</strong></td>
<td><strong>AO1</strong></td>
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<td>The research undertaken to identify the role of each department was incomplete and provides only a basic outline of the role of the department. There is an understanding of the knowledge and skills required by those working in a scientific environment but this does not relate specifically to the biochemistry and microbiology departments. (* See below)</td>
<td>Although research undertaken into the role of each department was generally complete it lacks depth and contains some inaccuracies in terms of the role of the department. Details of the knowledge and skills used by those working in the biochemistry and microbiology departments are by no means comprehensive but, where evident, they support the link between the knowledge and skills of those employed and the role of the department. (1-2 marks)</td>
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<tr>
<th>AO2</th>
<th><strong>AO2</strong></th>
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<tr>
<td>The knowledge gained through research was applied to only a few aspects of the portfolio. There are many omissions and/or inaccuracies. A report was produced which covers some aspects of the work undertaken by some of the departments in the pathology service. The report contains only the briefest outline of the importance of health and safety principles relating to the work of each department. The portfolio contains much irrelevant material and fails to move beyond a collection of facts. (* See below)</td>
<td>The knowledge gained through research was applied to some aspects of the portfolio. However, there are several omissions and/or inaccuracies. A report was produced which covers some aspects of the work undertaken by the departments in the pathology service and a summary of the health and safety constraints and also the role of health and safety principles in relation to each department. There were many procedural omissions or inaccuracies. (1-3 marks)</td>
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<td>(4-6 marks)</td>
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* Award 0 marks if nothing creditworthy is displayed in the portfolio.
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<th>AO1</th>
<th>Research evidence reveals a good understanding of the role of each department. However, the research lacked depth and did not allow for a comprehensive explanation of the types of specimens tested, the types of test or the stages involved in the processing of specimens, the standard procedures to be used for each analysis, and how each analysis would be conducted in a hospital department – including details of apparatus used. Details of the knowledge and skills used by those working in the biochemistry and microbiology departments were complete and related to the requirements of the department.</th>
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<td><strong>Mark Band 3</strong></td>
<td>Thorough and accurate research allowed for a detailed explanation of the role of each department, the types of specimens each will test and the stages involved in the processing of these specimens, the standard procedures to be used for each analysis and how each analysis would be conducted in a hospital department – including details of apparatus used. There are clear links shown between the knowledge and skills required of those working in the biochemistry and microbiology departments and how these relate to the role of each department.</td>
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<td><strong>Mark Band 4</strong></td>
<td>(7-8 marks)</td>
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<tr>
<td>AO2</td>
<td>The knowledge gained through research was applied well to most aspects of the portfolio. However, there are a few slight omissions and/or inaccuracies. A detailed report was produced which covers most aspects of the work undertaken by the departments in the pathology service. The report contains a detailed summary of health and safety principles in relation to each department and the role played by legislation in maintaining health and safety principles. However, there are some omissions and/or inaccuracies.</td>
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<td><strong>Mark Band 3</strong></td>
<td>(7-9 marks)</td>
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<tr>
<td><strong>Mark Band 4</strong></td>
<td>The knowledge gained through research was applied consistently well to all aspects of the portfolio. This enabled a comprehensive report to be produced which covers all aspects of the work undertaken by the departments in the pathology service. The importance of health and safety principles in relation to each department and the role played by legislation in maintaining health and safety procedures is clearly demonstrated in the report.</td>
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<td><strong>Mark Band 4</strong></td>
<td>(10-12 marks)</td>
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<td>AO3 (i)</td>
<td>Mark Band 1</td>
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<td>With extensive and frequent teacher intervention, both analyses were attempted but the standard across them is variable. There are many procedural inaccuracies with only a cursory use of the outlined standard procedures, risk assessment and health and safety procedures. Unfamiliarity in the use of equipment led to observations and measurements being minimal, incomplete and imprecise. (*) See below</td>
<td>Both analyses were attempted; however, there was a need for some teacher intervention or guidance. Observations and measurements were recorded for both, but procedural inaccuracies and unfamiliarity with the use of equipment meant that precision in results was variable. Standard procedures, risk assessments and health and safety procedures were used, but not fully. Observations and measurements were not wholly reliable and neither recorded logically nor presented clearly.</td>
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<th>AO3 (ii)</th>
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<th>Mark Band 2</th>
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<td>Given standard procedures were inconsistently documented. Poor planning has allowed for some risk assessments to be conducted and the production of some health and safety procedures; however these are generally incomplete and will be of little use in conducting the analyses. Observations and results were incomplete and/or largely inaccurate and did not allow for a proper evaluation. There was little attempt to compare the apparatus and standard procedure used in a school/college laboratory with that of a hospital department. The summary of similarities and differences was sparse with little or no reference to how the differences affect the final results obtained in the school/college laboratory. Information in the portfolio is poorly organised and lacks a coherent structure although it may contain some valid points. The portfolio contains significant errors and/or omissions in the use of technical terms, spelling, punctuation and grammar leading to a lack of clarity. (*) See below</td>
<td>Given standard procedures were documented. Planning has allowed for risk assessments to be conducted and the production of health and safety procedures; however these are inconsistent. They contained some inaccuracies and did not allow the analyses to be followed through to a satisfactory conclusion. There were some appropriate observations and measurements recorded which led to some straightforward evaluation. There was an attempt to compare the apparatus and standard procedure used in a school/college laboratory with that of a hospital department. The summary of similarities and differences was detailed with some reference to how these affect the final results obtained; however, this contained some omissions/inaccuracies. Information in the portfolio shows some organisation and structure and contains some valid evidence. The portfolio contains some errors and/or omissions in the use of technical terms, spelling, punctuation and grammar leading to inconsistency in clarity.</td>
<td>(1-5 marks)</td>
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* Award 0 marks if nothing creditworthy is displayed in the portfolio.
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<th>AO3 (i)</th>
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<td>With minimal teacher involvement, both analyses were carried out to a consistently high standard and equipment was used skilfully and safely to collect a range of results. # There were some deviations from standard procedure, risk assessment and/or health and safety procedures which had an effect on the overall accuracy of the results obtained. The results were generally recorded logically and presented clearly.</td>
<td>There was a consistently high standard of work across both analyses with skilful use of equipment. With relative autonomy, standard procedures, risk assessments and health and safety procedures were strictly adhered to. # Observations and measurements were wholly reliable and recorded logically and clearly to a high level of precision.</td>
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<th>AO3 (ii)</th>
<th>Mark Band 3</th>
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<td>Given standard procedures were fully documented. Planning allowed risk assessments to be conducted and documented along with appropriate health and safety procedures; however, there were a few omissions. Observations and measurements were complete and allowed for some detailed interpretation and explanation of the results obtained from both analyses. There is evidence that detailed evaluation took place but this was inconsistent across both pieces of work. There was a good attempt to compare the apparatus and standard procedure used in a school/college laboratory with that of a hospital department. The summary of similarities and differences is complete and was used to explain how the differences affect the final results obtained in the school/college laboratory. However, there were a few omissions and/or inaccuracies. Information in the portfolio is mainly well organised and structured and is supported by valid evidence. The portfolio is expressed with reasonable clarity but has a few minor errors and/or omissions in the use of technical terms, spelling, punctuation and grammar.</td>
<td>The given standard procedures were comprehensively documented. Detailed planning allowed comprehensive risk assessments to be conducted and documented along with appropriate health and safety procedures produced for both analyses. The clearly documented observations and measurements allowed for intelligent interpretation, explanation and evaluation of the results for both analyses. The evaluation was comprehensive and detailed, and explained inconsistencies and anomalies in the results obtained. There was a rigorous attempt to compare the apparatus and standard procedure used in a school/college laboratory with that of a hospital department. The summary of similarities and differences is comprehensive and explains in detail why there will be differences between the results obtained in the school/college laboratory and those in a hospital department. Information in the portfolio is logically organised leading to a coherent structure and is supported by a range of valid evidence. The portfolio is clearly expressed with few minor errors in the use of technical terms, spelling, punctuation and grammar.</td>
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<td>(11-15 marks)</td>
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Ecology studies the relationship between living organisms and the environment. Ecology forms the basis of our understanding of agriculture, forestry and fisheries. It is called on to predict the consequences of a wide range of matters from the release of industrial pollutants, agricultural practices and the clearance of tropical rain forest to the building of a dam. For present and future generations, knowledge of ecology is necessary to understand, maintain and preserve life on the planet.

In this unit you will learn about:

- conducting an ecological survey and how to estimate the distribution and/or number of organisms in a habitat;
- how to describe a habitat;
- the environmental damage caused by an activity and how this damage may be reduced;
- the recycling, by a local authority, of one chosen material.

This unit links to other GCE Applied Science units, in particular those with a biological aspect. Through practical investigations this unit also links with Unit 1 (Investigating Science at Work). It also links with other GCE subjects such as biology and physics. This unit will help you to prepare for higher education courses in biology and physics or other science-related subjects with a biology/physics component or for work in a science-based occupation.

You need to produce a portfolio of evidence which considers the ecology of an ecosystem and the impact mankind has had on the environment.

Your portfolio of evidence should comprise:

A. details of an ecological survey, including food chains, food webs and energy flow within a chosen habitat including:

- the identification of a particular habitat;
- an account of research undertaken in relation to the ecological survey. This will include and explanation of techniques which could be used;
- the use of a suitable sampling technique, to estimate the distribution and/or numbers of organisms and use this information to estimate population size;
- a summary of the physical and biological characteristics of the habitat based on the findings of your sampling;
• details of feeding relationships including food webs and food chains based on the findings of your sampling;
• energy flow within the habitat based on the findings of your sampling.

B. a report which describes how humans may have caused, or may cause, damage to a habitat. How this actual or potential damage can be/has been reduced, and the relevance of any conservation measures, including:
• the identification of the reason for one cause of actual or potential damage to the environment;
• the explanation of the effects of this actual or potential damage;
• how this actual or potential damage can be/has been reduced;
• the identification of any conservation measures that would be put in place to address this damage.

C. a report which describes the recycling of a chosen material by a local authority including:
• identification of one material to be recycled and current government targets in relation to this;
• how the material is collected by your chosen local authority and how to encourage participation in the collection scheme;
• the significance, economic and environmental, of recycling this material by a local authority.

25.3 You need to know, understand and be able to demonstrate

In order to complete the requirements of this unit you will need to know, understand and be able to demonstrate relevant knowledge of the following:

• the type and populations of organisms that live in a habitat;
• the relationships of organisms with their physical and biological environment;
• environmental change and damage;
• managing conservation;
• recycling materials.

The type and populations of organisms that live in a habitat

Ecologists have to define a habitat in order to examine the role of different organisms within it and how these organisms interact. Certain organisms live in, and may be restricted to, certain places. Ecologists are interested in how numbers of organisms might change over a period of time, and how they might be affected by human populations.

You should identify a particular habitat and conduct an ecological survey. You should learn how to sample the organisms in a habitat using either:
• random quadrats, or;
• sampling along transects.

You should learn how to measure population size, or abundance of organisms in a habitat, using:

• counting methods and capture/recapture techniques;
• estimates of percentage cover, or relative abundance scales, where the simple counting of individuals is difficult.

You should then be able to estimate the distribution and/or numbers of organisms in a particular habitat.

**The relationships of organisms with their physical and biological environment**

In order to explain why organisms live in a particular habitat, it is necessary to investigate the physical (abiotic) and biological (biotic) characteristics of their environment.

In relation to the particular habitat you should be able to:

• describe the physical characteristics of the habitat – geology and soil, topography, climate, weather, latitude – and local factors such as humidity, sunlight, temperature and wind speed;
• describe the biological characteristics of the habitat – this will involve feeding relationships and competition;
• use food chains and food webs to show feeding relationships;
• demonstrate, through understanding, the energy relationships between organisms in a habitat;
• demonstrate, through understanding, the quantitative relationships shown by pyramids of number, biomass and energy.

**Environmental change and damage**

All human activities have an impact on our environment. The land, water and air may be affected by these activities. We cannot avoid this but we can make sure we understand the impact of the activity and minimise it. We can use science and technology to develop efficient controls to reduce those impacts we cannot eliminate.

You should consider the environmental damage caused by human activity and be able to explain how this damage is controlled or reduced in a habitat related to, one of the following activities;

• an industrial process – including the manufacturing process, waste disposal and the products themselves;
• the burning of fossils fuels – the contribution to acid rain, the greenhouse effect and the role of alternative energy
sources;

- an agricultural production system – discussing the impact on water pollution by fertilisers and other chemicals such as pesticides or waste products. You should consider the role of crop rotation, biological control, selective breeding and organic methods;

- an urban development – the immediate impact of a new development and the longer term impact of the development;

- mining and quarrying – consider the immediate impacts on the environment of the mine/quarry as well as other factors such as transport noise, disruption and pollution. You should consider the use of biotechnology in metal extraction and the returning of land to a useful or environmentally friendly purpose – for example the Eden Project;

- leisure, recreation and tourism – consider the impact of over-use of the environment by tourism where leisure and recreational activities put pressure on habitats by factors such as erosion due to foot traffic, disturbance due to wave action/pollution of water or car parking and the resulting environmental damage. Other similar impacts of human activity would be appropriate but should target a particular environment or habitat and link this to clear descriptions of the activity causing the damage and the restorative action taken to limit this impact.

Managing conservation

You should consider any conservation measures put in place to reduce damage to a habitat as a result of the activity you have chosen. This could include:

- conservation of species;

- conservation of habitats, land reclamation and the recycling of urban land and protected areas such as green belts and national parks;

- statutory protected areas and areas of outstanding natural beauty;

- conservation of the biosphere, reduction in the use of CFCs to prevent the spread of holes in the ozone layer, reduction of emissions and current carbon dioxide levels to slow down global warming.

Recycling materials

All local authorities are under pressure from central government to ensure that they recycle a certain proportion of the waste generated in their area. You should identify a particular material – for example paper, glass, metal, oil or fabric. You should be able to detail the issues relating to the recycling of your chosen material, including:
• the current government target in relation to the recycling of the chosen material. You will need to consider government policies and strategies which have been developed to allow the local authority to meet this target;

• whether or not the local authority meets the targets set by the government for the recycling of the chosen material and the penalties imposed for not meeting the target;

• how the chosen material is collected by the local authority from those who participate in the recycling scheme;

• how the local authority encourages participation in the scheme to ensure it meets the government target in relation to the recycling of the chosen material;

• how the collected material is processed. Does the local authority processes the material or is it passed to a processing centre?

• the local and global environmental and economic significance of recycling the material.
### Assessment Criteria: Unit 16 – Ecology, Conservation and Recycling

#### Assessment evidence

You need to produce a portfolio of evidence containing:

A. details of an ecological survey, including food chains, food webs and energy flow in a chosen habitat; (AO1, AO3)

B. a report which describes how humans may have caused, or may cause, damage to a habitat. How this actual or potential damage can be/has been reduced, and the relevance of any conservation measures; (AO1, AO2)

C. a report which describes the recycling of a chosen material by a local authority. (AO1, AO2)

<table>
<thead>
<tr>
<th>Mark Band 1</th>
<th>Mark Band 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AO1</strong> There is only a limited account of the research undertaken regarding the ecological survey, a specific habitat may have been chosen but there will be little understanding of the scientific principles required for the ecological survey. A source of environmental damage was identified but explanations of the cause and effect are generally incomplete and unfocused. The information provided in the report on recycling is also not well focused, with little evidence of any real scientific knowledge and understanding. (* See below)</td>
<td>There is evidence of research undertaken regarding the ecological survey and a specific habitat has been identified. There is some discussion of food chains and food webs in the chosen habitat and some examples are suggested. A source of environmental damage is clearly identified and the explanation of the causes and effect are generally complete with some inaccuracies. There is evidence of knowledge about how the recycling is undertaken, and this is clearly linked to the local authority. (3-4 marks)</td>
</tr>
<tr>
<td>(1-2 marks)</td>
<td></td>
</tr>
</tbody>
</table>

| **AO2** There is little discussion of how humans have caused damage to a habitat but there are only unsubstantiated claims displaying little scientific knowledge. There is very little application of knowledge and understanding across the reports. There is a failure to move beyond the presentation of the facts, especially in relation to the recycling of materials. There is little consideration of any economic or environmental significance of recycling material. (* See below) | There is an attempt to apply the knowledge presented but it does not go much beyond the straightforward and well known. There is discussion of the effects of damage or potential damage to the habitat, but with limited explanation or consideration of how reduction is possible. There is little grasp of the scientific principles behind the recycling of materials. Though there is consideration of recycling materials, this tends to be focused on well known and familiar environmental factors related to a global scale. (4-6 marks) |
| (1-3 marks)                                                                |                                                                             |

* Award 0 marks if nothing creditworthy is displayed in the portfolio.
<table>
<thead>
<tr>
<th>Mark Band 3</th>
<th>Mark Band 4</th>
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</thead>
<tbody>
<tr>
<td><strong>AO1</strong></td>
<td><strong>AO1</strong></td>
</tr>
<tr>
<td>A clear account of the research undertaken in relation to the ecological survey is provided. A habitat is selected with appropriate techniques explained clearly and the findings developed into suitable feeding relationships. A cause of environment damage is clearly identified, as are effects. This information is developed to explain how the impact could be reduced. There is knowledge of the technique of recycling of the chosen material by the local authority. The portfolio lacks the scientific understanding behind the knowledge shown.</td>
<td>A clear account of the research undertaken in relation to the ecological survey is provided. A habitat is selected and the appropriate techniques are explained clearly and the findings developed into suitable feeding relationships and energy flow. A cause of environmental damage is identified clearly, as are the effects. This information is then developed to explain how the impact could be reduced. This has been linked clearly to conservation methods within the environment. The examples fully support the outline provided and the treatment of the recycling of the material, which is wholly related to the local authority.</td>
</tr>
<tr>
<td>(5-6 marks)</td>
<td>(7-8 marks)</td>
</tr>
<tr>
<td><strong>AO2</strong></td>
<td><strong>AO2</strong></td>
</tr>
<tr>
<td>There is application of knowledge of conservation and ecology and it is relevant to the findings of the written reports. Though the knowledge is fairly thorough, there are limitations in the understanding of the scientific principles in both or one of the reports. There is consideration of the economic and environmental significance of recycling the material.</td>
<td>Scientific knowledge from the unit is applied in an appropriate manner across the reports. There is a clear and concise evaluation of the damage or potential damage to the habitat and full consideration of how it could be reduced. It is clear that knowledge of the scientific principles behind the recycling of the stated material was applied appropriately. There is a full, in depth evaluation of the economic and environmental significance of recycling material.</td>
</tr>
<tr>
<td>(7-9 marks)</td>
<td>(10-12 marks)</td>
</tr>
<tr>
<td>Mark Band 1</td>
<td>Mark Band 2</td>
</tr>
<tr>
<td>------------</td>
<td>------------</td>
</tr>
<tr>
<td><strong>AO3 (i)</strong></td>
<td>There was a need for frequent teacher intervention and guidance in order to progress and collect data which could be evaluated. # There was an attempt to record some measurements, though these were fairly basic and did not display any clear understanding of how to undertake the sampling techniques learned in the unit. (* See below)</td>
</tr>
<tr>
<td></td>
<td>The results show that some skill and precision was used in collecting the data; however, this was not consistent across the sampling techniques used. There was, on occasion, a need for some teacher intervention/guidance. # Ecological survey methods were used well to investigate the distribution of organisms. Various measurements of physical features of the environment were recorded but there was little consideration given to relating this data to the distribution of organisms. There was little consideration given to estimations of the population sizes of organisms.</td>
</tr>
<tr>
<td>(1-5 marks)</td>
<td>(6-10 marks)</td>
</tr>
<tr>
<td><strong>AO3 (ii)</strong></td>
<td>The limited amount of data collected restricted the discussions of the findings of the sampling. Some simple consideration was given to the physical and biological characteristics of the habitat studied. There is a lack of scientific understanding in the survey – though there is consideration of basic food chains there is little development to even simple food webs. Some consideration was given to ideas of energy relationships in the habitat though this was at a simplistic level and shows a confused understanding of the principles. Information in the portfolio is poorly organised and lacks a coherent structure although it may contain some valid points. The portfolio contains significant errors and/or omissions in the use of technical terms, spelling, punctuation and grammar leading to a lack of clarity. (* See below)</td>
</tr>
<tr>
<td></td>
<td>The data collected enabled some reasonable discussions of the physical and biological characteristics in the habitat. The data collected was used to construct food chains and food webs though these show a lack of real scientific understanding. There is evidence of an understanding of energy relationships, though this is not fully linked to the data collected in the habitat, with inconsistencies being apparent. Information in the portfolio shows some organisation and structure and contains some valid evidence. The portfolio shows some errors and/or omissions in the use of technical terms, spelling, punctuation and grammar leading to inconsistency in clarity.</td>
</tr>
<tr>
<td>(1-5 marks)</td>
<td>(6-10 marks)</td>
</tr>
</tbody>
</table>

* Award 0 marks if nothing creditworthy is displayed in the portfolio.
# teacher/assessor evidence required
### Mark Band 3

**AO3 (i)** With minimal teacher involvement, skill and precision used in collecting data was shown. # The ecological survey includes methods to investigate distribution of organisms. Measurements were taken of the physical features of the environment, observations were recorded and this data is compared to the distributions of species. There are some inaccuracies in the estimations of the number of organisms and population sizes.

(11-15 marks)

**AO3 (ii)** There is a clear understanding of how the data recorded can be related to considerations of the physical and biological characteristics in the habitat. Food chains and food webs are explored and these show an understanding of the principles involved, though there are inaccuracies evident when compared with the data collected. Energy relationships linked to the habitat are evident, though the discussions do not display a precise scientific understanding of the underlying principles learned in the unit. Information in the portfolio is mainly well organised and structured and is supported by valid evidence. The portfolio is expressed with reasonable clarity but has a few minor errors and/or omissions in the use of technical terms, spelling, punctuation and grammar.

(11-15 marks)

# teacher/assessor evidence required

### Mark Band 4

**Mark Band 4**

There is evidence of working with relative autonomy throughout the survey, and also that the sampling techniques were undertaken skilfully and with precision.# The ecological survey methods used were comprehensive and appropriate data recorded. Precise and reliable measurements of physical features were recorded, displayed and appropriate links made to the distribution of organisms. Data was considered to make reliable estimations of the number of organisms found and estimate the population size.

(16-20 marks)

**Mark Band 4**

The extensive sampling methods used are justified and are appropriate to the environment and consideration of the examination of the physical and biological characteristics. There is a comprehensive discussion of the significance of the measurements and, by considering relevant food chains and webs from the data, a thorough scientific knowledge is displayed. A complete energy relationship was produced which is related clearly to the data collected. Information in the portfolio is logically organised leading to a coherent structure and is supported by a range of valid evidence. The portfolio is clearly expressed with few minor errors in the use of technical terms, spelling, punctuation and grammar.

(16-20 marks)

# teacher/assessor evidence required
Key Skills and Other Issues

Key Skills

Key Skills qualifications have been phased out and replaced by Functional Skills qualifications in English, Mathematics and ICT from September 2010.
## Spiritual, Moral, Ethical, Social, Cultural and Other Issues

### 27.1 Spiritual, Moral, Ethical, Social and Cultural Issues

The AQA GCE AS and Advanced Level qualifications in Applied Science offer a wide range of opportunities for the exploration of spiritual, moral, ethical, social and cultural issues. Current moral issues in biology may be explored in the healthcare units, ecological issues in the ecology unit, social and cultural issues form parts of the underlying science in most units. Issues which fall naturally into the work of particular units include bioengineering, (Unit 8 Medical Physics and Unit 12 The Actions and Development of Medicines), GM foods (Unit 4 Food Science and Technology), morality of food distribution, (Unit 4) use of blood transfusions (Unit 15 The Role of the Pathology Service), resource usage in materials, (Unit 16 Ecology, Conservation and Recycling), energy usage and conservation (Unit 16), animal testing for medicines, (Unit 12).

### 27.2 European Dimension

AQA has taken account of the 1998 Resolution of the Council of the European Community and associated specimen papers. European examples should be used where appropriate in the delivery of the subject content. Relevant European legislation is identified within the specification where applicable.

### 27.3 Environmental Education

AQA has taken account of the 1998 Resolution of the Council of the European Community and the Report *Environmental Responsibility; An Agenda for Further and Higher Education* 1993 in preparing this specification and associated specimen papers. The nature of this specification makes it ideally suited to enable candidates to appreciate the decisions that link scientific processes with the demand for recycling of materials and the recognition of environmental management systems within industry. The study of Unit 16 (Ecology, Conservation and Recycling) should encourage students to develop a responsible attitude towards the environment.

### 27.4 Avoidance of Bias

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

### 27.5 Issues for centres in Wales and Northern Ireland

Terms, legislation or aspects of government that are different from those in England should not disadvantage candidates in Wales or Northern Ireland. Where such situations might occur, including in the external tests, the terms used have been selected as neutral, so that programmes can be developed to reflect local and regional circumstances.

### 27.6 Developing Practical Skills

This specification provides opportunities for candidates to carry out experimental and investigative activities in order to develop their practical skills. It is also expected that teachers will use
experimental and investigative activities to enhance teaching and learning within the centre.

Wherever possible, experimental and investigative activities should be set in contexts appropriate to, and reflect the demand of, the content of the unit.

In the course of their experimental and investigative activities candidates should learn to:

*Plan*

Identify or define a question or problem. Choose effective and safe procedures, selecting appropriate methods and apparatus, to enable, through practical investigation, the question be answered or problem solved.

*Implement*

Set up apparatus with due regard to safety. Use apparatus effectively to make and record sufficient relevant observations and measurements to an appropriate degree of precision. Where necessary, modify procedures to limit the effect of both systematic and random errors.

*Analyse*

Present work in an appropriate format, analysing observations and showing an awareness of the limitations of experimental measurement when commenting on patterns and trends in experimental data.

*Draw conclusions*

Draw valid conclusions by applying appropriate knowledge and understanding.

*Evaluate*

Assess the reliability of data and the conclusions drawn from them. Show an awareness of the limitations inherent in scientific activity.

### 27.7 Health and safety

AQA recognises the need for safe practice in laboratories and tries to ensure that experimental work required for the specification complies with up-to-date safety recommendations.

Candidates are introduced to health and safety issues and are made aware of the significance of safe working practice. This is initially addressed in Unit 1 (Investigating Science at Work) but is a theme throughout all of the units where candidates are required to undertake practical work.

Nevertheless, centres are primarily responsible for the safety of the candidates and teachers/assessors should carry out their own risk assessment of practical work.

### 27.8 Mathematical Requirements

In order to be able to develop the knowledge, understanding and skills, candidates need to have been taught and to have acquired competence in the areas of mathematics set out below.
Arithmetic and computation You should be able to:

- recognise and use expressions in decimal and standard form;
- use ratios, fractions and percentages;
- use calculators to handle $\sin x$.

Handling Data You should be able to:

- make order of magnitude calculations;
- use an appropriate number of significant figures;
- find arithmetic means;
- understand the use of the prefixes giga (G), mega (M), kilo (k), milli (m), micro ($\mu$) and nano (n);
- construct and interpret bar charts, pie charts and histograms.

Algebra You should be able to:

- change the subject of an equation by manipulation of the terms;
- substitute numerical values into algebraic equations using appropriate units for physical quantities.

Graphs You should be able to:

- translate information between graphical, numerical and algebraic forms;
- plot two variables from experimental or other data;
- construct a line of best fit;
- determine the slope and intercept of a linear graph;
- draw and use the slope of a tangent to a curve as a measure of rate of change;
- understand the possible significance of the area between a curve and the $x$-axis and be able to calculate it or measure it by counting squares as appropriate;
- extrapolate and interpolate from a drawn/given graph.

27.9 Calculators

It is assumed that candidates will have use of calculators which have at least the functions of addition (+), subtraction (−), multiplication (×), division (÷), square root (√), sine (sin), cosine (cos) and tangent (tan).

Further details of the use of calculators in examinations can be found in Section 3 of the *Instructions for the Conduct of Examinations* – JCGQ.

27.10 ICT

This specification can be used to develop an awareness of the use and importance of ICT in scientific work. Candidates should be made aware of the ways in which scientists use ICT as part of their work e.g. Examples could include how research will use automated techniques or software systems.
In addition, this specification can provide many opportunities for the effective use of ICT, from the capture and analysis of experimental data, the retrieval of information downloaded electronically for research purposes to the use of word processing and spreadsheet software to produce portfolio assignments.
Centre-Assessed Units

28

Guidance on Setting Centre-Assessed Units

28.1 Portfolio Advisers  AQA-appointed Portfolio Advisers will be able to assist centres with any matters relating to portfolio units. Each centre is allocated a Portfolio Adviser as soon as AQA is informed that they are following the specification. Centres are, therefore, requested to ensure that they have completed an Intention To Enter form as soon as they start to offer this specification.

28.2 Guidance on Applying the Portfolio Assessment Criteria  When assessing candidates’ work, teachers/assessors should consider the level of attainment in four broad areas:

- the level of independence and originality in portfolio preparation;
- the depth and breadth of understanding of the content of the unit demonstrated;
- the level of evaluation and analysis employed;
- the level of skills, required in the unit, that have been demonstrated.

In the Assessment Criteria for each unit, mark ranges are specified for each Assessment Objective (criterion). When assessing a candidate’s portfolio of work teachers/assessors should, for each Assessment Objective, first identify the criterion description within which that work falls, then use their professional judgement to decide which mark within that range best describes the depth and quality of the work.

To achieve the higher mark bands, candidates should show greater depth and breadth of understanding, higher level skills, higher levels of synthesis, analysis and evaluation and higher levels of independence and originality as required in the Assessment Criteria.

Work that clearly meets all the requirements of the mark band description should be awarded the maximum mark identified. Aspects of the work that might fall short of meeting, in full, the description but which do not, in the judgement of the teacher/assessor sufficiently influence the overall level of achievement to merit the work being assigned to a lower mark band, will reduce the mark awarded within the identified range available. This can be expressed as identifying the ‘best-fit’ approach where the areas of strength in the work submitted by the candidate can be allowed to compensate for weaknesses in other areas.
In addition, it must be appreciated that work that is judged to meet the criteria for the highest mark bands will be expected, where appropriate, to demonstrate a high level of Quality of Written Communication, including the use of appropriate terminology, as identified in the Assessment Objectives (Section 6).

The candidate’s total mark for the unit is determined by adding the marks for the different Assessment Objectives.

Further guidance about the marking process will be provided through Teacher Standardising Meetings (Section 30.1 Standardising Meetings) and in the Teachers’ Guide to accompany this specification.

### 28.3 Assessment of Group Work

Group work is a useful way of obtaining information for some activities but it is important that individual candidates meet the assessment criteria requirements. Teachers/Assessors assessing the evidence will need to be convinced of its individual authenticity. Questioning can be used in order to clarify the validity, authenticity and sufficiency of evidence and, under these circumstances, the teacher/assessor may wish to include a dated witness statement detailing this evidence. It is expected that the use of such statements will be kept to a minimum so that they constitute a very minor part of the submitted evidence.

It is recognised that there can be instances where candidates are required to carry out tasks as part of a group and the group-working skills are an integral part of the assessment requirements. In such cases this general guidance on group work will be superseded by the specific requirements and instructions of the individual unit(s).

### 28.4 Teacher/Assessor Evidence

Assessment grids clearly indicate tasks which candidates must perform to meet Assessment Objectives (AOs). In some instances no written evidence is required to be produced by the candidate, for example, where a candidate is required to carry out and investigation with due regard to safety. These are clearly indicated in the appropriate assessment grid by the use of (#)

In such instances there is a requirement for teacher/assessor evidence to be provided. This can be provided in either the following ways:

- an annotation within the portfolio unit to indicate where the requirement has been met;
- a separate witness testimony, attached to the front of the portfolio of evidence.
## 29 Supervision and Authentication

### 29.1 Supervision of Candidates' Work

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

### 29.2 Guidance by the Teacher

The work assessed must be solely that of the candidate concerned. Any assistance given to an individual candidate which is beyond that given to the group as a whole but within the parameters laid down by the specification must be recorded on the Candidate Record Form.

### 29.3 Unfair Practice

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

### 29.4 Authentication of Candidates’ Work

Both the candidate and the teacher are required to sign declarations on the Candidate Record Form, confirming that the work submitted for assessment is the candidate’s own. The teacher declares that the work was conducted under the specified conditions and records details of any additional assistance.
30.1 Standardising Meetings

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

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

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

30.2 Internal Standardisation of Marking

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

**31.1 Recording Assessments**

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

**31.2 Submitting Marks and Sample Work for Moderation**

For each portfolio unit a mark for each candidate must be submitted to AQA by the date specified in the year in which the unit is to be awarded. Centres will be informed which candidates’ work is required in the samples to be submitted to the moderator.

**31.3 Factors Affecting Individual Candidates**

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

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

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

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

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

**31.4 Retaining Evidence**

The centre must retain the work of candidates, with *Candidate Record Forms* and *Centre Declaration Sheet*, under secure conditions, from the time it is assessed until the day after the deadline for enquiries about results, to allow for the possibility of an enquiry upon results. The work may be returned to candidates after the issue of results provided that no enquiry upon results is to be made which will include re-moderation of the work in the portfolio unit(s). If an enquiry upon result is to be made, the work must remain under secure conditions until requested by AQA.
32.1 Moderation Procedures

Moderation of the portfolio work is by inspection of a sample of candidates’ work, sent by post from the centre to a moderator appointed by AQA. The centre marks must be submitted to AQA and the moderator by specified dates, and the sample of work must reach the moderator by the date requested.

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

32.2 Post-Moderation Procedures

On publication of the GCE results, the centre is supplied with details of the final marks for the portfolio unit(s).

The candidates’ work is returned to the centre after the examination with a report form from the moderator giving feedback to the centre on the appropriateness of the tasks set, the accuracy of the assessments made, and the reasons for any adjustments to the marks.

Some candidates’ work may be retained by AQA for archive purposes.
33.1 Qualification Titles
The qualifications based on these specifications have the following titles:

- AQA Advanced Subsidiary GCE in Applied Science
- AQA Advanced Subsidiary GCE (Double Award) in Applied Science
- AQA Advanced Level with AS (Additional) in Applied Science
- AQA Advanced Level GCE in Applied Science
- AQA Advanced Level GCE (Double Award) in Applied Science

33.2 Grading System
The Advanced Subsidiary Single Award qualification will be graded on a five-scale: A, B, C, D and E. Candidates who fail to reach the minimum standard for grade E will be recorded as U (unclassified) and will not receive a qualification certificate.

The Advanced Single Award qualification will be graded on a six-grade scale: A*, A, B, C, D and E. To be awarded an A*, candidates will need to achieve a grade A on the full A level qualification and an A* on the aggregate of the A2 units. Candidates who fail to reach the minimum standard for grade E will be recorded as U (unclassified) and will not receive a qualification certificate.

The Advanced Subsidiary Double Award qualification will be graded on a nine-grade scale: AA, AB, BB, BC, CC, CD, DD, DE and EE. Candidates who fail to reach the minimum standard for grade E will be recorded as U (unclassified) and will not receive a qualification certificate.

The Advanced with Advanced Subsidiary (additional) qualification will be graded on a ten-grade scale: A*A, AA, AB, BB, BC, CC, CD, DD, DE and EE. To be awarded an A*A, candidates will need to achieve an AA on the full qualification and an A* on the aggregate of the three A2 units. Candidates who fail to reach the minimum standard for EE will be recorded as U (unclassified) and will not receive a qualification certificate.

The Advanced Double Award qualification will be graded on an eleven-grade scale: A*A*, A*A, AA, AB, BB, BC, CC, CD, DD, DE and EE. To be awarded an A*A*, candidates will need to achieve a grade AA on the full A level qualification and an A* on the aggregate of the best three A2 units. Candidates who fail to reach the minimum standard for grade EE will be recorded as U (unclassified).
and will not receive a qualification certificate.

Where the unit results permit, a candidate who fails to achieve a Double Award will be able to claim an award for an appropriate subset of units. For example, a candidate who is recorded as U for the Advanced Level Double Award may have sufficiently good unit results to claim an Advanced Subsidiary Single Award, Advanced Subsidiary Double Award, Advanced Level Single Award and/or Advanced with Advanced Subsidiary (additional) award. Centres will be required to request a revised qualification entry or entries in such circumstances.

Individual assessment unit results will be certificated.

### 33.3 Internally-assessed Units

The raw marks out of 60 will be scaled to a range of 100 uniform marks. The ranges of uniform marks available for each grade are as follows:

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<thead>
<tr>
<th>UMS</th>
<th>U</th>
<th>E</th>
<th>D</th>
<th>C</th>
<th>B</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 - 39</td>
<td>40 - 49</td>
<td>50 - 59</td>
<td>60 - 69</td>
<td>70 - 79</td>
<td>80 - 100</td>
</tr>
</tbody>
</table>

A candidate’s work will be awarded a raw mark as detailed in Section 28.2 – Guidance on Applying the Portfolio Assessment Criteria. It is possible for a candidate’s work to be awarded a raw mark at the bottom of the mark range that results in a Grade U award for that unit. These marks will be converted to Uniform Marks and count towards the total Uniform Mark Score.

### 33.4 Grading of Each Unit

For both internally- and externally-assessed units, the minimum raw mark for each grade will be recommended by an awarding committee. The boundary decisions will be reported to centres for each unit at each assessment opportunity. For both internally- and externally-assessed units candidates’ raw marks will be converted by AQA to Uniform marks, which will be reported to the centre.
The Uniform Mark Score achieved by the candidate for each unit is recorded and added to those for the other units to give an overall Uniform Mark total. This total for the qualification is then compared to the ranges allocated to each grade.

**UMS for the AS Single Award Qualification**

<table>
<thead>
<tr>
<th>U</th>
<th>E</th>
<th>D</th>
<th>C</th>
<th>B</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 119</td>
<td>120 - 149</td>
<td>150 - 179</td>
<td>180 - 209</td>
<td>210 - 239</td>
<td>240 - 300</td>
</tr>
</tbody>
</table>

**UMS for the AS Double Award Qualification**

<table>
<thead>
<tr>
<th>U</th>
<th>EE</th>
<th>DE</th>
<th>DD</th>
<th>CD</th>
<th>CC</th>
<th>BC</th>
<th>BB</th>
<th>AB</th>
<th>AA</th>
</tr>
</thead>
</table>

**UMS for the A Level Single Award Qualification**

<table>
<thead>
<tr>
<th>U</th>
<th>E</th>
<th>D</th>
<th>C</th>
<th>B</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 239</td>
<td>240 - 299</td>
<td>300 - 359</td>
<td>360 - 419</td>
<td>420 - 479</td>
<td>480 - 600</td>
</tr>
</tbody>
</table>

To be awarded an A* for the A level single award, candidates will need to achieve a grade A on the A level and a total of at least 270 uniform marks on the A2 units.

**UMS for the A Level with AS (Additional) Qualification**

<table>
<thead>
<tr>
<th>U</th>
<th>EE</th>
<th>DE</th>
<th>DD</th>
<th>CD</th>
<th>CC</th>
<th>BC</th>
<th>BB</th>
<th>AB</th>
<th>AA</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 359</td>
<td>360 - 404</td>
<td>405 - 449</td>
<td>450 - 494</td>
<td>495 - 539</td>
<td>540 - 584</td>
<td>585 - 629</td>
<td>630 - 674</td>
<td>675 - 719</td>
<td>720 - 900</td>
</tr>
</tbody>
</table>

To be awarded an A*A for the level with AS (additional) award, candidates will need to achieve a grade AA on the whole qualification and a total of at least 270 uniform marks on the A2 units. A*A is the highest grade available for this qualification.

**UMS for the A Level Double Award Qualification**

<table>
<thead>
<tr>
<th>U</th>
<th>EE</th>
<th>DE</th>
<th>DD</th>
<th>CD</th>
<th>CC</th>
<th>BC</th>
<th>BB</th>
<th>AB</th>
<th>AA</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 479</td>
<td>480 - 539</td>
<td>540 - 599</td>
<td>600 - 659</td>
<td>660 - 719</td>
<td>720 - 779</td>
<td>780 - 839</td>
<td>840 - 899</td>
<td>900 - 959</td>
<td>960 - 1200</td>
</tr>
</tbody>
</table>

To be awarded an A*A* for the A level double award, candidates will need to achieve a grade AA on the A level and a total of at least 540 uniform marks on the A2 units. To be awarded an A*A, candidates will need to achieve a grade AA on the A level and a total of at least 270 uniform marks on the best three A2 units.
### 33.6 Shelf-Life of Unit Results

The shelf-life of individual unit results, prior to the award of the qualification, is limited only by the shelf-life of the specification.

### 33.7 Assessment Unit Re-Sits

Each unit is available in June only. Each assessment unit may be re-taken an unlimited number of times within the shelf-life of the specification. The best result will count towards the final award.

Candidates who wish to repeat an award must enter for at least one of the contributing units and also enter for certification (cash-in). There is no facility to decline an award once it has been issued.

### 33.8 Minimum Requirements

Candidates do not have to reach a designated minimum standard on each unit to achieve certification. They will be graded on the basis of their performance on the qualification overall.
The performance descriptors for GCE Applied Science aim to describe learning outcomes and levels of attainment likely to be shown by a representative candidate performing at the A/B and E/U boundaries for the AS and A2. They illustrate the expectations at these boundaries for the AS and A2 as a whole; they have not been written at specification or unit level.

Each performance descriptor is aligned to one assessment objective. An alphabetical system has been used to denote each element of a performance description. There is no hierarchy of elements.

Performance descriptors are designed to assist examiners in exercising their professional judgement at awarding meetings where the grade A/B and E/U boundaries will be set by examiners using professional judgement. This judgement will reflect the quality of the candidates’ work, informed by the available technical and statistical evidence. Performance descriptors will be reviewed continually and updated where necessary.

Teachers may find performance descriptors useful in understanding candidates’ performance across qualifications as a whole but should use the marking criteria identified in the specification when assessing candidates’ work.

The performance descriptions for GCE Applied Science indicate the level of attainment characteristic of A/B and E/U boundary candidates respectively for the AS component and the A2 component. They amplify the assessment objectives which apply to the whole award. They give a general indication of the required learning outcomes. The descriptions should be interpreted in relation to the content outlined in the specification: they are not designed to define that content. The grade awarded will depend in practice upon the extent to which the candidate has met the assessment objectives overall. Shortcomings in some aspects of the assessment may be balanced by better performance in others.

The requirement for all Advanced Subsidiary and Advanced Level specifications to assess candidates’ Quality of Written Communication will be met through all three assessment objectives.

Within this specification Quality of Written Communication is assessed in all portfolio units and in the A2 externally assessed units.
AS Performance Descriptors

A/B boundary

To match AO1 (see Section 6.1)

Candidates:

- demonstrate their knowledge and understanding of science with few omissions;
- use scientific terminology and conventions accurately in all their work;
- select relevant information, present it clearly and logically, and then evaluate it.

To match AO2 (see Section 6.2)

Candidates:

- describe, interpret and explain phenomena and effects using scientific principles;
- apply scientific facts and principles to familiar and unfamiliar situations;
- describe, interpret and evaluate quantitative and qualitative data;
- identify and explain issues arising from scientific activities, which impact on society;
- carry out straightforward calculations, obtaining correct solutions to an appropriate degree of accuracy.

To match AO3 (see Section 6.3)

In given practical tasks, candidates:

- produce risk assessments, consistent with COSHH guidelines, and use them to carry out given tasks safely, using a range of techniques and equipment with an appropriate degree of accuracy;
- make and record relevant observations and measurements with appropriate precision and process these accurately;
- interpret their results and draw conclusions.

E/U boundary

To match AO1 (see Section 6.1)

Candidates:

- demonstrate some knowledge and understanding of science. There may be significant omissions;
• use basic scientific terminology and conventions in their work;
• select and clearly present information.

To match AO2 (see Section 6.2)

Candidates:
• describe phenomena and effects using scientific principles;
• apply scientific facts and principles to familiar situations;
• describe and give limited interpretation of quantitative and qualitative scientific data;
• describe issues arising from scientific activities, which impact on society;
• carry out straightforward calculations sometimes obtaining correct solutions.

To match AO3 (see Section 6.3)

In given practical tasks, candidates, with guidance:
• use risk assessments and carry out given tasks safely using a range of techniques and equipment;
• make and record relevant observations and measurements;
• provide some interpretation of their results.

A Level Performance Descriptors

A/B boundary

To match AO1 (see Section 6.1)

Candidates:
• demonstrate their knowledge and understanding of science from most parts of the specification;
• use scientific terminology and conventions accurately in all their work;
• select relevant information, present it clearly and logically, and then evaluate and justify it.

To match AO2 (see Section 6.2)

Candidates:
• describe, interpret and explain phenomena and effects using scientific principles;
• apply scientific facts and principles to familiar and unfamiliar situations;
• describe, interpret and evaluate quantitative and qualitative data;
• identify and explain issues arising from scientific activities, which impact on society;
• carry out complex calculations, obtaining correct solutions to an appropriate degree of accuracy.

To match AO3 (see Section 6.3)

In all practical tasks, candidates:
• produce risk assessments, consistent with COSHH guidelines, and use them to carry out their tasks safely, using a range of techniques and equipment with an appropriate degree of accuracy;
• make and record relevant observations and measurements with appropriate precision and process these accurately;
• interpret their results and draw conclusions, discussing their significance.

In the synoptic investigation, candidates also:
• independently make a realistic and achievable plan for an investigation, linked to other areas of the AS/A Level specification;
• critically evaluate their investigation, incorporating amendments into the plan where appropriate;
• produce a logical and well-structured report of their investigation, showing detailed scientific understanding of their work.

E/U boundary

To match AO1 (see Section 6.1)

Candidates:
• demonstrate some knowledge and understanding of science. There may be significant omissions;
• use some scientific terminology and conventions in their work;
• select and clearly present information.

To match AO2 (see Section 6.2)

Candidates:
• describe phenomena and effects using scientific principles;
• apply scientific facts and principles to familiar situations;
• describe and give limited interpretations of quantitative and qualitative scientific data;
• describe issues arising from scientific activities, which impact on society;
• carry out straightforward calculations, generally obtaining correct solutions.

In all practical tasks, candidates:

• use risk assessments to carry out their tasks safely, using a range of techniques and equipment;
• make and record some relevant observations and measurements;
• provide, with guidance, some interpretation of their results in terms of their scientific knowledge and understanding.

In the synoptic investigation, candidates also:

• make a plan for an investigation, linked to other areas of the AS/A Level specification;
• make an appropriate evaluation of the investigation;
• produce a clear and accurate report of their investigation.
## Overlaps with Other Qualifications

<table>
<thead>
<tr>
<th>B.1</th>
<th>GCE Advanced Subsidiary and Advanced Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The qualification has some overlap with other AQA qualifications. These include:</td>
</tr>
<tr>
<td></td>
<td>GCE Physics (Specification A) - Units 2, 5, 8, 9 and 10</td>
</tr>
<tr>
<td></td>
<td>GCE Physics (Specification B) - Units 2, 5, 8, 9 and 10</td>
</tr>
<tr>
<td></td>
<td>GCE Chemistry - Units 3, 5, 6, 11, 12 and 13</td>
</tr>
<tr>
<td></td>
<td>GCE Biology (Specification A) - Units 9 and 14</td>
</tr>
<tr>
<td></td>
<td>GCE Biology (Specification B) - Unit 16</td>
</tr>
</tbody>
</table>

It is also anticipated that there will be some overlap between Unit 1 and Unit 7 with all of the above specifications. This overlap will result from the practical skills and processes required to successfully complete the practical demands of these units successfully.

<table>
<thead>
<tr>
<th>B.2</th>
<th>Relationship with National Occupational Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Where a clear relationship exists with <em>National Occupational Standards</em>, details are stated in the <em>About this Unit</em> Section of the specification.</td>
</tr>
</tbody>
</table>
**Formulae Sheet**

You will need to be able to recall, use and manipulate the formulae below, showing consideration for correct units to obtain correct values.

You will then be required to compare calculated values and relate, where applicable, to known values.

**Unit 2 – Energy Transfer Systems**

- potential energy \( (E_p) = \text{mass} \times \text{acceleration} \times \text{height} \) due to gravity
- kinetic energy \( (E_k) = \frac{1}{2} \times \text{mass} \times \text{velocity}^2 \)

- power \( (P) = \frac{\text{energy transferred}}{\text{time taken}} \) or \( = \frac{\text{work done}}{\text{time taken}} \)

- cost \( (C) = \text{power} \times \text{time} \times \text{cost per unit} \)

- efficiency \( (%) = \frac{\text{useful energy output}}{\text{total energy input}} \times 100\% \)

**Unit 5 – Choosing and Using Materials**

- density \( (\rho) = \frac{\text{mass}}{\text{volume}} \)

- Young modulus \( (E) = \frac{\text{stress}}{\text{strain}} \)

**Unit 8 – Medical Physics**

- \( \frac{1}{T_e} = \frac{1}{T_p} + \frac{1}{T_b} \)

- velocity \( (v) = \text{frequency} \times \text{wavelength} \)

- \( \alpha = \left( \frac{Z_2 - Z_1}{Z_2 + Z_1} \right)^2 \)

- refractive index, \( n = \frac{\sin i}{\sin r} \)

- \( \sin c = \frac{1}{n} \)
Unit 11 – *Controlling Chemical Processing*

- $Q = mc\Delta T$

Unit 14 – *The Healthy Body*

No formulae appear in the specification for this unit.
Candidate Record Form & Centre Declaration Sheet

Candidate Record Forms and Centre Declaration Sheets are available on the AQA website in the Administration area. They can be accessed via the following link:

http://www.aqa.org.uk/admin/p_course.php