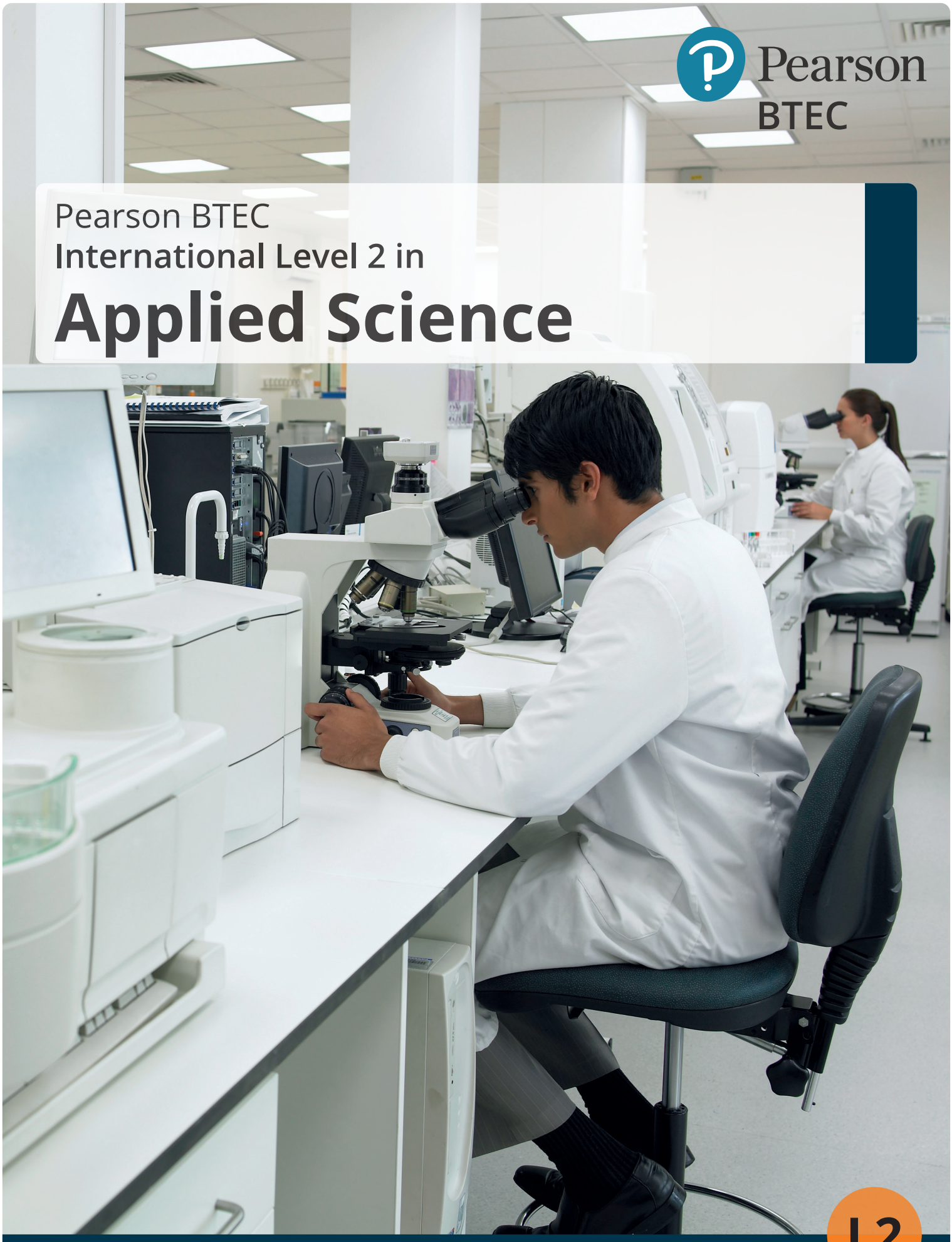

Pearson BTEC

Pearson BTEC
International Level 2 in

Applied Science

L2

Specification

First teaching from September 2020

Issue 2

Pearson BTEC International Level 2 Qualifications in Applied Science

Specification

First teaching September 2020

Issue 2

About Pearson

We are the world's leading learning company operating in countries all around the world. We provide content, assessment and digital services to learners, educational institutions, employers, governments and other partners globally. We are committed to helping equip learners with the skills they need to enhance their employability prospects and to succeed in the changing world of work. We believe that wherever learning flourishes so do people.

This specification is Issue 2. We will inform centres of any changes to this issue. The latest issue can be found on our website.

References to third-party material made in this specification are made in good faith. Pearson does not endorse, approve or accept responsibility for the content of materials, which may be subject to change, or any opinions expressed therein. (Material may include textbooks, journals, magazines and other publications and websites.)

All information in this specification is correct at time of publication.

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Welcome

With a track record built over 40 years of learner success, our BTEC International Level 2 qualifications are recognised internationally by governments and employers. These qualifications are designed to enhance the curriculum and prepare learners for the ever-changing world of work. BTEC International Level 2 qualifications allow learners to progress to study at Level 3 and above or to the workplace.

Career-ready education

BTECs enable a learner-centred approach to education, with a flexible, unit-based structure and knowledge applied to project-based assessments. BTECs focus on the holistic development of the practical, interpersonal and thinking skills required to be successful in employment and higher education.

When creating the BTEC International Level 2 qualifications in this suite, we worked with many employers, colleges and schools to ensure that we met their needs.

BTEC addresses these needs by offering:

- a range of BTEC qualification sizes, each with a clear purpose, so that there is something to suit each learner's choice of study programme and progression plans
- internationally relevant content, which is closely aligned with employer and further education needs
- assessments and projects chosen to help learners progress; this means that some assessments and projects are set by you to meet local needs, while others are set by Pearson, ensuring a core of skills and understanding common to all learners.

We provide a full range of support, both resources and people, to ensure that learners and teachers have the best possible experience during their course. See *Section 10 Resources and support* for details of the support we offer.

Summary of Pearson BTEC International Level 2 Qualifications in Applied Science specification Issue 2 changes

Summary of changes made between the previous issue and this current issue	Page number
The *Structures of the qualifications at a glance* Advanced units have been removed.	Pages 4 and 5
Section 2 Structure Advanced units have been removed from the Certificate including starred information at the end of the table. Optional units have been grouped into Biology, Chemistry and Physics and information has been included to state that learners now must complete at least one unit from each of the Biology, Chemistry and Physics group of units to achieve the qualification.	Page 11 Page 12
Unit 22: Biotechnology Procedures and Applications The words 'can be' and 'to' have been removed in B.M2 criteria in the Assessment criteria grid to make the criteria clearer for learners.	Page 229

If you need further information on these changes or what they mean, contact us via our website at: qualifications.pearson.com/en/support/contact-us.html.

Contents

Introduction to the BTEC International Level 2 qualifications for the applied science sector

This specification contains all the information you need to deliver the Pearson BTEC International Level 2 Qualifications in Applied Science. We also refer you to other handbooks and policies. This specification includes all the units for these qualifications.

These qualifications are part of the suite of science qualifications offered by Pearson. In this suite, there are qualifications that focus on different progression routes, allowing learners to choose the one best suited to their aspirations. These qualifications are not regulated in England.

All qualifications in the suite share some common units and assessments, which gives learners some flexibility in moving between sizes.

In the science sector these qualifications are:

Pearson BTEC International Level 2 Award in Applied Science

Pearson BTEC International Level 2 Certificate in Applied Science

Pearson BTEC International Level 2 Extended Certificate in Applied Science

Pearson BTEC International Level 2 Diploma in Applied Science.

This specification signposts the other essential documents and support that you need as a centre in order to deliver, assess and administer the qualifications, including the staff development required. A summary of all essential documents is given in *Section 7 Administrative arrangements*. Information on how we can support you with these qualifications is given in *Section 10 Resources and support*.

The information in this specification is correct at the time of publication.

Qualifications, sizes and purposes at a glance

Title	Size and structure	Summary purpose
Pearson BTEC International Level 2 Award in Applied Science	120 GLH Equivalent in size to one International GCSE. Four units that are mandatory, and one unit is assessed by a Pearson Set Assignment. Mandatory content (25%).	This qualification is designed to support learners who want an introduction to the sector through applied learning and for whom an element of applied science would be complementary. The qualification supports progression to further study at Level 3/ pre-tertiary level, not necessarily in applied science subjects, and may be part of a programme of study that includes BTEC International Level 3 qualifications and/or International A Levels.
Pearson BTEC International Level 2 Certificate in Applied Science	240 GLH Equivalent in size to two International GCSEs. Eight units, of which five are mandatory and two units are assessed by a Pearson Set Assignment. Mandatory content (25%).	This qualification is designed to support learners who are interested in learning about the applied science industry alongside other fields of study, with a view to progressing to a wide range of courses at Level 3/pre-tertiary level, not necessarily in applied science-related subjects. The qualification is designed to be taken as part of a programme of study that includes other appropriate BTEC International Level 2 qualifications or International GCSEs.
Pearson BTEC International Level 2 Extended Certificate in Applied Science	360 GLH Equivalent in size to three International GCSEs. Twelve units, of which nine are mandatory, and three units that are assessed by a Pearson Set Assignment. Mandatory content (25%).	This qualification is designed to support learners who want to study applied science as a substantial element of a one-year, full-time course alongside smaller courses in other subjects, or for those wanting to take it alongside another area of complementary or contrasting study as part of a two-year, full-time study programme. The qualification would support progression to further education at Level 3/pre-tertiary level if taken as part of a programme of study that included other BTEC International Level 2 qualifications or International A Levels.

Title	Size and structure	Summary purpose
Pearson BTEC International Level 2 Diploma in Applied Science	480 GLH Equivalent in size to four International GCSEs. Sixteen units, of which 10 are mandatory and four units are assessed by a Pearson Set Assignment. Mandatory content (25%).	This qualification is designed to support learners who want to study applied science as a one-year, full-time course, or for those wanting to take it alongside another area of complementary or contrasting study as part of a two-year, full-time study programme. The qualification would support progression to Level 3/pre-tertiary level courses if taken as part of a programme of study that included other BTEC International Level 2 qualifications or International GCSEs.

Structures of the qualifications at a glance

This table shows all the units and the qualifications to which they contribute. The full structure for this Pearson BTEC International Level 2 in Applied Science is shown in *Section 2 Structure*. **You must refer to the full structure to select units and plan your programme.**

Key

Pearson Set Assignment units are shown in bold | **M** **Mandatory units** | **O** **Optional units**

Unit (number and title)	Unit size (GLH)	Award (120 GLH)	Certificate (240 GLH)	Extended Certificate (360 GLH)	Diploma (480 GLH)
1 Principles of Science	**30**	**M**	**M**	**M**	**M**
2 Chemistry and Our Earth	**30**	**M**	**M**	**M**	**M**
3 Energy and Our Universe	**30**	**M**	**M**	**M**	**M**
4 Biology and Our Environment	**30**	**M**	**M**	**M**	**M**
5 Applications of Chemical Substances	**30**		**O**	**M**	**M**
6 Applications of Physical Science	**30**		**O**	**M**	**M**
7 Health Applications of Life Science	**30**		**O**	**M**	**M**
8 Scientific Skills	**30**		**M**	**M**	**M**
9 Practical Scientific Project	**30**			**M**	**M**
10 World Energy	**30**		**O**	**O**	**O**
11 How Scientific Theories Are Formulated	**30**			**O**	**M**
12 The Living Body	**30**		**O**	**O**	**O**
13 Monitoring the Environment	**30**		**O**	**O**	**O**
14 Growing Plants for Food	**30**		**O**	**O**	**O**
15 Investigating a Crime Scene	**30**		**O**	**O**	**O**
16 Science in Medicine	**30**			**O**	**O**
17 Understanding Human Behaviour	**30**			**O**	**O**

continued overleaf

Unit (number and title)	Unit size (GLH)	Award (120 GLH)	Certificate (240 GLH)	Extended Certificate (360 GLH)	Diploma (480 GLH)
18 Designing and Making Useful Devices in Science	**30**		**O**	**O**	**O**
19 Chemical Analysis and Detection	**30**			**O**	**O**
20 Exploring Our Universe	**30**			**O**	**O**
21 Electronics in Action	**30**			**O**	**O**
22 Biotechnology Procedures and Applications	**30**			**O**	**O**
23 Further Chemistry	**30**			**O**	**O**
24 Further Physics	**30**			**O**	**O**

Qualification and unit content

Pearson has developed the content of the new BTEC International Level 2 qualifications in collaboration with employers and subject experts so that content is up to date and includes knowledge, understanding, skills and personal attributes required in the sector.

The mandatory content ensures that all learners are following a coherent programme of study and that they acquire knowledge, understanding and skills that will be worthwhile and fulfilling, and will also provide a basis for further study at Level 3. Learners are expected to show achievement across mandatory units as detailed in *Section 2 Structure*.

BTEC qualifications encompass applied learning that brings together knowledge and understanding with practical and technical skills. This applied learning is achieved through learners performing vocational tasks that encourage the development of appropriate vocational behaviours and transferable skills. Transferable skills include communication, teamwork, and research and analysis, which are valued by employers. Opportunities to develop these skills are signposted in the units.

Our approach provides rigour and balance, and promotes the ability to apply learning immediately in new contexts. The units include guidance on approaches to breadth and depth of coverage, which can be modified to ensure that content is current and reflects international variations.

Assessment

Assessment is designed to fit the purpose and objective of the qualification. It includes a range of assessment types and styles suited to vocational qualifications in the sector. All assessment is internal but some mandatory units are assessed using Pearson Set Assignments.

Pearson Set Assignment (PSA) units

Some units in the qualifications are assessed using a Pearson Set Assignment. Each assignment is set by Pearson and is marked by teachers.

Set assignment units are subject to external standards verification processes common to all BTEC units. By setting an assignment for some units, we can ensure that all learners take the same assessment for a specific unit. Learners are permitted to resit set assignment units during their programme. Please see *Section 6 Internal assessment* for further information.

Set assignments are available from June each year and are valid until the end of August in the following year. For detailed information on the Pearson Set Assignments, please see the table in *Section 2 Structure*. For further information on preparing for assessment, see *Section 5 Assessment structure*.

Internal assessment

All units in the sector are internally assessed and subject to external standards verification. Before you assess you will need to become an approved centre, if you are not one already. You will need to prepare to assess using the guidance in *Section 6 Internal assessment*.

For units where there is no Pearson Set Assignment, you select the most appropriate assessment styles according to the learning set out in the unit. This ensures that learners are assessed using a variety of styles to help them develop a broad range of transferable skills. Learners could be given opportunities to:

- write up the findings of their own research
- use case studies to explore complex or unfamiliar situations
- carry out projects for which they have choice over the direction and outcomes
- demonstrate practical and technical skills using appropriate tools/ processes etc.

For these units, Pearson will provide an Authorised Assignment Brief that you can use. You will make grading decisions based on the requirements and supporting guidance given in the units. Learners may not make repeated submissions of assignment evidence. For further information, please see *Section 6 Internal assessment*.

Language of assessment

Assessment of the units for these qualifications is available in English but can be translated as necessary.

Learners taking the qualification/s may be assessed in sign language where it is permitted for the purpose of reasonable adjustment. For information on reasonable adjustments, see *Section 7 Administrative arrangements*.

Grading for units and qualifications

Achievement of the qualification requires demonstration of depth of study in each unit, assured acquisition of a range of practical skills required for employment or for progression to higher education, and successful development of transferable skills. Learners who achieve a qualification will have achieved across mandatory units where applicable.

Units are assessed using a grading scale of Distinction (D), Merit (M), Pass (P) and Unclassified (U). All mandatory and optional units contribute proportionately to the overall qualification grade, for example a unit of 60 GLH will contribute double that of a 30 GLH unit.

Qualifications in the suite are graded using a scale of P to D*, **or** PP to D*D*. Please see *Section 9 Understanding the qualification grade* for more details. The relationship between qualification grading scales and unit grades will be subject to regular review as part of Pearson's standards monitoring processes, on the basis of learner performance and in consultation with key users of the qualifications.

1 Qualification purpose and progression

Pearson BTEC International Level 2 qualifications in Applied Science

Who are these qualifications for?

The Pearson BTEC International Level 2 qualifications in Applied Science are designed either for learners in the 14–19 age group who wish to pursue a career in science via Level 3 and then to higher education, or through junior science employment.

Which size qualification to choose?

Choosing the most suitable size of qualification will depend on the learner's broader programme of study. For example, a learner who wishes to focus mainly on applied science may take the Diploma, while a learner who selects a smaller qualification, such as the Award or Certificate, will likely combine it with International GCSEs, in order to support their desired progression.

Qualification structures have been designed to enable a learner who starts with the smallest qualification to progress easily to the larger qualifications.

What do these qualifications cover?

The content of these qualifications has been designed to support progression to particular roles in science, most likely via further study at Level 3 and then through higher education routes in the particular areas.

All learners will be required to take mandatory content that is directly relevant to progression routes in all of the identified areas.

In addition, learners take optional units that support the progression route identified in the qualification title.

What could these qualifications lead to?

These qualifications support progression to further study in science, for example courses in BTEC International Level 3 in Applied Science.

How do these qualifications provide transferable skills?

In the BTEC International Level 2 units, there are opportunities during the teaching and learning phase for learners to practise developing transferable skills. Where we refer to transferable skills in this specification, we are generally referring to skills in the following three main categories:

- **cognitive and problem-solving skills** – using critical thinking, approaching non-routine problems, applying expert and creative solutions, using systems and technology
- **interpersonal skills** – communicating, working collaboratively, negotiating and influencing, self-presentation
- **intrapersonal skills** – self-management, adaptability and resilience, self-monitoring and development.

There are also specific requirements in some units for assessment of these skills where relevant, for example where learners are required to undertake real or simulated activities. These skills are indicated in the units and in *Appendix 1: Transferable employability skills*.

How do the qualifications provide transferable knowledge and skills for further and higher education?

All BTEC International Level 2 qualifications provide transferable knowledge and skills that prepare learners for progression to university. The transferable skills that universities value include:

- the ability to learn independently
- the ability to research actively and methodically
- the ability to give presentations and be active group members.

BTEC learners can also benefit from opportunities for deep learning, where they are able to make connections across units and select areas of interest for detailed study.

2 Structure

Qualification structures

The structures for the qualifications in this specification are:

- Pearson BTEC International Level 2 Award in Applied Science
- Pearson BTEC International Level 2 Certificate in Applied Science
- Pearson BTEC International Level 2 Extended Certificate in Applied Science
- Pearson BTEC International Level 2 Diploma in Applied Science.

Pearson BTEC International Level 2 Award in Applied Science

Mandatory units

- There are four mandatory units, which include three internal units and one set assignment unit. Learners must complete and achieve a Pass or above in all the mandatory units.

Pearson BTEC International Level 2 Award in Applied Science				
Unit number	**Unit title**	**GLH**	**Type**	**How assessed**
Mandatory units – learners complete and achieve all units				
1	Principles of Science	**30**	**Mandatory**	Set assignment
2	Chemistry and Our Earth	**30**	**Mandatory**	Internal
3	Energy and Our Universe	**30**	**Mandatory**	Internal
4	Biology and Our Environment	**30**	**Mandatory**	Internal

Pearson BTEC International Level 2 Certificate in Applied Science

Mandatory units

There are five mandatory units, which include three internal units and two set assignment units. Learners must complete and achieve a Pass or above in all mandatory units.

Optional units

Learners must complete at least one unit from **each** of the Biology, Chemistry and Physics group of units. In total, learners must complete at least three optional units.

Pearson BTEC International Level 2 Certificate in Applied Science				
Unit number	**Unit title**	**GLH**	**Type**	**How assessed**
Mandatory units – learners complete and achieve all units				
1	Principles of Science	**30**	**Mandatory**	Set assignment
2	Chemistry and Our Earth	**30**	**Mandatory**	Internal
3	Energy and Our Universe	**30**	**Mandatory**	Internal
4	Biology and Our Environment	**30**	**Mandatory**	Internal
8	Scientific Skills	**30**	**Mandatory**	Set assignment
Optional units				
Biology group – learners must select at least one optional unit from this group				
7	Health Applications of Life Science	**30**	**Optional**	Internal
12	The Living Body	**30**	**Optional**	Internal
13	Monitoring the Environment	**30**	**Optional**	Internal
14	Growing Plants for Food	**30**	**Optional**	Internal
Chemistry group – learners must select at least one optional unit from this group				
5	Applications of Chemical Substances	**30**	**Optional**	Internal
15	Investigating a Crime Scene	**30**	**Optional**	Internal
Physics group – learners must select at least one optional unit from this group				
6	Applications of Physical Science	**30**	**Optional**	Internal
10	World Energy	**30**	**Optional**	Internal
18	Designing and Making Useful Devices in Science	**30**	**Optional**	Internal

Pearson BTEC International Level 2 Extended Certificate in Applied Science

Mandatory units

There are nine mandatory units, which include six internal units and three set assignment units. Learners must complete and achieve a Pass or above in all mandatory units.

Optional units

Learners must complete at least three optional units.

Pearson BTEC International Level 2 Extended Certificate in Applied Science				
Unit number	**Unit title**	**GLH**	**Type**	**How assessed**
Mandatory units – learners complete and achieve all units				
1	Principles of Science	**30**	**Mandatory**	Set assignment
2	Chemistry and Our Earth	**30**	**Mandatory**	Internal
3	Energy and Our Universe	**30**	**Mandatory**	Internal
4	Biology and Our Environment	**30**	**Mandatory**	Internal
5	Applications of Chemical Substances	**30**	**Mandatory**	Internal
6	Applications of Physical Science	**30**	**Mandatory**	Internal
7	Health Applications of Life Science	**30**	**Mandatory**	Internal
8	Scientific Skills	**30**	**Mandatory**	Set assignment
9	Practical Scientific Project	**30**	**Mandatory**	Set assignment
Optional units – learners must complete three optional units				
10	World Energy	**30**	**Optional**	Internal
11	How Scientific Theories Are Formulated	**30**	**Optional**	Set assignment
12	The Living Body	**30**	**Optional**	Internal
13	Monitoring the Environment	**30**	**Optional**	Internal
14	Growing Plants for Food	**30**	**Optional**	Internal
15	Investigating a Crime Scene	**30**	**Optional**	Internal
16	Science in Medicine	**30**	**Optional**	Internal
17	Understanding Human Behaviour	**30**	**Optional**	Internal

Optional units – learners must complete three optional units *continued*				
18	Designing and Making Useful Devices in Science	**30**	**Optional**	Internal
19	Chemical Analysis and Detection	**30**	**Optional**	Internal
20	Exploring Our Universe	**30**	**Optional**	Internal
21	Electronics in Action	**30**	**Optional**	Internal
22	Biotechnology Procedures and Applications	**30**	**Optional**	Internal
23	Further Chemistry	**30**	**Optional**	Internal
24	Further Physics	**30**	**Optional**	Internal

Pearson BTEC International Level 2 Diploma in Applied Science

Mandatory units

There are 10 mandatory units, which include six internal units and four set assignment units. Learners must complete and achieve a Pass or above in all mandatory units.

Optional units

Learners must complete at least six optional units.

Pearson BTEC International Level 2 Diploma in Applied Science				
Unit number	**Unit title**	**GLH**	**Type**	**How assessed**
Mandatory units – learners complete and achieve all units				
1	Principles of Science	**30**	**Mandatory**	Set assignment
2	Chemistry and Our Earth	**30**	**Mandatory**	Internal
3	Energy and Our Universe	**30**	**Mandatory**	Internal
4	Biology and Our Environment	**30**	**Mandatory**	Internal
5	Applications of Chemical Substances	**30**	**Mandatory**	Internal
6	Applications of Physical Science	**30**	**Mandatory**	Internal
7	Health Applications of Life Science	**30**	**Mandatory**	Internal
8	Scientific Skills	**30**	**Mandatory**	Set assignment
9	Practical Scientific Project	**30**	**Mandatory**	Set assignment
11	How Scientifics Theories are Formulated	**30**	**Mandatory**	Set assignment
Optional units – learners must complete six optional units				
10	World Energy	**30**	**Optional**	Internal
12	The Living Body	**30**	**Optional**	Internal
13	Monitoring the Environment	**30**	**Optional**	Internal
14	Growing Plants for Food	**30**	**Optional**	Internal
15	Investigating a Crime Scene	**30**	**Optional**	Internal
16	Science in Medicine	**30**	**Optional**	Internal
17	Understanding Human Behaviour	**30**	**Optional**	Internal

Optional units – learners must complete six optional units *continued*				
18	Designing and Making Useful Devices in Science	**30**	**Optional**	Internal
19	Chemical Analysis and Detection	**30**	**Optional**	Internal
20	Exploring Our Universe	**30**	**Optional**	Internal
21	Electronics in Action	**30**	**Optional**	Internal
22	Biotechnology Procedures and Applications	**30**	**Optional**	Internal
23	Further Chemistry	**30**	**Optional**	Internal
24	Further Physics	**30**	**Optional**	Internal

Set assignment units

This is a summary of the type and availability of set assignment units. For more information, see *Section 5 Assessment structure*, and the units and sample assessment materials.

Unit	Type	Availability
Unit 1: Principles of Science	· An assignment set by Pearson and marked by the centre. · The advised assessment period is 15 hours.	**Two available for each series.**
Unit 8: Scientific Skills	· An assignment set by Pearson and marked by the centre. · The advised assessment period is 15 hours.	**Two available for each series.**
Unit 9: Practical Scientific Project	· An assignment set by Pearson and marked by the centre. · The advised assessment period is 22 hours.	**Two available for each series.**
Unit 11: How Scientific Theories Are Formulated	· An assignment set by Pearson and marked by the centre. · The advised assessment period is 16 hours.	**Two available for each series.**

Employer involvement in assessment and delivery

You are encouraged to give learners opportunities to be involved with employers. For more information, please see *Section 4 Planning your programme*.

3 Units

Understanding your units

The units in this specification set out our expectations of assessment in a way that helps you to prepare your learners for assessment. The units help you to undertake assessment and quality assurance effectively.

Each unit in the specification is set out in a similar way. This section explains how the units work. It is important that all teachers, assessors, internal verifiers and other staff responsible for the programme review this section.

Section	Explanation
Unit number	The number is in a sequence in the sector. Numbers may not be sequential for an individual qualification.
Unit title	This is the formal title that we always use, it appears on certificates.
Level	All units are at Level 2.
Unit type	This shows if the unit is internal or assessed using a Pearson Set Assignment. See structure information in *Section 2 Structure* for details.
Guided Learning Hours (GLH)	Units have a GLH value of 30. This indicates the number of hours of teaching, directed activity and assessment expected. It also shows the weighting of the unit in the final qualification grade.
Unit in brief	This is a brief formal statement on the content of the unit that is helpful in understanding its role in the qualification. You can use this in summary documents, brochures, etc.
Unit introduction	This is written with learners in mind. It indicates why the unit is important, how learning is structured and how it might be applied when they progress to employment or higher education.
Assessment	For internal set assignment units, this section states whether set assignments are required to be completed.
Learning aims	These help to define the scope, style and depth of learning of the unit. You can see where learners should be learning standard requirements ('understand') or where they should be actively researching ('investigate'). You can find out more about the verbs we use in learning aims in *Appendix 2: Glossary of terms used*.
Summary of unit	This section helps teachers to see at a glance the main content areas given against the learning aims and the structure of the assessment. The content areas and structure of assessment must be covered. The forms of evidence given are suitable to fulfil the requirement.

Section	Explanation
Content	This section sets out the required teaching content of the unit. Content is compulsory except when shown as 'e.g.'. Learners should be asked to complete summative assessment only after the teaching content for the unit or learning aim(s) has been covered.
Assessment criteria	Each learning aim has Pass and Merit criteria. Each assignment has at least one Distinction criterion. A full glossary of terms used is given in *Appendix 2: Glossary of terms used.* All assessors need to understand our expectations of the terms used. Distinction criteria represent outstanding performance in the unit. Some criteria require learners to draw together learning from across the learning aims.
Essential information for assignments	This shows the maximum number of assignments that may be used for the unit to allow for effective summative assessment and how the assessment criteria should be used to assess performance.
Further information for teachers and assessors	This section gives you information to support the implementation of assessment. It is important that this is read carefully alongside the assessment criteria, as the information will help with interpretation of the requirements.
Resource requirements	Any specific resources that you need to be able to teach and assess are listed in this section. For information on support resources, see *Section 10 Resources and support*.
Essential information for assessment decisions	This section gives guidance on and examples for each learning aim or assignment the expectations for Pass, Merit and Distinction standard.
Assessment controls	This section gives details of the rules that learners need to abide by when taking the assessment.
Links to other units and other curriculum subjects	This section shows you the main relationships between different units and any clear links to other curriculum subjects. This helps you to structure your programme and make best use of available materials and resources.
Employer involvement	This section gives you information on the units, which can be used to involve learners with employers. This will help you to identify the kind of involvement that is likely to be most successful.
Opportunities to develop transferable employability skills	This section gives you guidance on how transferable employability skills might be developed in teaching and assessment of the unit.

Index of units

This section contains all the units developed for these qualifications. Please refer to *pages 4–5* to check which units are available in all qualifications in the applied science sector.

Unit 1: Principles of Science

Level: **2**
Unit type: **Pearson Set Assignment**
Guided learning hours: **30**

Unit in brief

This is a mandatory unit that provides the foundation for all the other units in the programme. It introduces cell biology, genetics, homeostasis and nervous and endocrine control, atomic structure, the periodic table and chemical reactions, energy and electromagnetic waves.

Unit introduction

It is important that science technicians and scientists are able to use fundamental core concepts to work efficiently and effectively in science organisations and other organisations that use science.

It is essential, for example, that biologists working in health-related science organisations have knowledge of cell structures and their function, tissues and organ systems, and the roles of the nervous and endocrine systems. Biologists working in horticulture will need knowledge of plant cells, and those working in forensic science will require knowledge of DNA.

In the chemical industry, science employees need to have knowledge of atomic structure, elements in the periodic table and chemical compounds, and need to be able to use and apply this knowledge to chemical reactions involved in the manufacture of useful products. Knowledge of acids, alkalis and pH is essential for people working in soil science, environmental science and cosmetic science.

Science employees working in organisations involving energy will need knowledge of the different forms of energy, energy stores, energy transformations and alternative energy sources. Physicists working for a country's national electricity grid will need knowledge of energy transfers, energy transfer measurement and energy efficiency. Scientists working in hospital scanning departments will need knowledge of the dangers and uses of X-rays and other features of the electromagnetic spectrum.

The aim of this unit is to study fundamental core science concepts in biology, chemistry and physics. A strong grasp of these concepts will enable learners to use and apply this knowledge and understanding in vocational contexts when studying other units within this specification.

Assessment

This unit has a set assignment. Learners must complete a Pearson Set Assignment Brief.

Learning aims

In this unit you will:

A Understand eukaryotic cells, inheritance and the control of homeostasis

B Understand atomic structure, the periodic table and chemical reactions

C Understand energy and electromagnetic waves.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand eukaryotic cells, inheritance and the control of homeostasis	**A1** Cells and organs **A2** Inheritance **A3** Homeostasis, control and communication	This unit is assessed through a Pearson Set Assignment.
B Understand atomic structure, the periodic table and chemical reactions	**B1** Atomic structure **B2** Periodic table **B3** Chemical reactions	
C Understand energy and electromagnetic waves	**C1** Energy and energy stores **C2** Energy transfers and transformations **C3** Waves and the electromagnetic spectrum	

Content

Learning aim A: Understand eukaryotic cells, inheritance and the control of homeostasis

A1 Cells and organs

- Structure, function and adaptations of eukaryotic cells:
  - motor and sensory neurones
  - red blood cells
  - white blood cells
  - egg cells and sperm cells
  - palisade cells
  - root hair cells
  - xylem and phloem cells
  - guard cells.
- Functions of cell organelles:
  - nucleus
  - cytoplasm
  - cell membrane
  - mitochondria
  - chloroplasts
  - plant cell wall
  - vacuole.

A2 Inheritance

- DNA:
  - structure (double helix, complementary base pairs)
  - genes
  - mutations that are beneficial and harmful
  - chromosomes.
- Dominant and recessive alleles:
  - heterozygous and homozygous genotypes
  - phenotypes.
- Monohybrid inheritance:
  - Punnett squares
  - genetic diagrams
  - ratios of offspring
  - pedigree analysis, e.g. sickle cell disease, Huntingdon's disease.

A3 Homeostasis, control and communication

- Structure of the nervous system:
  - central nervous system involving the brain and spinal cord
  - peripheral nervous system involving sensory and motor neurons.
- Nerve impulses:
  - synapses and chemical transmission
  - spinal reflex arc, e.g. knee jerk
  - involuntary and voluntary responses
  - receptors and effectors.

- Hormones, glands, transport in circulation, target organs.
- Comparison of nervous and endocrine control, e.g. speed, route, duration of response.
- Homeostasis:
  - internal environment
  - negative feedback
  - nervous control of body temperature
  - endocrine control of blood glucose concentration.

Learning aim B: Understand atomic structure, the periodic table and chemical reactions

B1 Atomic structure

- Atomic structure, atomic number, mass number, isotopes, relative atomic mass.
- Subatomic particles, relative size, charge.

B2 Periodic table

- Arrangement by atomic number by groups and periods.
- Nuclear symbols and electronic configuration of first 20 elements (rules and energy levels (electron shells)).
- Positions of metals and non-metals.

B3 Chemical reactions

- Chemical reactions:
  - products differ from reactants
  - elements, compounds, mixtures, molecules.
- Chemical equations:
  - formulae
  - word equations and balanced equations.
- Acids, bases, alkalis, pH scale, universal indicator and litmus.
- Neutralisation:
  - salts
  - reactions of acids and bases, e.g. hydrochloric acid, nitric acid and sulfuric acid with a metal oxide, sodium hydroxide, sodium carbonate, copper carbonate and calcium carbonate, reactions of hydrochloric acid and sulfuric acid with metals.
- Chemical tests for hydrogen and carbon dioxide.
- Applications of neutralisation reactions, e.g. alkalosis, acidosis, indigestion, swimming pools, soils, aquaria, lakes.
- Hazards and hazard symbols of chemicals used in this learning aim.

Learning aim C: Understand energy and electromagnetic waves

C1 Energy and energy stores

- Forms of energy including examples of:
  - thermal
  - electrical
  - light
  - sound
  - mechanical (kinetic and potential)
  - nuclear.
- Energy stores:
  - chemical
  - kinetic (in a moving object)
  - gravitational potential
  - elastic potential (stretched or compressed spring)
  - thermal (warm object)
  - nuclear.
- Sources of energy:
  - Renewable, e.g. solar, wind, biofuels, hydroelectric, wave, tidal, geothermal
  - non-renewable, e.g. fossil fuels, nuclear.

C2 Energy transfers and transformations

- Energy transfers:
  - mechanical (force moves through a distance)
  - electrical (electrical devices)
  - conduction (temperature differences)
  - convection (currents in a fluid)
  - radiation, e.g. infrared.
- Measurements:
  - energy – joule (J)
  - power – watt (W)
  - power calculations using:

$$\text{power (watts)} = \frac{\text{energy (joules)}}{\text{time (secs)}}$$

- Sankey diagrams to represent energy transformations.
- Efficiency:
  - energy transfers and transformations in real-life situations, e.g. domestic appliances, vehicles, industrial applications
  - conservation of energy
  - proportion of energy transferred to useful form
  - efficiency calculations:

$$\text{efficiency} = \frac{\text{useful energy}}{\text{total energy supplied}} \times 100\%$$

C3 Waves and the electromagnetic spectrum

- Wave characteristics and units:
  - amplitude
  - frequency
  - wavelength
  - wave speed
  - calculations.
- Electromagnetic (e.m.) spectrum:
  - radio waves, e.g. broadcasting and satellite transmissions
  - microwaves, e.g. cooking, satellite transmissions, communications, weather forecasting
  - infrared, e.g. cooking, thermal imaging, optical fibres, remote controls, security systems
  - visible light, e.g. vision, photography, illumination
  - ultraviolet, e.g. fluorescent lamps, detecting forged banknotes, disinfecting water
  - X-rays, e.g. observing the internal structure of objects, medical X-rays
  - gamma rays, e.g. sterilising food and medical equipment, detection and treatment of cancer.
- Harmful effects of excessive exposure to e.m. radiation:
  - microwaves cause internal heating of body cells
  - infrared causes skin burns
  - ultraviolet damages surface cells and eyes, leading to skin cancer and eye conditions
  - X-rays and gamma rays cause mutation or damage to cells in the body.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Understand eukaryotic cells, inheritance and the control of homeostasis		
A.P1 Describe the structure and functions of eukaryotic cells. **A.P2** Describe the structure of DNA and the function of genes. **A.P3** Describe the structure of the nervous system.	**A.M1** Relate the structure of specialist cells to their functions. **A.M2** Explain the outcomes of monohybrid genetic crosses. **A.M3** Explain the function of the nervous and endocrine systems.	**A.D1** Use examples to analyse the way in which the body maintains a constant internal environment.
Learning aim B: Understand atomic structure, the periodic table and chemical reactions		
B.P4 Describe atomic structure. **B.P5** Describe features of the periodic table. **B.P6** Describe chemical reactions.	**B.M4** Explain the organisation of elements in the periodic table. **B.M5** Correctly use balanced equations to explain the outcomes of chemical reactions.	**B.D2** Evaluate applications of neutralisation reactions.
Learning aim C: Understand energy and electromagnetic waves		
C.P7 Describe forms and sources of energy. **C.P8** Describe examples of the transfer of energy. **C.P9** Describe features of waves.	**C.M6** Calculate the efficiency of energy transformations. **C.M7** Explain the benefits and disadvantages of using electromagnetic radiation.	**C.D3** Explain how energy losses due to energy transformations in the home or workplace can be minimised.

Essential information for assignments

This unit is assessed using a Pearson Set Assignment Brief.

Further information for teachers and assessors

Resource requirements

For this unit, learners must have access to a laboratory to enable them to study the topics in this unit through practical work. This should include, as a minimum, microscopy, chemistry (to study the reactions listed in the unit content) and physics (energy transfers, transformations and stores).

Essential information for assessment decisions

Learning aim A

For Distinction standard, learners must be able to use the examples of the regulation of body temperature and blood glucose levels to analyse methodically and in detail how the nervous system and hormones maintain homeostasis in a healthy individual.

For Merit standard, learners could use illustrations to explain how the structure of the specialised cells listed in the unit content enables them to carry out their functions. This must include describing the roles of the organelles in those functions.

Learners must be able to use Punnett squares and genetic diagrams to explain monohybrid crosses and to predict the ratios of genotypes and phenotypes in offspring. They must be able to use pedigree analysis to predict whether or not individuals will have an inherited disease or characteristics or be carriers.

Learners must be able to explain that the peripheral nervous system sends messages in the form of electrical impulses to and from the central nervous system. They must be able to provide an illustrated explanation of a spinal reflex arc, including identifying sensory and motor neurones (and the direction in which they carry messages), receptors and effectors, and the synapses in the spinal cord. They must be able to describe how chemicals carry messages across synapses.

Learners must be able to use examples to explain how endocrine glands release hormones that are carried in the circulation to target organs. They must be able to compare the timescale of a response controlled by the nervous system with one controlled by hormones.

For Pass standard, learners will produce illustrated descriptions of at least two animal and two plant cells and their organelles and functions. They will describe the structure of DNA and that genes give instructions for individual characteristics and can be dominant or recessive; alleles are different forms of the same gene that give rise to heterozygous and homozygous genotypes.

Learners will use illustrations to describe the structure of the central nervous system and the peripheral nervous system.

Learning aim B

For Distinction standard, learners must judge the reliability and usefulness of methods to correct pH imbalances in specific situations. They must explain the advantages and disadvantages of different approaches, considering safety as well as effectiveness. They must provide balanced chemical equations for each of the methods that they consider.

For Merit standard, learners must be able to use the rules for filling electron shells to determine the electronic configuration of given elements in the range 1 to 20 and to explain the positions in the periodic table of these elements. They must be able to describe isotopes and explain why the relative atomic mass (RAM) of an element is often not a whole number. They must be able to calculate RAM.

Learners must be able to produce balanced equations for selected reactions in the unit content and be able to describe how they would test for carbon dioxide and hydrogen. Learners must be able to define acids, bases and alkalis, and be able to use pH and the colour of litmus and universal indicator to identify a substance or solution as acid, base or alkali.

For Pass standard, learners must be able to use diagrams to illustrate and describe the structure of atoms, including isotopes. They will be able to describe features of the periodic table (including the features of groups and periods and identify the positions of elements, metals and non-metals).

Learners will be able to describe what happens when two substances react together and they must be able to use word equations to describe the reaction.

Learning aim C

For Distinction standard, learners must explain how to improve the efficiency of energy use in real-life situations. This must include a correct quantitative analysis of the input of energy and the losses, including the nature of those losses, and the amount of useful energy available. Learners must provide quantitative explanations of how the losses can be reduced (e.g. insulation, replacing filament bulbs with LEDs), providing accurate Sankey diagrams.

For Merit standard, learners must explain the transformation of energy in real-life situations and calculate the efficiency of these transformations correctly. They must use Sankey diagrams correctly in their explanations.

Learners must explain the uses of different forms of electromagnetic radiation, including the benefits, potential harm and other drawbacks, and how the harmful effects can be controlled.

For Pass standard, learners must use examples to describe forms of energy, methods for storing energy, renewable and non-renewable sources of energy, explaining what is meant by these terms.

Learners must use energy transfer diagrams to illustrate and describe the transfer of energy in domestic, industrial or other real-life situations.

Learners must be able to interpret wave diagrams correctly to identify the characteristics of transverse waves and perform calculations correctly using wave speed = wavelength × frequency. They must be able to describe the electromagnetic spectrum, including identifying uses for rays from each region.

Assessment controls

Time: this assignment has a recommended time period. This is for advice only and can be adjusted depending on the needs of learners.

Supervision: you should be confident of the authenticity of learner's work. This may mean that learners be supervised.

Resources: all learners should have access to the same types of resources to complete the assignment.

Research: learners should be given the opportunity to carry out research outside of the learning context if required for the assignment.

Links to other units and other curriculum subjects

This unit is likely to be one of the first to be taken. It links to all other units in the programme.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers
- examples of real data/results from science-based industry/healthcare (with identifying features removed)
- visits to appropriate organisations.

Opportunities to develop transferable skills

In completing this unit, learners will have the opportunity to develop:

- self-management and planning skills
- observation skills
- written communication skills
- numeracy skills
- skills in biological drawing
- the ability to interpret data
- the ability to carry out independent research.

Unit 2: Chemistry and Our Earth

Level: **2**
Unit type: **Internal**
Guided learning hours: **30**

Unit in brief

This unit builds on chemistry concepts introduced in *Unit 1: Principles of Science*. It provides knowledge and understanding of the physical and chemical properties of naturally occurring substances and those that are used in a wide range of industrial processes.

Unit introduction

A knowledge and understanding of the properties of chemical substances is vital for making certain scientific decisions. For example, this knowledge and understanding would be applied when deciding which starting materials to use when carrying out chemical reactions to manufacture products such as pharmaceuticals, computer-chip technology materials and food products.

Learners will cover the properties of elements from groups 1 and 7 in the periodic table, where some elements, like sodium, are very reactive metals, while others, like chlorine, are very reactive non-metals. Other elements, like helium, are very unreactive – helium's properties make it suitable for use in balloons and in the gas mixture for diving tanks. This is extended further as learners study the structure of elements, and how they bond together to form molecules, which are covalently or ionically bonded.

Learners will also look at how the physical and chemical properties of chemical substances are influenced by their structure and bonding. Industrial processes need to take into account the rate at which a chemical reaction takes place. Reactions have to be slow enough to be safe but fast enough to allow the chemicals to be made profitably. Learners will study the factors that affect the rates of chemical reactions and the reaction conditions that optimise their effectiveness in industry.

Learners will also study how the Earth's natural activities, and the use of naturally occurring materials as starting materials in industrial processes, have an impact on the Earth and the environment. This is extended to studying sustainable development issues with regard to human activities, and possible solutions to reduce the amount of fossil fuels used in domestic and industrial situations.

The aim of this unit is to use and develop the knowledge that learners have gained in *Unit 1: Principles of Science* using locally relevant industrial and related contexts. These contexts might include the role of environmental science in best industrial practice and maximising the yield of industrial reactions.

Learning aims

In this unit you will:

A Investigate chemical reactivity and bonding

B Investigate how the uses of chemical substances depend on their chemical and physical properties

C Investigate the factors involved in the rate of chemical reactions

D Understand the factors that are affecting the Earth and its environment.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Investigate chemical reactivity and bonding	**A1** Chemical and physical properties of groups 1 and 7 of the periodic table **A2** Bonding and structure	A written practical report showing the characteristic features of group 1 and group 7 elements. The trends within these groups with an explanation in terms of electronic structure. Scientific diagrams and tables on ionic and covalent substances. A table comparing at least four properties of each. Dot-and-cross diagrams of the substances listed to explain how the bonds are formed. An explanation of properties in terms of the bonding and structure, with examples of substances to explain how the application of these substances relies on their specific properties.
B Investigate how the uses of chemical substances depend on their chemical and physical properties	**B1** Use of chemicals based on their physical properties **B2** Use of chemicals based on their chemical properties	An information document on the properties of four useful chemical products and how these properties relate to the application of these products.
C Investigate the factors involved in the rate of chemical reactions	**C1** Equations **C2** Reaction rates **C3** Industrial processes	A practical scientific report showing evidence from experiments and collated data on chemical reactions in order to explain all the factors that make the reaction go faster, maximise yield and optimise atom economy.
D Understand the factors that are affecting the Earth and its environment	**D1** Natural activity factors **D2** Human activity factors **D3** Sustainable development issues	A scientific article to present a balanced view of the likely environmental impact of your company and how this may be minimised. Explain the environmental impact of natural events.

Content

Learning aim A: Investigate chemical reactivity and bonding

A1 Chemical and physical properties of groups 1 and 7 of the periodic table

- Trends in physical properties of groups 1 and 7:
  - appearance
  - melting point/boiling point
  - electrical conductivity.
- Reactivity:
  - reactivity with water for group 1
  - displacement reactions for group 7.
- Trends in chemical properties in group 1 and group 7:
  - relationship with electronic configuration.

A2 Bonding and structure

- Formulae of (substances) molecules:
  - covalent
  - ionic.
- Covalent bonding:
  - hydrogen, chlorine, carbon dioxide, methane, water, oxygen
  - ionic bonding
  - sodium chloride, magnesium oxide, magnesium chloride.
- Properties of simple molecular, giant covalent and ionic substances.

Learning aim B: Investigate how the uses of chemical substances depend on their chemical and physical properties

B1 Use of chemicals based on their physical properties

- Physical properties:
  - electrical conductivity
  - thermal conductivity
  - melting and boiling points
  - solubility in different solvents
  - viscosity.

B2 Use of chemicals based on their chemical properties

- Chemical properties
  - sodium azide in airbags
  - argon in welding
  - silicon in computer-chip technology
  - carbon dioxide in fire extinguishers.

Learning aim C: Investigate the factors involved in the rate of chemical reactions

C1 Equations

- Word equations.
- Simple balanced chemical equations (including state symbols: (s), (l), (g), (aq)).
- Recognise reactants and products in a reaction:
  - displacement
  - combustion
  - neutralisation.

C2 Reaction rates

- Effect of catalysts (lowering the (activation) energy needed for a reaction to occur).
- Effect of other factors on rate of reaction:
  - surface area
  - concentration
  - temperature.
- Use of reaction rate graphs.
- Collision theory.

C3 Industrial processes

- The concept of yield:
  - theoretical yield
  - mass of product obtained – actual yield (and concept that this is less than the theoretical yield).
- Altering rates of reaction.
- Atom economy.

Learning aim D: Understand the factors that are affecting the Earth and its environment

D1 Natural activity factors

- Influence of tectonic plates and volcanic eruptions on:
  - the Earth's crust
  - the evolution of the atmosphere and oceans.

D2 Human activity factors

- Obtaining materials from the sea, land and air, e.g.:
  - coal, natural gas, oil, metal ores, salt, nitrogen, oxygen.
- Production of useful materials from their natural sources.
- Effects on the environment:
  - local
  - global.
- Effects of chemical processing:
  - energy factors
  - health and safety
  - disposal.

D3 Sustainable development issues

- Human choices:
  - recycling
  - use of fossil fuels versus nuclear fission fuels.
- Human solutions:
  - renewable energy
  - biofuels (ethanol)
  - nuclear fusion.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Investigate chemical reactivity and bonding		
A.P1 Describe the physical and chemical properties of group 1 and group 7 elements. **A.P2** Compare properties of ionic and covalent substances. **A.P3** Draw dot-and-cross diagrams of simple ionic and covalent substances.	**A.M1** Describe trends in the physical and chemical properties of group 1 and group 7 elements. **A.M2** Explain the properties of ionic and covalent substances. **A.M3** Describe the formation of ionic and covalent substances.	**A.D1** Explain the trends in chemical properties of group 1 and group 7 elements in terms of electronic structure.
Learning aim B: Investigate how uses of chemical substances depend on their chemical and physical properties		
B.P4 Describe how chemical substances are used based on their physical properties. **B.P5** Describe how chemical substances are used based on their chemical properties.	**B.M4** Explain how physical and chemical properties of chemical substances make them suitable for their uses.	**B.D2** Relate applications of compounds to their properties and to their bonding and structure. **B.D3** Assess the suitability of different types of substance for a specified use.
Learning aim C: Investigate the factors involved in the rate of chemical reactions		
C.P6 Describe the factors that can affect the rates of chemical reactions. **C.P7** Identify the number and types of atoms in balanced chemical equations.	**C.M5** Explain how different factors affect the rate of industrial reactions **C.M6** Explain the terms 'yield' and 'atom economy' in relation to specific chemical reactions.	**C.D4** Analyse how different factors affect the rate and yield of an industrial reaction.

Pass	Merit	Distinction
Learning aim D: Understand the factors that are affecting the Earth and its environment		
D.P8 Describe the human activities that affect the Earth and its environment. **D.P9** Describe natural factors that have changed the surface and atmosphere of the Earth.	**D.M7** Discuss the extent to which human activity has changed the environment, in comparison to natural activity.	**D.D5** Evaluate possible solutions to changes in the environment, occurring from natural or human activity.

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is also further information on our website.

There is a maximum number of four summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.P2, A.P3, A.M1, A.M2, A.M3, A.D1)

Learning aim: B (B.P4, B.P5, B.M4, B.D2, B.D3)

Learning aim: C (C.P6, C.P7, C.M5, C.M6, C.D4)

Learning aim: D (D.P8, D.P9, D.M7, D.D5)

Further information for teachers and assessors

Resource requirements

There are no special resources needed for this unit.

Essential information for assessment decisions

Learning aim A

For Distinction standard, learners should explain the trend in chemical properties that they have described at Merit standard using their understanding of electronic structure. They must give three examples of substances (one giant ionic, one giant covalent and one simple molecular) and relate their properties to their bonding and structure. Learners could give examples of the applications of these substances that demonstrate a reliance on these properties.

For Merit standard, learners must describe one physical trend and one chemical trend for each group. For example, learners could describe the change in boiling point and displacement reactions for group 7 elements, and the change in melting point and chemical reactivity of group 1 elements with water. They must explain the properties identified at Pass standard in terms of the bonding and structure of ionic and covalent substances. Learners could use their dot-and-cross diagrams to describe how ions, molecules and chemical bonds are formed.

For Pass standard, learners must classify elements as being group 1 and group 7 of the periodic table and describe the physical and chemical properties of the groups 1 and 7 elements, making comparisons of ionic and covalent substances. They must draw dot-and-cross diagrams for all substances listed in A.2 of the unit content for Learning aim A as a minimum and classify substances as being covalent or ionic.

Learning aim B

For Distinction standard, learners can be given a range of chemical substances and must assess them for a specified use. They could pick the most appropriate chemical substance for several specified uses. They must explain why the chemical substances are most appropriate for the specified use, in terms of physical and chemical properties. They must look at each property in turn and explain why the property makes it appropriate or inappropriate for the specified use. Learners must then explain why the overall properties make it the most appropriate chemical substance.

For Merit standard, learners could investigate, for example, the physical and chemical properties of substances related to an industry (e.g. cement or plaster in construction) or a use (e.g. mobile phones). Learners could carry out simple comparisons of data for thermal or electrical conductivity, melting point or boiling point and solubilities. They could identify trends in the data and make predictions for chemicals with similar physical properties. Learners could also be given the boiling points of different chemicals and predict their state at room temperature and when under pressure, e.g. the separate fractions obtained from the fractional distillation of crude oil. At least three chemical substances must be studied.

For Pass standard, learners must link the use of chemical substances to their physical properties and must describe at least two examples. They must list some common useful chemical products. They may produce a leaflet or poster to do this but they must identify the properties that make these products useful and must link the use of these chemical substances to their chemical properties. They must describe at least two examples.

Learning aim C

For Distinction standard, learners should include an analysis of how different factors affect the rate and yield of an industrial reaction. This should include information on the operating conditions used in industry for the reaction.

For Merit standard, learners should explain how changing the rates of reactions affects certain industrial processes. They must explain the terms 'atom economy' and 'yield' in relation to at least one of the three equations looked at for Pass standard.

For Pass standard, learners must describe the effect of various factors on rate of reaction. They must cover the effects of concentration, surface area, temperature and presence of a catalyst on the rates of chemical reactions, and show that, for example, increasing temperature increases the rate of reaction. Learners can be given at least three balanced chemical equations for which they must identify the reactants and the products in each, to include their symbols, state and whether the reaction is reversible. They must identify the number and types of atom in these equations.

Learning aim D

For Distinction standard, learners should explain how the effects of at least two environmentally damaging natural or human activities may be reduced by evaluating possible solutions. This may be in relation to the activities and/or the factors described for Pass and Merit standard.

For Merit standard, learners must discuss how humans may exercise choices that could limit or worsen the effects of the environmental damage they cause. This could be in relation to the two activities described for Pass standard. Learners must also discuss how natural factors have changed the atmosphere and surface of the Earth. This could be limited to a specific volcanic eruption or a clash of tectonic plates. Learners must consider the effects of several events, like those for Pass standard, which have happened over millions of years.

For Pass standard, learners must describe at least two human activities that have environmental consequences, as outlined in the content. They must describe at least two natural factors, for example volcanic eruption or movement of tectonic plates.

Links to other units and other curriculum subjects

This unit links to:

- Unit 1: Principles of Science
- Unit 5: Applications of Chemical Substances
- Unit 19: Chemical Analysis and Detection
- Unit 23: Further Chemistry.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers and interview opportunities
- work experience
- business material as exemplars
- visits to appropriate business organisations.

Opportunities to develop transferable skills

In completing this unit, learners will have the opportunity to further develop knowledge and understanding of chemistry principles.

Unit 3: Energy and Our Universe

Level: **2**
Unit type: **Internal**
Guided learning hours: **30**

Unit in brief

This unit covers ionising radiation, how energy is produced and transferred through to a country's system operator of electricity and gas supply and the Solar System.

Unit Introduction

Nuclear scientists are currently investigating the use of nuclear fusion to gain a source of energy that is safe and does not have the radioactivity issues associated with nuclear fission. Meanwhile, medical physicists are researching ways of improving the use of medical imaging and methods to fight cancer.

In this unit, learners will explore ionising radiations, their uses and sources, including alpha, beta, gamma and X-rays. Learners will also investigate radioactive decay, half-life, nuclear fission and fusion, and issues associated with nuclear energy.

Most electrical devices (televisions, computers, washing machines, etc.) need electrical energy that is transmitted from power stations to homes and businesses to operate. Learners will be introduced to the basics of electrical circuits, power supplies and the transmission of electrical energy. Learners will also investigate how this important form of energy is brought to homes.

Our Universe is a fascinating place, which is evolving over time. Learners will look at the composition of the Solar System, methods of exploring it and the evidence for a constantly changing and expanding Universe.

The aim of this unit is to enable learners to develop knowledge and skills related to important fundamental physical concepts. Where possible, this should be done in locally relevant industrial and related contexts such as energy supply and safe working with nuclear materials. With an emphasis on experimental investigations, and to some extent computer simulations, learners will also explore some aspects of the physics of our world and beyond.

Learning aims

In this unit you will:

A Understand ionising radiation, its uses and sources

B Know how electrical energy produced from different sources can be transferred through a country's system operator of electricity and gas supply to homes and industry

C Know the components of the Solar System, the way the Universe is changing and the methods we use to explore space.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand ionising radiation, its uses and sources	**A1** Structure of nuclei and ionising radiation **A2** Types of ionising radiation **A3** Nuclear fission and fusion	Describing and explaining radioactivity, half-life and radioactive decay, including worked examples of how to calculate the half-life of radioactive isotopes. Describing, comparing and justifying the use of radioactive isotopes in the home and workplace. Describing fission and fusion and how they can be controlled. A case study of a nuclear accident, describing and evaluating the impact it has had on the environment.
B Know how electrical energy produced from different sources can be transferred through a country's system operator of electricity and gas supply to homes and industry	**B1** Producing AC and DC electricity **B2** Power supplies **B3** Transmitting electricity to homes and industry	A signed observation sheet from the teacher (circuit building) and a table of results showing your predictions using $V = IR$. A poster describing transmission of electricity in a country's system operator of electricity and gas supply and assessing qualitative ways to minimise energy losses in the process. An information leaflet quantitatively assessing energy losses in the grid and when transforming electrical energy into other forms of energy in the home.

Learning aim	Key content areas	Assessment approach
C Know the components of the Solar System, the way the Universe is changing and the methods we use to explore space	**C1** The Solar System and its formation **C2** Observing the Universe **C3** The changing Universe	Posters, 3D display or PowerPoint® presentation with notes/information leaflet or video blog to describe the Universe and our Solar System and how they were formed during the Big Bang. Information leaflet or poster identifying and describing the suitability of different methods of observing the Universe and how the information collected can provide evidence of the dynamic nature of the Solar System and Universe. Verbal or written evaluation of the evidence supporting the Big Bang theory. (If the evidence is verbal and has not been recorded, an observation sheet/witness statement will need to be provided.)

Content

Learning aim A: Understand ionising radiation, its uses and sources

A1 Structure of nuclei and ionising radiation

- Key terms 'atomic (proton) number' and 'mass (nucleon) number', and using symbols in the correct format.
- An alpha particle is equivalent to a helium nucleus, a beta particle is an electron emitted from the nucleus and gamma rays are high-frequency electromagnetic waves.
- Alpha, beta and gamma radiations are emitted from unstable nuclei randomly.
- Ionising radiations cause atoms to gain or lose electrons to form ions.

A2 Types of ionising radiation

- Alpha, beta and gamma radiations are compared in terms of their abilities to penetrate and ionise, and the effects of different radiations on living cells.
- Uses of ionising radiations, including alpha, beta, gamma and X-rays.

A3 Nuclear fission and fusion

- Investigate radioactive decay in terms of reducing activity and amount of radioactive material.
- Investigate half-life of radioactive isotopes in terms of reducing activity and calculations involving half-life and their graphical representations.
- Nuclear fission is large nuclei breaking down to form smaller nuclei and energy is released by the process of controlled nuclear fission. Nuclear fusion is the creation of larger nuclei from smaller nuclei.
- Environmental issues associated with nuclear energy, e.g. storage of waste products, uncontrolled release of radioactive material.
- Energy release by nuclear fusion in stars and the difficulty in harnessing energy from nuclear fusion on Earth.

Learning aim B: Know how electrical energy produced from different sources can be transferred through a country's system operator of electricity and gas supply to homes and industry

B1 Producing AC and DC electricity

- Electrical circuits (need for a complete circuit, electrical symbols (battery, cell, switch, fuse, voltmeter, ammeter, resistor, filament lamp), current (A, mA), voltage (V, mV) and resistance (Ω, kΩ)).
- Construction of simple series and parallel circuits.
- Measuring current and voltage using meters.
- Use the equation:
  voltage (volts) = current (amps) ´ resistance (ohms) $V = IR$
- Direct current (d.c.) and alternating current (a.c.).

B2 Power supplies

- Types of battery.
- Solar cell.
- Simple generators, e.g. rotating a coil in a permanent magnetic field.
- Production of electricity, e.g. basic alternating current generator, batteries as a source of direct current (rechargeable and non-rechargeable).
- Environmental impact, e.g. comparison of environmental impact of electricity generation from renewable and non-renewable sources.
- Electrical power and the equation:
  power (watts) = voltage (volts) ´ current (amps) $P = VI$
- Efficiency of electricity generation from different sources.

B3 Transmitting electricity to homes and industry

- A country's system operator of electricity and gas supply, e.g. used to transmit electrical energy (power).
- Step-up and step-down transformers and the reduction of energy losses during transmission.

Learning aim C: Know the components of the Solar System, the way the Universe is changing and the methods we use to explore space

C1 The Solar System and its formation

- Composition, e.g. stars, planets, dwarf planets and natural satellites, comets and meteors, asteroids.
- Formation of the Solar System.
- Space tourism and the future of space flight.

C2 Observing the Universe

- Optical, radio, infrared, UV, X-ray and gamma telescopes.
- Reflecting, ground-based and space-based telescopes.
- Space probes and robots.

C3 The changing Universe

- The Big Bang theory.
- The structure and dynamic nature of the Universe, e.g. Solar System, stars and galaxies, large-scale structure.
- Looking back in time.
- Evidence for an expanding Universe, e.g. galaxies moving away from each other (red shift).
- Cosmic microwave background radiation as support for the Big Bang theory.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Understand ionising radiation, its uses and sources		**A.D1** Calculate the half-life of radioactive isotopes. **A.D2** Justify the selection of a radioactive isotope for a given use within the home or workplace. **A.D3** Evaluate the environmental impacts of a nuclear fission reactor accident, in terms of half-life.
A.P1 Describe half-life in terms of radioactive decay. **A.P2** Describe the different types of ionising radiation. **A.P3** Describe the problems associated with the use of radioactive isotopes. **A.P4** Describe how controllable nuclear fission and fusion reactions are.	**A.M1** Use graphs to explain radioactive decay and half-life. **A.M2** Compare the benefits and drawbacks of using radioactive isotopes in the home or workplace. **A.M3** Describe the environmental impact of radioactive material from nuclear fission reactors released into the environment.	
Learning aim B: Know how electrical energy produced from different sources can be transferred through a country's system operator of electricity and gas supply to homes and industry		**B.D4** Assess, in quantitative terms, ways to minimise energy losses either when transmitting electricity or when transforming electricity into other forms for consumer applications.
B.P5 Describe methods of producing AC and DC electricity. **B.P6** Use $V = IR$ to predict values in electric circuit investigations. **B.P7** Describe how electricity is transmitted to the home or industry.	**B.M4** Compare the efficiency and environmental impact of electricity generated by different sources. **B.M5** Assess, in qualitative terms, ways to minimise energy losses when transmitting electricity.	
Learning aim C: Know the components of the Solar System, the way the Universe is changing and the methods we use to explore space		**C.D5** Evaluate the evidence leading to the Big Bang theory of how the Universe was formed.
C.P8 Describe the structure of the Universe and our Solar System. **C.P9** Describe the suitability of different methods for observing the Universe. **C.P10** Identify evidence that shows the dynamic nature of the Universe.	**C.M6** Describe how the Universe and the Solar System were formed. **C.M7** Explain how evidence shows that the Universe is changing.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is also further information on our website.

There is a maximum number of three summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.P2, A.P3, A.P4, A.M1, A.M2, A.M3, A.D1, A.D2, A.D3)

Learning aim: B (B.P5, B.P6, B.P7, B.M4, B.M5, B.D4)

Learning aim: C (C.P8, C.P9, C.P10, C.M6, C.M7, C.D5)

Further information for teachers and assessors

Resource requirements

There are no special resources needed for this unit.

Essential information for assessment decisions

The contents of this unit should be approached from a practical point of view as far as possible, with simulations used where necessary, e.g. simulations into the nature of radioactivity. Industrial and related contexts for assessment should be locally relevant where possible and could include:

- for learning aim A, safe working with, and disposal of, nuclear materials in the medical industry
- for learning aim B, approaches taken by a local energy supplier to responsibly manage demand.

Learning aim A

For Distinction standard, learners are required to perform calculations involving the half-life of radioactive isotopes. The teacher and assessor should avoid providing learners with a series of questions that are just exercises in calculations. The problems should be set in context, perhaps using the results from simulations learners have watched. The idea is to enable the learner to carry out calculations and, in doing so, understand how published figures for half-lives are arrived at. Learners will need to justify the selection of one radioactive isotope for a given use in society and evaluate the impact of an accident at a nuclear power plant in terms of using half-life diagrams.

For Merit standard, learners will have the opportunity to describe, in words and mathematically using graphical methods, radioactive decay and half-life. It is also expected that the learner can compare the benefits and drawbacks of using radioactive isotopes in the home (such as in smoke detectors) or in the workplace (such as for sterilising medical equipment, radioactive tracers and measuring the thickness of paper).

Learners need to describe the environmental impact of radioactive uncontrolled release from a nuclear reactor. This could be a recent event that has long-term effects on the environment.

For Pass standard, only a description of half-life is required in terms of radioactive decay; there is no requirement for a qualitative or quantitative explanation. Learners will need to show an understanding of atomic structure and the different types of ionising radiation. Learners need to describe at least two problems with the use of radioactive isotopes. A description of how controllable nuclear fission and fusion reactions are is required and it would be expected that learners would refer to examples from nuclear reactors and the Solar System to aid their description.

Learning aim B

For Distinction standard, learners will include quantitative arguments, which the assessor needs to look at for appropriate assessment of this criterion. This work will build on the comparison of efficiencies, environmental impact and qualitative assessment of ways to minimise energy losses when electricity is transmitted.

For Merit standard, learners are required to carry out a comparison in relation to efficiency. More able learners could include calculations to aid their arguments, rather than just providing a description. Learners are also required to provide a qualitative assessment on minimising energy losses.

For Pass standard, learners will need to describe the three different methods used for producing electricity. It is assumed that practical work has been done on circuit building etc. in order to underpin the learners' ability to use the equation $V = IR$. Teachers may feel that the assessment of B.P6 and B.P7, where an understanding of AC and DC currents and the transmitting of electricity is required, can be linked together. Note that it is stipulated that practical work must be completed correctly. Observation sheets and/or witness statements are required as evidence in support.

Learning aim C

For Distinction standard, learners must provide a coherent evaluation of the evidence of the Big Bang theory. The expectation for learner work is that the ideas and evidence that led to the Big Bang theory are explored and not simply described.

For Merit standard, learners need to give a simple description of the Big Bang theory and formation of the Solar System. They must also explain how the evidence of cosmic microwave background radiation provides evidence to support the Big Bang theory.

For Pass standard, learners need to describe the structure of the Universe and our Solar System. This can be done as a large-scale structure to include galaxies, and other star systems. Learners will also need to describe the suitability of three different methods used to observe the Universe and evidence of an expanding Universe needs to be identified by looking at the red shift of galaxies.

Links to other units and other curriculum subjects

This unit links to:

- Unit 11: How Scientific Theories Are Formulated
- Unit 20: Exploring Our Universe.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers
- work experience
- visits to planetarium, observatory or science conventions, nuclear power stations, wind farms and conventional coal/oil/gas power stations.

Opportunities to develop transferable skills

In completing this unit, learners will have the opportunity to develop research and planning skills, and demonstrate changes in perception of new ideas and scientific concepts.

Unit 4: Biology and our Environment

Level: **2**
Unit type: **Internal**
Guided learning hours: **30**

Unit in brief

This unit looks at the causes of variation between organisms and how organisms interact with each other. It also considers the effects of human activity on the environment and factors that affect human health.

Unit introduction

Environmental science technicians and scientists work for local authorities, the government and charities to monitor the effects of human activities on local, national and global environments.

Learners will study the different activities humans carry out that cause damage to the environment. Learners will gain an understanding of how the pollutants released from human activities affect air, water and land, using primary and/or secondary data to determine how different pollutants affect living things. The use of indicators in measuring pollution levels is explored and learners will study the methods and schemes used to try to reduce or counteract the effects of human activity on the environment.

Scientists in health programmes monitor the various factors that impact on human health and seek to improve the health of the population. To complete the study of this unit, learners will investigate the causes of disease, including genetic disease, and how various diseases can be prevented and treated. Learners will have the opportunity to investigate the problems associated with the misuse of treatment regimes and implications that resistant forms of bacteria have on the future treatment of disease.

Learners will study and compare the adaptations of different organisms and how these adaptations determine the success of organisms in their environment. Learners will have the opportunity to demonstrate how adaptations bring about evolution or, on the contrary, bring about species extinction.

The aim of this unit is to further develop learners understanding of the core concepts they have learnt in *Unit 1: Principles of Science* by studying relationships between different organisms and the environment. Where possible this should be done using industrial and related contexts such as local government monitoring of the environmental impact of industries and the proper use of medicines.

Learning aims

In this unit you will:

A Investigate the relationships that different organisms have with each other and with their environment

B Demonstrate an understanding of the effects of human activity on the environment and how these effects can be measured

C Explore the factors that affect human health.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Investigate the relationships that different organisms have with each other and with their environment	**A1** Variation between organisms **A2** Natural selection and evolution **A3** Interdependence of organisms **A4** Classification of organisms **A5** Identifying organisms	A display for a museum including: · a presentation on classification · posters on interactions between organisms and genetic and environmental causes of variation leading to evolution.
B Demonstrate an understanding of the effects of human activity on the environment and how these effects can be measured	**B1** Human activities **B2** Pollution **B3** Indicators of pollution **B4** Measures to reduce human impacts	A field study in a local ecosystem, collecting and analysing samples and explaining the impact of human activities. Posters describing how the impacts of human activity could be reduced.
C Explore the factors that affect human health	**C1** Microorganisms causing disease **C2** Prevention and treatment of infections **C3** Bacteria can become resistant to antibiotics **C4** Non-infectious disease **C5** Genetic disorders **C6** Benefits of physical activity	Produce a leaflet describing lifestyle choices and biological, social and genetic factors affecting health and how illness can be prevented and treated.

Content

Learning aim A: Investigate the relationships that different organisms have with each other and with their environment

A1 Variation between organisms

- The characteristics of organisms vary within and across species:
  - genetic variation – variation in characteristics can be caused by genes, including genetic mutation
  - environmental variation – some characteristics can be influenced by the environment.

A2 Natural selection and evolution

- Evolution is a gradual process, involving gene mutation and natural selection, that can lead to the development of new species:
  - populations or organisms show variation
  - organisms less well adapted to their environment are less likely to survive due to competition for resources, predation and environmental influences
  - organisms best adapted to their environment will survive to breed and pass on their genes to the next generation
  - over a period of time the proportion of individuals with the favourable adaptation will increase and the individuals without the adaptation may disappear altogether.

A3 Interdependence of organisms

- Interdependence of organisms can be illustrated using food chains and webs, and by predator-prey relationships.

A4 Classification of organisms

- Organisms are classified depending on their characteristics:
  - the main characteristics of the five kingdoms
  - division of the animal kingdom into vertebrates and invertebrates
  - the main characteristics of vertebrates.

A5 Identifying organisms

- Construct and use keys to show how organisms can be identified.

Learning aim B: Demonstrate an understanding of the effects of human activity on the environment and how these effects can be measured

B1 Human activities

- How human activities alter ecosystems through:
  - deforestation to supply timber and clear land for agriculture
  - agriculture to meet an increasing demand for food
  - transportation – of food and for travel.

B2 Pollution

- How pollutants produced as a result of human activity can affect ecosystems:
  - overuse of fertiliser causing eutrophication
  - toxic herbicides and pesticides that can bioaccumulate and disrupt terrestrial and aquatic food chains.

B3 Indicators of pollution

- Living and non-living indicators can be used as a measure of the level of pollution in an ecosystem:
  - lichens are sensitive to sulfur dioxide
  - algae and freshwater shrimps as indicators of water pollution
  - dissolved oxygen and nitrate concentration in water as non-living indicators of water pollution
  - limestone buildings can be eroded by acid rain.

B4 Measures to reduce human impacts

- There are measures that can be taken to counteract or reduce the impact of human activity on ecosystems:
  - recycling and reusing materials saves natural resources and reduces the amount of waste produced
  - conservation techniques of reforestation, replacement planting and breeding programmes
  - use of renewable resources
  - using organic fertilisers and biological pest control as an alternative to chemical fertilisers and pesticides.

Learning aim C: Explore the factors that affect human health

C1 Microorganisms causing disease

- Infectious disease can be caused by microorganisms (bacteria and viruses) that affect living cells:
  - bacteria produce toxins that harm living cells
  - viruses invade living cells causing cell death.

C2 Prevention and treatment of infections

- The methods used to prevent and treat disease
  - vaccinations can be used to prevent disease
  - antibiotics can be used to treat diseases caused by bacteria.

C3 Bacteria can become resistant to antibiotics

- Overuse and incorrect use of antibiotics:
  - incorrect use (e.g. against viral infections)
  - need to take the full course.
- Examples of resistance to antibiotics.

C4 Non-infectious disease

- Non-infectious disease can be caused by lifestyle or the environment:
  - misuse of recreational drugs can lead to mental illness
  - inadequate diet can lead to deficiency diseases
  - cigarette smoke can cause diseases of the circulatory system
  - ultraviolet light can cause skin cancer
  - excessive consumption of alcohol can lead to liver disease
  - poor air quality can lead to asthma.

C5 Genetic disorders

- Influence of genes on human health:
  - genetic disorders can affect human health
  - pedigree analysis can be used to show the inheritance of genetic disease.

C6 Benefits of physical activity

- Physical activity helps to keep the body healthy.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Investigate the relationships that different organisms have with each other and with their environment		
A.P1 Describe the role of genes and the environment in variation. **A.P2** Describe how characteristics are used to classify organisms. **A.P3** Describe the different ways in which organisms show interdependence.	**A.M1** Explain the role of genes and the environment in evolution. **A.M2** Discuss the factors that affect the relationship between different organisms.	**A.D1** Evaluate the impact of genes and the environment on the survival or extinction of organisms.
Learning aim B: Demonstrate an understanding of the effects of human activity on the environment and how these effects can be measured		
B.P4 Describe the impact that different human activities have on ecosystems. **B.P5** Describe how living and non-living indicators can be used to measure levels of pollutants. **B.P6** Describe the different methods used to help reduce the impact of human activities on ecosystems.	**B.M3** Analyse the effects of pollutants on ecosystems. **B.M4** Discuss the advantages and disadvantages of methods used to reduce the impact of human activity on ecosystems.	**B.D2** Explain the long-term effects of pollutants on living organisms and ecosystems. **B.D3** Evaluate the success of methods to reduce the impact of human activity on an ecosystem, for a given scenario.
Learning aim C: Explore the factors that affect human health		
C.P7 Describe how pathogens affect human health. **C.P8** Describe two different treatment regimes: one used to prevent a disease and one used to treat a disease. **C.P9** Describe how lifestyle choices can affect human health.	**C.M5** Explain how bacteria can become resistant to antibiotics. **C.M6** Explain the use of pedigree analysis. **C.M7** Discuss the advantages and disadvantages of vaccination programmes.	**C.D4** Evaluate the use of antibiotics, pedigree analysis and vaccination programmes in the treatment and prevention of childhood illnesses.

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is also further information on our website.

There is a maximum number of three summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.P2, A.P3, A.M1, A.M2, A.D1)

Learning aim: B (B.P4, B.P5, B.P6, B.M3, B.M4, B.D2, B.D3)

Learning aim: C (C.P7, C.P8, C.P9, C.M5, C.M6, C.M7, C.D4)

Further information for teachers and assessors

Resource requirements

There are no special resources needed for this unit.

Essential information for assessment decisions

Learning aim A

For Distinction standard, learners will provide clear evidence in their evaluation of how genes and the environment impact evolution, including information on how these factors, as well as gene mutation, can lead to the extinction of species or the formation of new species.

For Merit standard, learners will develop their understanding further to link strong characteristics with survival of the organism, showing in their evidence how natural selection is one of the key processes involved in evolutionary change.

Learners also need to discuss how different factors affect the relationship between different organisms.

For Pass standard, learners will be expected to describe how genes and the environment influence variation, with evidence to show understanding of how genetic factors can also be influenced by lifestyle or the environment. Learners will be able to draw on their knowledge and understanding of information gained in *Unit 1: Principles of Science* to describe how genes determine the basis for many characteristics and could demonstrate their understanding of this using genetic diagrams or Punnett squares. Learners should be able to identify genetic characteristics that can be altered by the environment (for example, weight or height) and give a brief description of how lifestyle or the environment affect these characteristics.

Learners also need to classify organisms using characteristics and describe how to do this. Learners may link this information to the interdependence of organisms by stating how the characteristics of organisms determine their place in food chains and webs. Further evidence could be provided in annotated diagrams, posters or flow charts that give details of the different ways in which organisms depend on each other, other than just feeding relationships. It is expected that learners will provide information on at least two different types of interdependent relationship, which will include the detail derived from food chains and webs.

Learning aim B

For Distinction standard, learners will be expected to research information and use their own understanding gained from the study of this unit to explain how pollutants could affect the ecosystems in the future. This work will include the effects on living organisms, including species survival, the effect on food chains and webs, and how these may be disrupted, with information that illustrates understanding of how the release of pollutants, if unchecked, will affect humans.

Learners will also provide evidence to show whether the various methods used to reduce or counteract the effects of pollution are successful and will suggest ways in which methods could be improved, or participation by communities could be improved. Learners may suggest alternative methods that could be introduced that would further help to counteract the effects of pollutants on the environment and ecosystems. Learners will be expected to extend their understanding to methods not covered at the lower grades, such as coppicing and reforestation techniques.

For Merit standard, learners are expected to use data to support the fact that human activities do have polluting effects. At this level learners may wish to study a local ecosystem and relate the diversity and health of the organisms to the conditions and level of pollution.

Learners will show understanding of the advantages and disadvantages of 'green schemes' such as recycling and this could be presented as an extension to the information submitted for Pass standard.

For Pass standard, learners will need to identify different human activities that affect ecosystems and describe how the polluting effects of these activities cause harm to living organisms and ecosystems.

Learners will recognise the different indicators that can be used to measure levels of specific pollutants, working independently to provide evidence that could be in the form of a report, a case study or a presentation.

Learners can study local schemes that may have been put in place to reduce human impacts, such as recycling centres or local supermarkets that may have strategies in place to help conserve natural resources or encourage recycling methods. At this level, learners will be expected to understand how such schemes help to counteract the polluting effects of human activities on the environment and provide evidence to show how sustainable activities, such as reducing, reusing and recycling materials, will help to conserve natural resources for future generations.

Learning aim C

For Distinction standard, learners need to extend the Merit level by evaluating the use of antibiotics, pedigree analysis and vaccination programmes in the treatment and prevention of childhood illnesses. Historical health campaign information may be useful. One example of each is expected.

For Merit standard, learners will need knowledge of the increasing concern caused by bacterial resistance to antibiotics and the reasons why it is important to follow treatment regimes strictly, as well as to ensure that the use of antibiotics is not abused. Learners should describe what practices are leading to resistance to antibiotics and the implications this may have in the future. Knowledge of the mechanisms of resistance is not required.

Learners will need to explain one example of when pedigree analysis would be used.

In discussing vaccination, learners should outline what vaccination is and consider its benefits and the possible consequences of not vaccinating (e.g. measles). Possible disadvantages should be considered in a balanced way, reflecting the fact that the evidence shows vaccination to be safe for the great majority of people. High-profile examples such as MMR can show how poor information can lead to reduced vaccination rates and, consequently, increased rates of serious infections.

For Pass standard, learners will identify and describe two pathogens that affect human health; this will be limited to bacteria and viruses. A description is required of the actions of bacteria and viruses and how these impact human health.

Learners will provide evidence to show their knowledge of how disease can be prevented using vaccination programmes and treated using antibiotics. Learners do not need to provide details of the processes by which vaccinations instigate an immune response or how antibiotics destroy bacteria.

Learners will produce evidence to show their knowledge of how exercise benefits health and how lifestyle choices can affect human health both positively and negatively. This includes smoking, diet, exercise and recreational drug use.

Links to other units and other curriculum subjects

This unit links to:

- Unit 1: Principles of Science
- Unit 7: Health Applications of Life Science
- Unit 13: Monitoring the Environment
- Unit 16: Science in Medicine.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers
- work experience.

Opportunities to develop transferable skills

In completing this unit, learners will have the opportunity to develop skills in team working, communication skills using a range of media and formats, and safe working in practical situations.

Unit 5: Applications of Chemical Substances

Level: **2**
Unit type: **Internal**
Guided learning hours: **30**

Unit in brief

This unit enables learners to build on key chemistry concepts learned in *Unit 1: Principles of Science* and *Unit 2: Chemistry and Our Earth* to develop an understanding of the principles behind industrial applications of chemistry.

Unit introduction

It is important for chemists working in the manufacturing industry to be able to measure the amount of energy given out or absorbed during chemical reactions. This will enable them to manufacture products safely and efficiently, and also to find uses for chemical reactions that increase or decrease in temperature, in applications such as heat or cold packs. For exothermic and endothermic reactions, learners will measure the amount of heat that some reactions give out and other reactions take in. Learners may also be able to relate this to the chemical bonds that are broken and made.

Organic compounds are used extensively in society. Many of these are derived from crude oil. Learners will look at how crude oil is distilled to produce different fractions. Many of these have uses as fuels. Learners will study the structure, reactions and uses of some important organic chemicals.

Chemists are constantly finding and developing new types of material and new ways to use existing materials. More and more composite materials are being used – for example, to make cars, aeroplanes and mobile phones, and in building materials. Some of these composites use waste plastics. Most recently, smart materials (those that change their properties in response to changes in their environment) are finding applications. Polymers with exceptional insulating properties are used in niche applications, such as firefighting. The aim of this unit is to build on some of the basic fundamental concepts that learners have learned in *Unit 1: Principles of Science* and *Unit 2: Chemistry and Our Earth* in relation to bonding and chemical reactions.

Learning aims

In this unit you will:

A Investigate and understand enthalpy changes associated with chemical reactions

B Investigate organic compounds used in society

C Explore the uses of nanochemicals and new materials.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Investigate and understand enthalpy changes associated with chemical reactions	**A1** Exothermic and endothermic reactions **A2** Measuring enthalpy changes **A3** Applications of enthalpy changes	Experimental and written reports, including diagrams and graphs.
B Investigate organic compounds used in society	**B1** Fractional distillation of crude oil **B2** Structural and displayed formulae of organic molecules **B3** Test tube reactions to identify classes of organic molecules **B4** Uses of organic molecules in society	A written report with diagrams. Presentation on the structure, uses and environmental impact of a range of organic chemicals, to include a practical report, models and diagrams. A report showing uses, benefits and drawbacks of a range of organic chemicals.
C Explore the uses of nanochemicals and new materials	**C1** Introduction to nanochemistry **C2** New materials	A report showing the uses, benefits, safety issues and drawbacks of a range of innovative materials.

Content

Learning aim A: Investigate and understand enthalpy changes associated with chemical reactions

A1 Exothermic and endothermic reactions

- Energy change in reactions:
  - exothermic reactions as reactions that give out heat energy
  - endothermic reactions as reactions that take in heat energy.
- Heat/enthalpy change associated with bond-breaking and bond-making.
- Overall enthalpy change for a reaction as a combination of bond-breaking and bond-making enthalpy changes.
- Simple energy profile diagrams.

A2 Measuring enthalpy changes

- Measurement of temperature changes for straightforward exothermic and endothermic reactions:
  - classification of temperature changes as positive or negative
  - temperature changes linked to heat energy evolved or absorbed.
- Reactions for which enthalpy changes may be measured should include (but are not limited to):
  - dissolution of sodium carbonate and ammonium chloride in water
  - neutralisation of acids
  - combustion of alcohols.
- Use the equation: $q = m\ Cp\ \Delta T$ heat energy absorbed by water (J) = mass of water (g) ´ specific heat capacity (J °C^{-}1 g^{-}1) ´ temperature change (°C) to determine the amount of heat energy absorbed by water in contact with the reaction.

A3 Applications of enthalpy changes

- Heat packs/cold packs.

Learning aim B: Investigate organic compounds used in society

B1 Fractional distillation of crude oil

- Fractional distillation of crude oil based on boiling ranges of components:
  - link between boiling ranges of hydrocarbons and length of hydrocarbon chain.
- Uses of fractions based on sizes of molecules:
  - refinery gases, petrol, kerosene, diesel oil, fuel oil, bitumens, waxes.
- Uses of alkanes as fuels:
  - natural gas (methane), bottled gas (propane and butane), petrol, diesel, kerosene.

B2 Structural and displayed formulae of organic molecules

- Alkanes:
  - methane, ethane, propane, butane.
- Alkenes:
  - structure of ethene, propene.
- Other organic molecules:
  - poly(ethene), ethanol, ethanoic acid, chloroethene, dichloromethane.
- Polymers:
  - poly(chloroethene) (PVC), poly(propene), tetrafluoroethene, poly(tetrafluoroethene) (PTFE).
- Use of a line to denote a single covalent bond/shared pair of electrons and two lines to denote a double bond/two shared pairs of electrons.

B3 Test tube reactions to identify classes of organic molecules

- Identification tests:
  - alkenes decolourise bromine water (addition)
  - carboxylic acids effervesce when sodium carbonate is added (neutralisation)
  - alcohols oxidised by acidified dichromate (VI) solution which changes from orange to green (oxidation).

B4 Uses of organic molecules in society

- Ethene:
  - manufacture of poly(ethene) and ethanol.
- Ethanol (made by fermentation/from ethene):
  - alcoholic drinks, biofuels, solvents, cosmetics.
- Ethanoic acid:
  - in vinegar and making esters.
- Dichloromethane:
  - in paint stripper and solvents.
- Chloroethene:
  - in polymerisation to PVC and uPVC
  - Teflon™ (PTFE) in non-stick coatings and low-friction bearings.
- Problems of organic molecules:
  - toxicity of compounds and products formed on combustion
  - flammability
  - non-biodegradability.

Learning aim C: Explore the uses of nanochemicals and new materials

C1 Introduction to nanochemistry

- Nanoscale.
- Carbon nanostructures:
  - fullerenes – buckyballs and nanotubes.
- Production of nanotubes.
- Uses of nanochemistry:
  - sun creams, mascara, textiles, sports equipment, single crystal nanowires for processors, mobile phone batteries.
- Implications of nanochemistry:
  - safety and environmental issues
  - ethical issues surrounding the use of nanochemicals whose properties are not fully understood.

C2 New materials

- Smart materials whose properties change in response to an external stimulus.
- Examples of materials that are highly specialised and their properties:
  - Kevlar®, GORE-TEX®, Thinsulate®, titanium dioxide.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Investigate and understand enthalpy changes associated with chemical reactions		**A.D1** Calculate the energy changes that take place during exothermic and endothermic reactions.
A.P1 Investigate temperature changes associated with exothermic and endothermic reactions using primary data.	**A.M1** Explain why an overall reaction is exothermic or endothermic.	
Learning aim B: Investigate organic compounds used in society		**B.D2** Analyse the relationship between the boiling range and the length of carbon chain of fractions. **B.D3** Explain the results of experiments to identify organic compounds in terms of their reaction type, structural and displayed formulae, and bonding. **B.D4** Evaluate the benefits and drawbacks of using organic materials.
B.P2 Describe the fractional distillation of crude oil to produce a range of useful products. **B.P3** Draw the structural and displayed formulae of organic molecules accurately. **B.P4** Identify an alkene and a carboxylic acid using primary observations. **B.P5** Describe the uses of organic compounds in our society.	**B.M2** Explain how fractional distillation separates compounds due to different boiling ranges. **B.M3** Describe the bonding and structure of organic molecules. **B.M4** Explain how a series of experiments can be used to identify organic compounds based on their solubility and reactions. **B.M5** Explain the problems associated with the use of organic molecules.	
Learning aim C: Explore the uses of nanochemicals and new materials		**C.D5** Evaluate the benefits and drawbacks of using nanochemicals, smart and specialised materials.
C.P6 Describe a use of nanochemicals, smart and specialised materials.	**C.M6** Explain the benefits of using nanochemicals, smart and specialised materials.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is also further information on our website.

There is a maximum number of three summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.M1, A.D1)

Learning aim: B (B.P2, B.P3, B.P4, B.P5, B.M2, B.M3, B.M4, B.M5, B.D2, B.D3, B.D4)

Learning aim: C (C.P6, C.M6, C.D5)

Further information for teachers and assessors

Resource requirements

For this unit, learners must have access to a laboratory with at least one fume cupboard and samples of specialised materials.

Essential information for assessment decisions

Learning aim A

For Distinction standard, learners must be able to calculate the heat absorbed by or taken from the water in contact with the reaction using the equation $mC_p\Delta T$, and relate this to the enthalpy changes for reactions in terms of breaking bonds (which requires heat) and making bonds (which releases heat).

For Merit standard, learners must be able to explain clearly the link between the sign of the temperature change and the heat absorbed by the water in contact with the reaction (or increase/decrease in temperature) and whether the reaction gives out heat or takes in heat. The words 'exothermic' and 'endothermic' should be used correctly. The role of the water in absorbing heat or supplying heat must be explained.

For Pass standard, learners should carry out two exothermic reactions and one endothermic reaction, and conclude, from the measurements of temperature change, that the reaction was exothermic (gave out heat) or endothermic (took in heat). They must understand the meanings of those terms. They must provide written meanings of the two terms to demonstrate their understanding.

Learning aim B

For Distinction standard, learners must be able to analyse and explain the link between the boiling point of the fractions and the length of their carbon chains. (Learners could be provided with boiling points for alkanes to plot a graph to then analyse and explain the trend observed.)

Learners need to use the results of the experiments to identify organic compounds using their reaction type, formulae and bonding in terms of their functional group, such as a double bond in an alkene, O-H bond in an alcohol and a -COOH functional group in a carboxylic.

Learners should be able to contrast the benefits and drawbacks of using two organic materials, for example PVC. Benefits like cost, stability, versatility and low toxicity could be contrasted with drawbacks like the coupling with endocrine disrupting plasticisers and the production of dioxins when incinerated. They should be able to arrive at a judgement about whether the benefits outweigh the risks.

For Merit standard, learners need to explain the boiling ranges of the different fractions to show how compounds are separated. This could be achieved by the use of secondary data such as a table or detailed annotation on a fractional distillation column diagram.

Learners must be able to describe single and double bonding as covalent and explain that the lines in the displayed formulae represent a shared pair of electrons. Learners should draw dot-and-cross diagrams for an alkane (with two or more carbons), an alkene (with two or more carbons), ethanol, ethanoic acid, a chloromethane and a unit of a polymer. All structures drawn for Pass must be correct in order to meet Merit standard.

Learners should be able to explain the basis on which the identifications were made for an unknown alkane, alkene, alcohol and carboxylic acid compound using their practical observations.

Learners should explain in detail the problems of at least two uses/applications of the organic compounds described at Pass level.

For Pass standard, learners must show that they can describe how fractional distillation of crude oil works and be able to identify the uses of a range of the fractions. That could be done by producing an annotated diagram of a fractional distillation column. They must specifically state the uses of propane and butane, petrol, diesel and kerosene.

Learners must be able to draw/provide a representation of straight chain alkanes accurately, with 1–6 carbon atoms, ethene, chloromethanes, chloroethene, poly(ethene), ethanol and ethanoic acid.

Learners should follow guidance to identify an alkane, alkene, alcohol and carboxylic acid (for example, ethanoic acid) from primary observations. They will be expected to identify the alkane and alkene on the basis of it being insoluble in water and by its ability to decolourise bromine water rapidly. For ethanoic acid this is by its pH and its reaction with sodium carbonate. The guidance given to learners could be in the form of a flow chart.

Learners should provide a brief account of at least two uses of:

- ethene as a feedstock – including as a raw material for ethanol manufacture
- ethene in polymerisation
- ethanol in alcoholic drinks – as a solvent, as a sterilisation agent, as a feedstock and as a fuel
- poly(ethene)
- poly(vinyl chloride) (PVC) – plasticised and unplasticised
- ethanoic acid in vinegar – as a pickling agent and as a feedstock for making esters.

Learning aim C

For Distinction standard, learners should explain the benefits and drawbacks of using nanochemicals, smart and specialised materials, and provide a reasoned judgement about whether the benefits outweigh the risks. Learners should research public concerns about nanochemicals, for example the possibility of nanochemicals passing through cell walls and causing disruption. They should be able to assess these concerns by providing a brief description and stating the source(s) of their information, and arguing whether the information is likely to be reliable on the basis of its source(s).

For Merit standard, learners should explain the benefits of using these (at least two) nanochemicals, smart materials and specialised materials.

For Pass standard, learners should describe, in detail, the use of at least one smart material, one application involving nanochemicals and one application of another sort of specialised material. Where the materials are used as part of a formulation/in conjunction with other materials, this should be described.

Links to other units and other curriculum subjects

This unit links to:

- Unit 1: Principles of Science
- Unit 5: Applications of Chemical Substances
- Unit 19: Chemical Analysis and Detection
- Unit 23: Further Chemistry.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers and interview opportunities
- work experience
- business material as exemplars
- visits to appropriate business organisations.

Opportunities to develop transferable skills

In completing this unit, learners will have the opportunity to develop knowledge and understanding of the applications of chemical processes.

Unit 6: Applications of Physical Science

Level: **2**
Unit type: **Internal**
Guided learning hours: **30**

Unit in brief

This unit looks at motion, forces, light and sound waves and electricity.

Unit introduction

Scientists have been vital in improving safety in everyday life and in developing many modern technologies by applying their knowledge of forces, waves and electricity. Learners will develop an understanding of motion and how it relates to road safety. Learners will also have the opportunity to find out how to represent motion graphically and to carry out investigations, for example on the way speed cameras operate.

Following on from this, learners will develop their understanding of forces and how they are used in applications such as weight measurement or car safety. This theme could be continued through to the investigation of the motion of vehicles.

Learners will also investigate light and find out, for example, how the reflection of light is used to make our roads safer. They could also explore how the human eye functions and how eye glasses are used to correct defects in vision.

Finally, learners will investigate how electricity is used in our world, looking at practical uses of electricity by building circuits.

The aim of this unit is to build on the fundamental concepts you have learned in *Unit 1: Principles of Science* and *Unit 3: Energy and Our Universe*. In this unit, learners will apply their knowledge and understanding to explore and investigate a range of applications of physics in the real world.

Learning aims

In this unit you will:

A Investigate motion

B Investigate forces

C Investigate light and sound waves

D Investigate electricity.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Investigate motion	**A1** Measurement of distance and time in simple investigations **A2** Uniform and non-uniform motion **A3** Kinetic and gravitational energy	Graphical representation of motion for a variety of situations to include: vehicles and general movement, energy transformation diagrams. Experiments that show how speed can be measured on local roads, kinetic energy and gravitational potential energy calculations. Suggestions on improving speed cameras so that they can detect if drivers are slowing down before speed cameras and speeding up after them. This behaviour is dangerous driving and councils would like to reduce it. Report on the conservation of energy when applied to transportation.
B Investigate forces	**B1** Interaction of forces **B2** Equations of force **B3** Forces and motion	An article or report detailing your findings and results from experiments. Example calculations and their application in the real world. Suggested production of a journalistic article outlining forces and related to transportation.

Learning aim	Key content areas	Assessment approach
C Investigate light and sound waves	**C1** Light **C2** Transmission medium **C3** Application of fibre optics and sound waves	Testing components for an optical manufacturer, including mirrors, prisms and lenses for accuracy. Make and compare measurements of the incident and reflected/refracted angles. You are a research sound technician and you have been asked to prepare a report about the insulation properties of materials and their capability of reflecting and transmitting sound from a source that produces a fixed frequency. A report outlining the physics involved in the reflection and transmission of sound, and the uses of the new materials in terms of reflecting sound and the transmission of sound and the use of fibre optics in medical diagnosis.
D Investigate electricity	**D1** Series/parallel circuits and measurements **D2** Ohm's law and circuit measurements **D3** Circuit component characteristics	Report, including diagrams, graphs and the effect of temperature on resistance. Produce a customised resistor, from resistance wire, at room temperature (not at the working temperature) (e.g. a 5-ohm resistor). Investigate the applications of thermistors for the product development department. Include light sensors and investigate the applications for light dependent resistors.

Content

Learning aim A: Investigate motion

A1 Measurement of distance and time in simple investigations

- Use the equation: distance (m) = speed (m/s) ´ time (s).
- Acceleration relates to a rate of change in velocity of an object.
- Use the equation: displacement (m) = velocity (m/s) ´ time (s).
- Use the equation: acceleration (m/s^2) = change in velocity (m/s) / time taken (s).

A2 Uniform and non-uniform motion

- Graphical representations of uniform and non-uniform motion (for objects that are stationary, moving at a constant speed, moving with increasing or decreasing speed).
- Conservation of energy in simple experiments, including energy transformation diagrams.

A3 Kinetic and gravitational energy

- Calculations of kinetic energy of moving objects in simple situations, using the following equation: KE = ½ ´ mass (kg) ´ (speed $(m/s)^2$
- Calculate change in gravitational potential energy using the following equation:
  GPE = mass (kg) ´ acceleration (m/s^2) due to gravity (gravitational field strength) change in height (m).
- Energy changes affecting transportation and stopping distance.

Learning aim B: Investigate forces

B1 Interaction of forces

- Forces arise from an interaction between two objects.
- The effect of balanced and unbalanced forces on objects.
- Work is done when a force moves through a distance.

B2 Equations of force

- Use the equation: work done (J) = force (N) ´ distance (m).
- Use the equation: force (N) = mass (kg) ´ acceleration (m/s^2).
- Identify 'pairs' of forces that act on different objects and understand that these forces are equal in size and opposite in direction.

B3 Forces and motion

- Friction and the normal reaction force arise in response to an applied force. The size of the frictional force matches the applied force up to a specific limit.
- Forces on a:
  - rocket during various stages of flight
  - parachutist.

Learning aim C: Investigate light and sound waves

C1 Light

- Light rays to represent light moving in straight lines.
- Laws of reflection applied to plane mirrors.
- Reflection of sound (echoes).
- Ray diagrams showing refraction of light in prisms and lenses:
  - convex
  - concave.
- Total internal reflection in prisms and optic fibres.
- A lens or mirror with a highly curved surface is more powerful than one with a less curved surface.
- The eye lens focuses light onto the retina and the use of optical lenses to correct simple eye problems.

C2 Transmission medium

- The need for a medium for the transmission of sound waves.
- The propagation of sound waves and the subsequent air pressure changes:
  - compression
  - rarefaction.
- Applications of light:
  - clear sightlines at road junctions
  - plane and convex mirrors as a rear view mirror
  - using lenses and mirrors in telescopes
  - how a simple periscope functions.

C3 Application of fibre optics and sound waves

- Applications of total internal reflection:
  - fibre optic cables used to provide a light source for keyhole surgery
  - reflectors for road safety.
- Applications of sound waves:
  - voice recognition
  - ultrasound
  - sonar.
- Breaking down kidney stones using ultrasound.

Learning aim D: Investigate electricity

D1 Series/parallel circuits and measurements

- Series circuits.
- Parallel circuits.
- Connect meters in circuits to measure voltages and currents.

D2 Ohm's law and circuit measurements

- Ohm's law (voltage, current and resistance relationships at a constant temperature).
- Measure currents and voltages and perform calculations to find resistance.
- The rules governing voltage and current when components are connected to a battery in series.
- The rules governing voltage and current when components are connected to a battery in parallel.

D3 Circuit component characteristics

- Voltage-current characteristics of a negative temperature coefficient (NTC) thermistor or a light-dependent resistor.
- Applications: thermistors (NTC) as a means of sensing temperature, or light-dependent resistors as a means of sensing the brightness of light.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Investigate motion		
A.P1 Produce accurate graphs to represent uniform and non-uniform motion using primary data. **A.P2** Calculate speed and velocity for simple experiments. **A.P3** Describe the conservation of energy for simple experiments, including energy transformation diagrams.	**A.M1** Interpret graphs to identify objects that are stationary, moving at a constant speed and moving with increasing or decreasing speed. **A.M2** Calculate kinetic energy and changes in gravitational potential energy.	**A.D1** Calculate the gradient for distance-time graphs and the gradient and area of speed-time graphs. **A.D2** Explain how changes in energy will affect transportation and stopping distances.
Learning aim B: Investigate forces		
B.P4 Describe the effects of balanced and unbalanced forces on objects. **B.P5** Calculate the work done by forces acting on objects for simple experiments. **B.P6** Describe how friction and normal reaction forces are produced in response to an applied force.	**B.M3** Calculate the force on objects, in relation to their mass and acceleration for an application. **B.M4** Explain how friction and normal reaction forces are produced in response to an applied force.	**B.D3** Explain the various forces involved, and their approximate sizes, in a variety of applications.
Learning aim C: Investigate light and sound waves		
C.P7 Describe, using diagrams, reflection and refraction of light for simple applications. **C.P8** Describe the importance of a medium for the transmission of sound waves through a variety of substances for simple applications.	**C.M5** Describe how lenses and mirrors can affect rays of light. **C.M6** Describe the propagation of sound waves, including compression and rarefaction.	**C.D4** Explain how reflection and refraction of light can be used in applications. **C.D5** Explain how sound waves can be applied in everyday uses.

Pass	Merit	Distinction
Learning aim D: Investigate electricity		**D.D6** Analyse an everyday life situation in which the resistance of a conducting wire is not constant. **D.D7** Evaluate the investigation into thermistors or LDRs, suggesting improvements to a real-life application.
D.P9 Measure currents and voltages in series and parallel electric circuits. **D.P10** Investigate an application of thermistors or LDRs using primary data.	**D.M7** Calculate resistances from measured currents and voltages. **D.M8** Mathematically or graphically process the results of the investigation into thermistors or LDRs to draw conclusions.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is also further information on our website.

There is a maximum number of seven summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.P2, A.P3, A.M1, A.M2, D.D1, D.D2)

Learning aim B: B (B.P4, B.P5, B.P6, B.M3, B.M4, B.D3)

Learning aim C: C (C.P7, C.P8, C.M5, C.M6, C.D4, C.D5)

Learning aim D: D (D.P9, D.P10, D.M7, D.M8, D.D6, D.D7)

Further information for teachers and assessors

Resource requirements

There are no special resources needed for this unit, although essential electronic components are necessary for electrical circuit investigation.

Essential information for assessment decisions

The following investigations are examples that could be carried out to enable learners to gain evidence to achieve the appropriate assessment criteria:

- investigate vehicle motion
- investigate thrill-seeking experiences, e.g. roller coaster rides
- investigate objects moving through different liquids or gases
- investigate energy changes affecting transportation and stopping distance
- investigate the use of frictional forces for different road conditions
- investigate the safety features of modern cars that involve forces
- investigate the effect of unbalanced forces on an accelerating mass.

Learning aim A

For Distinction standard, learners must use their distance-time and speed-time graphs to work out the gradient of any slopes shown from data in order to work out velocity and acceleration. Additionally, speed-time graphs should be used to work out the area under the graph to calculate the distance travelled in a given situation. Learners must explain how changes in energy transfer will affect transportation and stopping distances in given situations.

For Merit standard, learners need to interpret graphs to enable them to label and identify which objects are stationary, moving at constant speed and moving at an increasing or decreasing speed. Learners will also need to calculate kinetic energy and changes in gravitational potential energy in simple situations, using appropriate formulae and units.

For Pass standard, learners are expected to develop primary data from investigations carried out for non-uniform /non uniform motion and produce relevant graphs to describe the findings. Learners must use their measurements from experiments and use the correct formulae and units to calculate speed and velocity appropriately and accurately and use correct units consistently.

Learners should produce energy transformation diagrams to describe the conservation of energy.

Learning aim B

For Distinction standard, learners need to apply their understanding of forces to the variety of applications in the unit content by explaining the various forces involved, and their approximate sizes. This work will reinforce experimental investigation undertaken previously.

For Merit standard, learners need to use the appropriate equations to calculate the forces on objects accurately in relation to their mass and acceleration for a real-life application. Learners would then need to apply what they have learned in friction experiments to explain how friction and normal reaction forces are produced in response to an applied force.

For Pass standard, learners need to produce physical examples of situations for two balanced and two unbalanced forces and then describe the effect on objects in these conditions. Learners will also need to calculate the work done by objects for at least three simple experiments, using the appropriate formulae and units. Learners will carry out a friction experiment to demonstrate friction and normal reaction forces in response to an applied force, and then write a generalised description of the outcomes.

Learning aim C

For Distinction standard, learners need to apply their knowledge from previous notes and investigations to explain how reflection and refraction of light can be used in a real-life context, including the use of total internal reflection in optical fibres. This may also take the form of a suitable well-explained list of a selection of applications currently in use. Learners will also need to explain the use of sound waves in different situations.

For Merit standard, learners need to describe how lenses and mirrors, which are concave and convex, can affect rays of light by completing suitable investigations and using diagrams to explain what is happening. An explanation of the propagation of sound waves must be included and be clear in its meaning, with appropriate reference to compression and rarefaction.

For Pass standard, learners need to show an understanding of basic reflection principles by using plane mirrors and glass blocks/prisms to show reflection and refraction by drawing ray diagrams and understanding their use for simple applications. Learners will also need to describe the transmission of sound waves through a variety of mediums such as air, water and wall partitions, and why the medium is important in simple applications.

Learning aim D

For Distinction standard, learners could carry out an experiment to explain the limits of Ohm's law, and analyse a graph of their results in relation to temperature in an everyday situation (as in a filament bulb, for example). Learners need to evaluate their results from the investigation into thermistors or LDRs and suggest improvements that could be used in a real-life application.

For Merit standard, learners should use their results from D.P9 to calculate resistance from measured current and voltage in series and parallel circuits, using resistance = voltage / current. Learners need to process the results of their investigation into thermistors or LDRs to draw conclusions mathematically or graphically, for example to conclude which of a set of LDRs is most appropriate.

For Pass standard, learners will need to construct circuits and connect meters correctly to measure current and voltage of a suitable number of series and parallel circuits that they have built. Learners will also need to investigate, practically, an application of thermistors or LDRs to generate data on their effectiveness in a range of conditions.

Links to other units and other curriculum subjects

This unit links to:

- Unit 1: Principles of Science
- Unit 3: Energy and Our Universe
- Unit 8: Scientific Skills
- Unit 9: Practical Scientific Project
- Unit 21: Electronics in Action.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers and interview opportunities for medicine/diagnosis using fibre optics
- visits to electronic component and testing manufacturer
- visit to a motor vehicle manufacturer to experience the full range of tests used to improve friction on vehicle tyres.

Opportunities to develop transferable skills

In completing this unit, learners will have the opportunity to develop mathematical skills to achieve an outcome that can be linked to 'real-life' situations. Learners will also gain valuable experience in developing research and planning skills, identifying examples of relevant material and those that can be discarded.

Unit 7: Health Applications of Life Science

Level: **2**
Unit type: **Internal**
Guided learning hours: **30**

Unit in brief

This unit considers a range of factors that affect the health of individuals.

Unit introduction

The knowledge and skills developed in this unit are essential for biological science technicians and scientists working in biology, healthcare, laboratory services and other biology-related industries.

Learners will consider both the positive and negative aspects of diet and exercise, and the learning programme should encourage them to develop a balanced view of issues such as obesity and eating disorders. There will also be an opportunity to study the human immune system and how vaccinations can be used to boost the natural system. Consideration of the public's response to issues surrounding the use of vaccinations could also be included. There is a good opportunity for learners to investigate some of the screening programmes that are used to help early identification of conditions or early diagnosis of disease. A fascinating study can be made of how scientific research has improved in recent years. Other interesting medical applications, such as blood transfusions and stem cell research, are covered in this unit.

By the end of this unit, learners will have gained knowledge of medical advances and research that use biological processes in the prevention and treatment of certain conditions and diseases.

In this unit, learners will be able to build on their understanding of the fundamental concepts of biology that they have learned in previous biology units. This unit enables learners to develop and use their knowledge to investigate health-related factors in more detail.

Learning aims

In this unit you will:

A Investigate factors that contribute to healthy living

B Know how preventative measures can be used to support healthy living

C Investigate how some treatments are used when illness occurs.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Investigate factors that contribute to healthy living	**A1** Diet and health **A2** Exercise and health **A3** Health improvement	A report on the effects of diet and exercise on health and the use of health improvement programmes to promote healthy behaviours.
B Know how preventative measures can be used to support healthy living	**B1** Immunity **B2** Screening programmes	Producing an education programme that explains the use of vaccination and screening and evaluates their effectiveness.
C Investigate how some treatments are used when illness occurs	**C1** Antimicrobials and analgesics **C2** Transfusion and transplantation	Producing an information pack about the use of antimicrobials, analgesics, blood transfusion, organ transplants and stem cell therapy.

Content

Learning aim A: Investigate factors that contribute to healthy living

A1 Diet and health

- Principles, characteristics and the concept of a healthy balanced diet, including recommended daily intake of all food groups, and how dietary imbalance may lead to disorder in the human body, to include:
  - main food groups, e.g. proteins, carbohydrates, fats, vitamins, minerals and their functions
  - undereating and overeating
  - age and level of activity.

A2 Exercise and health

- The impact of exercise on the health of the human body, to include:
  - positive and negative effects of exercise, e.g. stress, cardiovascular health
  - weight-related issues
  - physical mobility issues.

A3 Health improvement

- Lifestyle measures to improve the health of the population, e.g. in relation to unhealthy eating, smoking and alcohol intake.

Learning aim B: Know how preventative measures can be used to support healthy living

B1 Immunity

- Principles of the immune system and immune response as the human body's first line of defence, to include:
  - physical barriers
  - chemical defences
  - non-specific responses, e.g. inflammation, phagocytosis
  - specific responses, e.g. antibodies
  - potential advantages and disadvantages of vaccination programmes.

B2 Screening programmes

- Screening programmes on the human body and their advantages and disadvantages, to include:
  - screening programmes to detect cancer, e.g. breast and prostate
  - screening programmes for antenatal, e.g. Down's syndrome
  - screening programmes for the newborn, e.g. phenylketonuria (PKU)
  - vascular screening programmes, e.g. atherosclerosis.

Learning aim C: Investigate how some treatments are used when illness occurs

C1 Antimicrobials and analgesics

- Principles, advantages/disadvantages and the use/misuse of simple treatments of disorders, to include:
  - antibiotics
  - anti-fungal treatments
  - antiviral treatments
  - analgesics.

C2 Transfusion and transplantation

- Principles and the uses of:
  - blood grouping and blood transfusion
  - organ donation
  - stem cell therapy.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Investigate factors that contribute to healthy living		
A.P1 Describe the possible effects of diet and exercise on the functioning of the human body. **A.P2** Develop a diet and exercise plan based on level and type of exercise and appropriate nutritional balance, to promote healthy living for an individual. **A.P3** Describe the ways in which health improvement measures are intended to improve the health of the population.	**A.M1** Explain how the diet and exercise plan will affect the functioning of the human body. **A.M2** Analyse rates of disease in the population in relation to lifestyle choices.	**A.D1** Evaluate the diet and exercise plan, and justify the menus and activities chosen. **A.D2** Evaluate measures taken to improve the health of the population.
Learning aim B: Know how preventative measures can be used to support healthy living		
B.P4 Describe how the immune system defends the body in relation to specific and non-specific immune responses. **B.P5** Describe the changes in the human body following vaccination. **B.P6** Describe the role of specific health screening programmes.	**B.M3** Compare the different defence mechanisms the immune system uses to protect the human body. **B.M4** Discuss the advantages and disadvantages of a specific health screening programme.	**B.D3** Evaluate the effectiveness of human vaccination and screening programmes.
Learning aim C: Investigate how some treatments are used when illness occurs		
C.P7 Investigate the use and misuse of antibiotics using secondary data. **C.P8** Describe the use of anti-fungal, antiviral and analgesic treatments. **C.P9** Explain the importance of blood group matching in blood transfusions.	**C.M5** Analyse the effectiveness of different kinds of medical treatment in healthcare using secondary data. **C.M6** Describe organ donation and approaches used to reduce rejection.	**C.D4** Evaluate the use of different kinds of medical treatment, justifying your opinions. **C.D5** Evaluate the potential benefits of stem cell therapy.

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is also further information on our website.

There is a maximum number of three summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.P2, A.P3, A.M1, A.M2, A.D1, A.D2)

Learning aim: B (B.P4, B.P5, B.P6, B.M3, B.M4, B.D3)

Learning aim: C (C.P7, C.P8, C.P9, C.M5, C.M6, C.D4, C.D5)

Further information for teachers and assessors

Resource requirements

There are no special resources needed for this unit.

Essential information for assessment decisions

This unit is assessed internally by the centre and externally verified by Pearson. Please read this guidance in conjunction with *Section 6 Internal assessment*.

The contents of this unit should be approached from a practical point of view as far as possible, for example through scientific investigative assignments.

Learning aim A

For Distinction standard, learners will justify the food choices for their diet plan and the activities chosen for the exercise plan. They need to link age and lifestyle to the choices given.

Learners must evaluate measures taken to improve the health of the population by looking at three different lifestyle choices, including smoking and unhealthy eating, and the measures taken to counteract (or cut out) these choices, for example eating freshly prepared foods rather than consuming convenient fast foods.

For Merit standard, learners need to demonstrate their understanding of diet and health by explaining how their diet and exercise plan will affect the functioning of the body.

Learners must analyse the rates of disease in the population in relation to lifestyle choices. This could be done from a case study from information given to learners by the teacher.

For Pass standard, learners need to provide evidence of a basic knowledge of the possible effects of diet and exercise on the functioning of the human body, to enable them to develop a diet and exercise plan for an individual. This must cover the following: balanced food groups (fats, carbohydrates, protein, vitamins and minerals); recommended daily intake; exercise (frequency, type and level appropriate to life stage).

Learners need to describe specific health improvement measures and their effects on rates of non-infectious disease.

Learning aim B

For Distinction standard, learners must evaluate the effectiveness of vaccination and screening programmes. Learners should evaluate at least three of the screening programmes identified in the learning aim. The evaluations should consider benefits and drawbacks, giving specific examples, and must lead to rational conclusions based on the information discussed in their account.

For Merit standard, learners need to compare how specific and non-specific immune responses, physical barriers and chemical defences prevent disease.

Learners need to discuss health screening programmes as in content B2, in the context of their advantages and disadvantages. This could be done in the form of a report or presentation with a table.

For Pass standard, learners need to describe the role of the immune system in the defence of the body and the changes that result in the body following vaccination.

Learners must also describe the main purposes and features of screening programmes for the conditions listed in the unit content.

Learning aim C

For Distinction standard, learners should use examples to evaluate the uses of antibiotics, antifungals and antiviral medicines. They must discuss the uses, benefits, risks and disadvantages of each and justify the choice of treatment for different infections.

Learners need to evaluate stem cell therapy, considering its current and potential benefits and the concerns, disadvantages and risks involved in specific uses.

For Merit standard, learners must use secondary data to analyse the effectiveness of antibiotics, antivirals and antifungals against infections. Learners should use examples to demonstrate an understanding of how the overuse of antibiotics contributed to the increase in hospital-acquired infections. The effectiveness of the treatments covered in the unit content can then be considered.

Learners need to give a description of the principles and uses of organ donation and the methods used to reduce organ rejection.

For Pass standard, learners should investigate and describe the use of antimicrobial and analgesic medicines. This must include the use of examples to describe the correct use of antibiotics, their ineffectiveness against viral infections, the need to complete the course and the consequences of misuse. They must also include descriptions of the correct use of antifungals, antivirals and analgesics.

Learners must explain the importance of blood group matching in transfusions by identifying ABO and Rh blood groups and identifying antibody/antigen interactions in the ABO system.

Links to other units and other curriculum subjects

This unit links to:

- Unit 1: Principles of Science
- Unit 4: Biology and Our Environment
- Unit 16: Science in Medicine.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers
- work experience.

Opportunities to develop transferable skills

In completing this unit, learners will have the opportunity to develop communication skills and the ability to present and interpret numerical data.

Unit 8: Scientific Skills

Level: **2**
Unit type: **Pearson set assignment**
Guided learning hours: **30**

Unit in brief

This unit enables learners to understand the skills required to undertake a scientific investigation.

Unit introduction

The aim of this unit is to further develop learners' knowledge and understanding of the scientific process and build on the scientific investigation skills they have developed in other units.

It is essential that scientists have good investigatory skills, for example:

- carrying out theoretical and practical research
- working in a pilot scale department
- carrying out quality control tests on chemical, biological or physical samples during the stages of the manufacture of products
- calibrating audiological, optical or medical equipment to ensure accuracy of readings when testing hearing
- growing cultures in a laboratory
- testing waste products
- ensuring food products are not harmful
- ensuring water is safe to drink
- testing and drawing conclusions from forensic science evidence.

The Pearson Set Assignment will require learners to demonstrate understanding and skills regarding planning, processing, presenting and analysing data, drawing conclusions and evaluating methodology.

Learners will need to demonstrate the application of the skills learned in this unit, based on familiar and unfamiliar contexts given in an assignment.

This unit will draw on learners' knowledge and understanding from Units 1 to 7 of this qualification.

When developing investigative skills learners can work together; however, for the assignment learners will work independently.

Assessment

This unit has a set assignment. Learners must complete a Pearson Set Assignment Brief.

Learning aims

In this unit you will:

A Understand how to produce an effective plan for an investigation

B Process, present and analyse data, drawing evidence-based conclusions from a practical investigation

C Evaluate evidence and investigative methods.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand how to produce an effective plan for an investigation	**A1** Produce an effective plan **A2** Provide a hypothesis	This unit is assessed through a Pearson Set Assignment.
B Process, present and analyse data, drawing evidence-based conclusions from a practical investigation	**B1** Process and present data **B2** Analyse data and draw evidence-based conclusions	
C Evaluate evidence and investigative methods	**C1** Draw inferences from a conclusion **C2** Evaluate investigative methods	

Content

Learning aim A: Understand how to produce an effective plan for an investigation

A1 Produce an effective plan

- Planning an investigation:
  - identify relevant equipment and give reasons for choices
  - identify risks that are relevant to the method and describe how they will be managed (risk assessment)
  - identify appropriate variables (dependent and independent) and describe how they will be controlled
  - give a suitable range and number of measurements and explain why these were chosen
  - outline a logically ordered method appropriate to a given hypothesis
  - outline a method of recording and processing the results.

A2 Provide a hypothesis

- Give a hypothesis based on relevant scientific ideas.
- Qualitative investigations, e.g. species present in a habitat, ions present in a compound, type of radiation.
- Quantitative investigations, e.g. population counts, concentration of a solution, velocity of moving particles.

Learning aim B: Process, present and analyse data, drawing evidence-based conclusions from a practical investigation

B1 Process and present data

- Tabulate data in a clear, logical way:
  - with appropriately headed columns
  - with units
  - in ascending order of independent variables.
- Identify anomalous results in tabulated data.
- Identify approaches to deal with anomalous results in tabulated data.
- Calculations from tabulated data:
  - excluding anomalous results where appropriate
  - calculating averages
  - calculations using given equations.
- Demonstrate appropriate use of significant figures and application of the correct level of accuracy to which a result can be used.
- Draw graphs:
  - bar charts
  - line graphs
  - pie charts.
- Identify anomalous results on graphs.

- Draw lines of best fit on graphs:
  - appropriate to the data, excluding any anomalies where appropriate
  - straight line of best fit
  - curve of best fit.
- Obtain data from a given graph to find a specific value.
- Obtain data from a given graph to carry out calculations.

B2 Analyse data and draw evidence-based conclusions

- Explain why anomalous results occur:
  - and do not fit the pattern of results
  - in the experimental process.
- Describe the trends and patterns identified in tabulated data and graphs:
  - directly and indirectly proportional
  - positive and negative correlation
  - quantitative relationships.
- Analyse evidence to draw a conclusion.

Learning aim C: Evaluate evidence and investigative methods

C1 Draw inferences from a conclusion

- Validity of evidence:
  - comment on the extent to which the evidence supports the conclusion
  - comment on the extent to which the hypothesis is supported by evidence.

C2 Evaluate investigative methods

- Effectiveness of investigative methods:
  - advantages and disadvantages of the method used
  - suggesting improvements
  - ways of extending the investigation to support the hypothesis further.

Assessment criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">Learning aim A: Understand how to produce an effective plan for an investigation</td><td rowspan="2">A.D1 Justify the plan with regard to testing the hypothesis, suggesting possible improvements.</td></tr>
<tr><td>A.P1 Write a hypothesis for an investigation based on relevant scientific ideas.
A.P2 Describe a planned method for a scientific investigation.
A.P3 Identify hazards and risks associated with the planned scientific investigation.</td><td>A.M1 Explain the appropriate variables and how and why they need to be controlled.
A.M2 Explain how potential risks will be managed.</td></tr>
<tr><td colspan="2">Learning aim B: Process, present and analyse data, drawing evidence-based conclusions from a practical investigation</td><td rowspan="2">B.D2 Evaluate the outcomes from the scientific investigation, suggesting possible improvements to the methodology.</td></tr>
<tr><td>B.P4 Carry out a given method for a scientific investigation in order to generate data.
B.P5 Record data obtained from the scientific investigation.</td><td>B.M3 Process the data obtained from the scientific investigation.
B.M4 Analyse the data obtained from the scientific investigation, including the observation of anomalous results.</td></tr>
<tr><td colspan="2">Learning aim C: Evaluate evidence and investigative methods</td><td rowspan="2">C.D3 Evaluate the methods and how to improve the data obtained in order to support the hypothesis and conclusion.</td></tr>
<tr><td>C.P6 Identify patterns in data which support the hypothesis of a scientific investigation.
C.P7 Draw conclusions from a scientific investigation.</td><td>C.M5 Explain the conclusions by including relevant scientific ideas.</td></tr>
</table>

Essential information for assignments

This unit is assessed using a Pearson Set Assignment Brief. A set assignment must be used to assess the learner.

Further information for teachers and assessors

Resource requirements

There are no special resources needed for this unit.

Essential information for assessment decisions

Learning aim A

For Distinction standard, learners must refer to the scientific principles underlying the investigation to justify the plan and explain how the method used can test the hypothesis. They must also suggest how the plan for the investigation could be improved in order to justify the hypothesis more effectively.

For Merit standard, learners must be able to define what is meant by dependent and independent variables with reference to planning the investigation. They must also explain how they will be controlled and the importance of doing this in the investigation. Learners will have identified the potential risks involved in carrying out the investigation, but they must assess the degree of risk in terms of the potential hazard and explain how the risks will be managed. (It is recognised that the level of risk will vary for different investigations.)

For Pass standard, learners must write a hypothesis for the scientific investigation that is based on the scientific principles underlying the investigation, i.e. there must be some justification for it on the basis of the scientific principles involved. There must be a description of how the method used to test the hypothesis will be carried out. This can involve a series of steps in numerical order, which should include reference to the preparation of materials and equipment, appropriate observations and measurements, and how the latter will be recorded. The potential hazards and risks identified in the investigation can be referred to in the appropriate steps of the method and/or summarised separately.

Learning aim B

For Distinction standard, learners must be able to evaluate the outcome of the scientific investigation with reference to the scientific principles involved. They should outline how the results of the investigation could be further checked in order to confirm the effectiveness of the method used or suggest how the investigation could be taken further.

For Merit standard, learners must process the data obtained from the scientific investigation, using line graphs (clearly showing the line of best fit through the points), bar charts or pie charts. All graphs and charts should be correctly titled, labelled and show the correct units. Calculations from tabulated data should demonstrate the correct level of accuracy and appropriate use of significant figures and standard form. There should be a clear analysis of the results obtained, observing trends. At least two possible reasons should be given for anomalous results (or if these are not present the potential for them to arise).

For Pass standard, learners must provide evidence that they have carried out the practical investigation. This could be a written log of their activities and/or an observation or witness statement by the assessor. They must be able to tabulate the data obtained from the investigation in a clear and logical manner. This should have appropriately headed columns, show the correct units and be in ascending numerical order of independent variables.

Learning aim C

For Distinction standard, learners must evaluate the method used for generating the evidence that supports the hypothesis and conclusion. They should state the advantages and disadvantages of the method, suggesting improvements and ways of extending the investigation to further support the hypothesis.

For Merit standard, learners must explain the extent to which the evidence supports the conclusion and the extent to which the outcome supports the hypothesis. There must be reference to the scientific principles underlying the investigation.

For Pass standard, learners must identify at least two patterns in the data from the scientific investigation that support the hypothesis. They should use this to draw conclusions from the scientific investigation.

Assessment controls

Time: this assignment has a recommended time period. This is for advice only and can be adjusted depending on the needs of learners.

Supervision: you should be confident of the authenticity of learner's work. This may mean that learners be supervised.

Resources: all learners should have access to the same types of resources to complete the assignment.

Research: learners should be given the opportunity to carry out research outside of the learning context if required for the assignment.

Links to other units and other curriculum subjects

This unit links to:

- Unit 1: Principles of Science
- Unit 2: Chemistry and Our Earth
- Unit 3: Energy and Our Universe
- Unit 4: Biology and Our Environment
- Unit 5: Applications of Chemical Substances
- Unit 6: Applications of Physical Science
- Unit 7: Health Applications of Life Science.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers and interview opportunities
- work experience
- visits to appropriate business organisations.

Opportunities to develop transferable skills

In completing this unit, learners will have the opportunity to develop skills in planning scientific investigations, presenting and processing data, and evaluating evidence and the investigative methods used.

Unit 9: Practical Scientific Project

Level: **2**
Unit type: **Pearson set assignment**
Guided learning hours: **30**

Unit in brief

This unit enables learners to further develop the understanding and skills acquired in *Unit 8: Scientific Skills* and other units to undertake a scientific project.

Unit introduction

In the scientific workplace, project management skills are essential for carrying out many jobs in research and development, manufacturing, quality control and analysis, for example. Different project management skills are necessary in each stage of a project: when planning; assembling apparatus; carrying out practical work safely; collecting; recording and presenting reliable data; analysing, evaluating results and drawing conclusions. This also includes skills such as following procedures, writing scientific logs, making accurate observations, accounting for errors and writing scientific reports.

At the beginning of this unit learners will choose and plan an appropriate scientific project, including identifying risks and health and safety considerations. They will be given opportunities to explore and investigate areas of scientific theory that they may have come across in their studies or in their workplace. This does not need to be a piece of original work.

Learners will be given the opportunity to investigate areas of interest that excite and extend their learning. They may be asked to carry out a practical investigation designed by somebody else or to suggest ways of carrying out an investigation of their own design. The scientific project is designed so they can show their scientific knowledge and practical skills.

After a discussion with their teacher, learners will be asked to plan, carry out and analyse the results of their investigation and present it as a scientific report. They will need to make a record of their activities as they carry out the project and monitor the progress against the original plan that they gave to their teacher.

Learners will carry out research, apply it to the project outcomes and present the outcomes as a scientific report. They will then review the project, analysing the information and drawing their own conclusions, as well as reviewing their own performance. Learners must make sure that they use clear communication skills so that a wider audience could understand the work.

The aim of this unit is to allow learners to build on their understanding of existing theories or practical work by carrying out a practical science project related to an area that is of interest. The unit draws on the skills developed in Units 1 to 8.

Assessment

This unit has a set assignment. Learners must complete a Pearson Set Assignment Brief.

Learning aims

In this unit you will:

A Plan a practical scientific project

B Use practical skills for scientific projects

C Analyse and present results.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Plan a practical scientific project	**A1** Project plan **A2** Health and safety and risk assessment **A3** Experimental methodology **A4** Use of information resources	This unit is assessed through a Pearson Set Assignment.
B Use practical skills for scientific projects	**B1** Experimental techniques **B2** Adherence to health and safety requirements **B3** Practical skills **B4** Recording results	
C Analyse and present results	**C1** Collection and processing of data **C2** Experimental accuracy **C3** Conclusions and evaluation **C4** Writing a report	

Content

Learning aim A: Plan a practical scientific project

A1 Project plan

- Aim.
- Scientific research.
- Hypothesis.
- Resources and equipment needed*.
- Outline of the activities suggested with a timetable.

A2 Health and safety and risk assessment

- Identification of health and safety risks and how to carry out an appropriate risk assessment*.
- Elimination and minimisation of any health and safety risk in accordance with:
  - appropriate legislation, e.g. UK Health and Safety at Work Act
  - Control of Substances Hazardous to Health (COSHH) Regulations
  - risk assessment
  - reporting, e.g. in UK Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR)
  - codes of practice
  - Good Laboratory Practice (GLP) and/or Good Manufacturing Practice (GMP) and/or Good Clinical Practice (GCP) as appropriate.

A3 Experimental methodology*

- Ensuring accurate and valid results:
  - observation
  - measurement/repeat measurement.
- Variables:
  - dependent and independent variables
  - controlling variables.

A4 Use of information resources

- Sourcing information:
  - identification of suitable information sources
  - location and extraction of relevant information sources (background reading, observations, previous investigations)
  - recording of information sources as a resource list.

* This builds on the content in *Unit 8: Scientific Skills* in relation to the planning of a scientific investigation.

Learning aim B: Use practical skills for scientific projects

B1 Experimental techniques

- Assembly of relevant equipment and materials.
- Following correct procedure.

B2 Adherence to health and safety requirements

- Appropriate legislation, e.g. UK Health and Safety at Work Act.
- Control of Substances Hazardous to Health (COSHH) Regulations.
- Risk assessment.
- Reporting, e.g. in UK Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR).
- Codes of practice.
- Good Laboratory Practice (GLP) and/or Good Manufacturing Practice (GMP) and/or Good Clinical Practice (GCP) as appropriate.

B3 Practical skills

- Appropriate use of equipment.
- Techniques for taking measurements.
- Observational skills when carrying out practical work.
- Repeating measurements when necessary.

B4 Recording results

- Accuracy.
- Suitable range and repeats of measurements.
- Maintenance of working laboratory logbooks and record keeping with integrity.

Learning aim C: Analyse and present results

C1 Collection and processing of data

- Collection of practical data and organisation into an appropriate format.
- Methods of data processing and analysis:
  - using mean, standard deviation, or other appropriate methods.
- Use of correct units of experimental quantities.

C2 Experimental accuracy

- Assessment of experimental accuracy* and precision:
  - in terms of the instruments used
  - accurate calculations.
- Validation of method and results.
- Identification of sources of error:
  - systematic and random errors
  - magnitude of errors in readings taken
  - error and accuracy in terms of the instruments being used.
- Identification of ways of minimising errors.

C3 Conclusions and evaluation

- How to draw conclusions* using scientific principles.
- How to carry out and record literature investigations.
- Consideration of the validity of the original hypothesis.
- Evaluation of methodology and conclusions.

C4 Writing a report

- How to write a scientific report of the investigation following correct scientific protocol in terms of:
  - structure
  - format
  - correct scientific language and terminology.
- How to include relevant references in the final report.

*This builds on the content in *Unit 8: Scientific Skills*.

Assessment criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">Learning aim A: Plan a practical scientific project</td><td rowspan="2">A.D1 Produce a comprehensive project plan that fully tests the hypothesis and will produce accurate and valid results using secondary sources.</td></tr>
<tr><td>A.P1 Produce a project plan using information from secondary sources.
A.P2 Describe the health and safety risks associated with the project plan and how they can be minimised.</td><td>A.M1 Produce a detailed project plan that will produce accurate and valid results.</td></tr>
<tr><td colspan="2">Learning aim B: Use practical skills for scientific projects</td><td rowspan="2">B.D2 Carry out practical work independently using appropriate equipment and techniques, using a suitable range of measurements, repeating measurements where necessary.</td></tr>
<tr><td>B.P3 Assemble and use appropriate equipment safely to collect reliable scientific data.
B.P4 Record scientific data, with appropriate headings, units and accuracy of data.</td><td>B.M2 Carry out practical work independently using appropriate equipment and techniques, and accurately recording results.</td></tr>
<tr><td colspan="2">Learning aim C: Analyse and present results</td><td rowspan="2">C.D3 Evaluate the scientific project and suggest changes to improve the validity of the outcomes.</td></tr>
<tr><td>C.P5 Explain the results of a scientific project.
C.P6 Present conclusions to a scientific project.
C.P7 Produce an accurate scientific report following accepted protocol.</td><td>C.M3 Draw own conclusions from scientific data following mathematical processing.</td></tr>
</table>

Essential information for assignments

This unit is assessed using a Pearson Set Assignment Brief. A set assignment must be used to assess learners.

Further information for teachers and assessors

Resource requirements

There are no special resources needed for this unit.

Essential information for assessment decisions

Learning aim A

For Distinction standard, learners will be assessed by the teacher and this includes learners being aware of constraints when using a laboratory. Learners need to show how their practical work fully tests the hypothesis, and if the initial data collected doesn't allow this, explain how further data will need to be collected.

For Merit standard, learners are expected to produce a project plan that should include the methodology and a summary of their research and relate the latter to their planned investigation. Learners will need to describe a number of research sources, including at least two different types of source, and show how the information obtained influenced (affected) their plans. Learners should show how the methodology is linked to the hypothesis and the minimisation of risk.

For Pass standard, learners must produce a detailed realistic working project plan that they have identified using secondary sources. The plan must clearly state the aim of the investigation, any research from secondary sources needed to complete the project, an appropriate list of resources and equipment needed, and an outline of the methodology. It should also incorporate a number of milestones or identified review points. Learners should consider and describe any health and safety risks that could be associated with the proposed project and practical investigation. They should show evidence of having carried out risk assessments and of taking steps to remove or reduce the identified risks.

Learning aim B

For Distinction standard, learners need to ensure that the practical work allows collection of a suitable range of measurements, which are repeated as necessary. Practical work will be well planned and carried out and reviewed with the minimum of support.

For Merit standard, learners will use specialist language more readily and demonstrate a greater level of understanding of the topic investigated. The practical work will be completed using appropriate techniques and equipment and will be well organised. This will enable them to discuss the importance of their laboratory books being accurate and well maintained.

For Pass standard, learners will be assessed performing the investigation in the laboratory. Learners must be observed as they assemble and use equipment and materials safely under supervision. Assessors must use observation records to satisfy this level. The recording of results and observations must be done through a working laboratory log, following industry guidelines as appropriate, and should pay attention to suitable levels of accuracy and precision.

Learning aim C

For Distinction standard, learners must evaluate the success, or otherwise, of their project. They must assess (decide) on the validity of the information they have obtained and decide whether their original hypothesis has been validated. The reasons for success or lack of success should be discussed (indicated). It may also include an identification of what they have learned and skills that they have used during the investigation, or what they would do differently next time, but this must be meaningful to the investigation and not just a bland generic statement. (The Distinction grade learner will use the teacher as a resource when necessary, will utilise a wide range of information sources and will show a detailed understanding of the concepts involved in the project.)

For Merit standard, quantitative analysis is required. It may be something as simple as finding the mean or using a standard deviation test. Learners then need to draw their own conclusions from this processed data.

For Pass standard, the practical data obtained should be organised and processed so that the results can be explained using methods suitable for the type of data collected. A qualitative approach is sufficient to meet this standard but learners must show that they have analysed their results. Correct SI units (Système International d'Unités) should be used and calculations must be accurate, with results that are clearly wrong being identified, checked and corrected. Sources of systematic and random errors must be identified. Learners must draw together the results of their work, clearly stating conclusions drawn from the data they obtained during the practical investigation. A scientific report must be produced that follows accepted scientific protocol in terms of the major headings used and with an attempt to write in the past tense and third person. All tables or diagrams should be labelled correctly. Errors caused by instruments and the accuracy of measurements must be discussed.

Assessment controls

Time: this assignment has a recommended time period. This is for advice only and can be adjusted depending on the needs of learners.

Supervision: you should be confident of the authenticity of learner's work. This may mean that learners be supervised.

Resources: all learners should have access to the same types of resources to complete the assignment.

Research: learners should be given the opportunity to carry out research outside of the learning context if required for the assignment.

Links to other units and other curriculum subjects

This unit links to:

- Unit 8: Scientific Skills.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers and interview opportunities
- work experience
- business material as exemplars
- visits to appropriate business organisations.

Opportunities to develop transferable skills

In completing this unit, learners will have the opportunity to develop research and planning skills.

Unit 10: World Energy

Level: **2**
Unit type: **Internal**
Guided learning hours: **30**

Unit in brief

This unit enables learners to learn about energy resources and energy demands.

Unit introduction

The demand for energy is growing as the human population rapidly increases. New sources of fossil fuels are being discovered and technological advances have meant that we can increase the amount of fossil fuels we can extract from present sources. New technologies have also meant that other sources of environmentally friendly sustainable energy have made an impact on demand. Global warming has brought countries together to sign international agreements to limit the amount of fossil fuels we use and limit carbon dioxide emissions. This movement towards sustainability has meant that many new environmental science occupations have been made available in the energy sector.

In this unit, learners will be introduced to more applications of energy, energy resources, factors affecting energy demands, and how those demands may be achieved in the future.

Learners will be given the opportunity to question why there is an apparent energy shortage and why it is claimed that the human race is affecting the natural environmental balance.

Learners will explore the importance of energy in our current way of life. This unit also gives them an insight into the reasons why most energy produced for human consumption comes at a high price. They will gain an understanding of the difficulties faced in producing energy by environmentally friendly methods and identify additional human problems that must be considered.

Learners will have the opportunity to study causes and possible preventions of pollution of the atmosphere and gain an appreciation of the important part that we can all play in conserving energy, recycling and accepting new and sustainable technologies.

Learners will also be introduced to key terms, such as 'low carbon economy', 'carbon footprint', and terms associated with the development of new technologies. In addition, this unit may help to raise learners' awareness of and interest in the activities of energy-producing industries and possible future employment in an energy-related organisation.

The aim of this unit is to enable learners to build on and apply fundamental energy concepts that they have learned in *Unit 1: Principles of Science, Unit 3: Energy and Our Universe* and *Unit 6: Applications of Physical Science*.

Learning aims

In this unit you will:

A Investigate present-day energy resources

B Investigate energy demands

C Explore future energy sources and energy storage.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Investigate present-day energy resources	**A1** Uses of energy **A2** Energy resources **A3** Relative costs and availability	Describing our present uses for electricity in the home and in industry. Implications of not having electrical energy. Describing the need for fuels in industry, manufacturing and transportation. Development of energy resources, including explanation of the formation of fossil fuels, nature of nuclear power, hydroelectricity and other renewable forms. Comparison of costs between fossil fuels and renewable forms of energy. Availability of fossil fuels based on the top five oil-producing countries.
B Investigate energy demands	**B1** Demand for energy **B2** Managing future demand for energy **B3** Key terminology	Describing how the world's population has increased in the last 200 years and comparison of population densities in various regions of the world. Looking at population demand and technological advances in industrial techniques as a way of managing the future demand for energy. Appraisal of effectiveness of world agencies to monitor and control environmental damage. Report on energy efficiencies, renewable energy and recycling. Definitions of key terms used in the management of energy demand.

Learning aim	Key content areas	Assessment approach
C Explore future energy sources and energy storage	**C1** Using unconventional fossil fuels **C2** Reducing our energy needs **C3** Energy storage methods	Description of availability of future fuel, demands and implications of continued use. Appraisal of effectiveness of alternative energy methods and reducing energy usage with improved technology. Description of developments in biofuels and future of nuclear power. Explanation of future storage methods and energy storage, including fuel cells and batteries.

Content

Learning aim A: Investigate present-day energy resources

A1 Uses of energy

- Electricity uses in our homes and in industry.
- Use of fuels in transport, industry and manufacturing.
- Fossil fuels and their formation (coal, oil and gas).
- Nuclear power.
- Hydroelectric power.
- Renewable forms of energy, including wind, geothermal, solar, biomass and waste, wave energy production and tidal energy.
- Relative costs, e.g. comparison of fossil fuels with alternative energy resources.
- Estimated availability of fossil fuels in the major producing countries, e.g. Saudi Arabia, United States of America (USA), Russia and Caspian region, Iraq.

A2 Energy resources

- Formation of fossil fuels.
- Description of nuclear power.
- Description of renewable fuels for electricity generation, such as hydroelectricity, solar panels and wind turbines, biomass and waste, wave energy production and tidal energy.

A3 Relative costs and availability

- Comparisons of fossil fuels with renewable energy resources.
- Estimated availability of fossil fuels in the major producing countries (Saudi Arabia, United States of America (USA), Russia and Caspian region, Iraq).

Learning aim B: Investigate energy demands

B1 Demand for energy

- Significance of world population increase in the last 200 years and geographical placement in affecting energy demands.
- Importance of invention and discovery in the Industrial Revolution in increasing energy demands (reliance on use of machinery/manufacturing/transport and dependence on natural resources).
- Relative usage and dependence on fossil fuels of major countries and emerging super-economies (China and India).
- Impact of increasing energy demand on the environment.

B2 Managing future demand for energy

- Importance of environmental monitoring and control (World Energy Council, International Energy Agency (IEA) and 28 member countries, 2009 Copenhagen Accord, G20 and reduction in fossil fuel subsidies).
- Improving energy efficiency (lighting, managing energy, insulation, low-power electronics).
- Improving resource efficiency (recycle, reduce packaging, less energy-intensive manufacturing, sustainable agriculture, low-carbon materials).
- Increasing use of renewable energies.

B3 Key terminology

- Low-carbon economy (low dependence on fossil fuels).
- Carbon footprint (our production of greenhouse gases in tonnes/kg).
- Global emissions (the production of greenhouse gases by all countries).

Learning aim C: Explore future energy sources and energy storage

C1 Using unconventional fossil fuels

- Shale oil.
- Canadian sands.
- Venezuelan 'extra heavy'.
- Caspian region oil and gas production.
- Implications of using high carbon dioxide (CO_2) emission sources.
- Implications of continued use of fossil fuels.

C2 Reducing our energy needs

- Low-carbon buildings.
- Low-energy buildings.
- Efficient industrial equipment.
- Improved and sustainable alternatives (solar panels, wind turbines).
- Public acceptance of renewable energy.
- Political willpower and funding.
- Emission control technology.
- Future plans for nuclear power.
- Carbon pricing policy for big companies.

C3 Energy storage methods

- Hydrogen economy and fuel cells.
- Improved batteries.
- Flywheel technology and capacitors (electrical energy).
- Heat-storage methods.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Investigate present-day energy resources		**A.D1** Evaluate the energy resources currently available.
A.P1 Describe current energy resources, their relative costs and how the energy produced is used.	**A.M1** Explain how current energy resources are obtained and how this is reflected in their cost.	
Learning aim B: Investigate energy demands		**B.D2** Evaluate methods available to manage increasing energy demand.
B.P2 Describe the factors associated with energy demand using key terminology.	**B.M2** Explain how energy demand has changed in the last 200 years.	
Learning aim C: Explore future energy sources and energy storage		**C.D3** Evaluate the potential usage of unconventional and other sources of energy.
C.P3 Describe future energy demands, storage and sources. **C.P4** Describe how energy requirements can be reduced.	**C.M3** Explain future energy requirements and the potential of future energy sources, including developments in storage technology.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is also further information on our website.

There is a maximum number of seven summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.M1, A.D1)

Learning aim: B (B.P2, B.M2, B.D2)

Learning aim: C (C.P3, C.P4, C.M3, C.D3)

Further information for teachers and assessors

Resource requirements

There are no special resources needed for this unit.

Essential information for assessment decisions

Learning aim A

For Distinction standard, learners must evaluate the energy resources currently available by providing a suitable table, showing the advantages and disadvantages of each type of resource. This should also include relative costs of production, availability in terms of amount and geographical area, damage caused to the environment and costs per unit. This table will allow learners to form their own opinions about the difficulties faced when selecting energy resources.

For Merit standard, learners must explain how the energy sources identified for A.P1 are obtained and how the process of obtaining these resources is reflected in their cost.

For Pass standard, learners need to describe each of the listed energy resources and provide relative costs per unit of electricity. The ways in which the energy produced from these resources is used must be included, with suitable examples.

Learning aim B

For Distinction standard, learners could produce a case study that evaluates the ways in which we can all manage the increasing demand for energy. There are numerous means available, from simply turning off unwanted lighting to the installation of solar panels in our roofs. Learners can demonstrate free thinking for this task. The content of the case study must be comprehensive and must include the impact of global monitoring treaties and the growth of energy-efficient and resource-efficient techniques.

For Merit standard, learners must explain the developments in energy demand using a timeline of events over the last 200 years. Research is fundamental for this task and can illustrate the extent to which oil production has increased and renewable energy resources are being used. This information can be presented on a world map, showing the areas of growth in demand over the course of time. Learners must also include the trend for forthcoming large energy demands, such as those from India and China, and a link drawn between the developments of energy demand in the west with those of present-day developing industrial nations.

For Pass standard, learners must describe factors linked to energy demand. Factors must include population growth, global industrial development and transport technology. There should also be mention of the impact of increasing energy demand on the environment and the importance of monitoring world energy usage.

Learning aim C

For Distinction standard, learners must produce a coherent evaluation of the new technologies currently developing in energy production. This will involve, for example, refining of systems in renewable resources, building development and energy storage devices. Learners should identify the need for research funding and political backing to ensure that modern initiatives can reduce energy use in everyday life. This task gives learners an opportunity to consider possible avenues for future energy, such as continued oil and gas production in some parts of the world, unconventional supplies and the feasibility of increasing reliance on more environmentally friendly sources.

It is also expected that the means to reduce energy use, such as efficiencies, carbon pricing and lightweight vehicle manufacture, will be included. An efficiency report could include a comparison between standard and low-energy lighting, for example.

For Merit standard, learners must explain the potential of future energy sources and storage technology to meet the expected future demand. An abundance of information is available on energy sources and storage requirements. The means to store energy for use when needed must be included and there should be particular reference to new technology and renewable energy storage. Learners are to describe batteries, capacitors and flywheel technology.

For Pass standard, learners will need to describe ways to reduce energy requirements, providing useful examples from those studied. Learners should also describe how future energy demand could be met using new sources and storage solutions.

Links to other units and other curriculum subjects

This unit links to:

- Unit 1: Principles of Science
- Unit 2: Chemistry and Our Earth
- Unit 4: Biology and Our Environment
- Unit 8: Scientific Skills
- Unit 13: Monitoring the Environment
- Unit 19: Chemical Analysis and Detection
- Unit 23: Further Chemistry.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers and interview opportunities
- work experience
- visits to appropriate business and industrial organisations, including energy producers.

Opportunities to develop transferable skills

In completing this unit, learners will have the opportunity to develop research and planning skills and use other subject disciplines to inform their research and completion of tasks.

Unit 11: How Scientific Theories Are Formulated

Level: **2**
Unit type: **Pearson set assignment**
Guided learning hours: **30**

Unit in brief

This unit will cover scientific theories and how they are formed.

Unit introduction

Scientific theories have been formulated, revised and improved over thousands of years by philosophers and scientists. Many of these theories have led to scientific and technological advances in many different science fields, such as astronomy, medicine and environmental science. It is important to study scientific theories to enable scientists to apply their knowledge, to use established scientific theory stages with a systematic and logical approach, to test whether a theory is correct and valid, and to ask questions about the validity of the theory.

This unit will help learners understand how scientific theories have been developed and the time and effort it has taken for many of the most well-known theories to become established. In addition, this unit will show learners the difficulties faced by theorists in presenting a new theory. It will highlight the need for a detailed and time-consuming scrutiny of scientific work by peer review before it can become an accepted theory. The unit includes a historical perspective on theory development with a study of some of the most well-known theories put forward by popular scientists.

There is an opportunity for learners to carry out independent research into theories past and present and to learn how to ask the right questions in science. In this unit, learners will be given an opportunity to express their opinions constructively and to demonstrate the thought needed to pose well-constructed questions in order to test the validity of established scientific practices.

This unit will give learners an introduction to investigative science by allowing them to study the fundamental processes that have been the cornerstone of scientific development and understanding for thousands of years.

Assessment

This unit has a set assignment. Learners must complete a Pearson Set Assignment Brief.

Learning aims

In this unit you will:

A Investigate historical scientific theories

B Explore the processes involved in developing a scientific theory

C Investigate the testing of theories and peer review.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Investigate historical scientific theories	**A1** Definition of a theory **A2** Key scientific theories	This unit is assessed through a Pearson Set Assignment.
B Explore the processes involved in developing a scientific theory	**B1** Definitions of hypothesis, validity and reliability **B2** Identification of the characteristic stages in theory development **B3** Data collection methods	
C Investigate the testing of theories and peer review	**C1** The scientific community and general consensus **C2** Scrutiny of a science investigation by other scientists	

Content

Learning aim A: Investigate historical scientific theories

A1 Definition of a theory

- Explaining a particular aspect of the natural world.
- Repeat testing.
- Verification using scientific method.
- Observations using accepted procedures.
- Ensuring appropriate measurements.
- Evaluation of results.
- Experimental controlled conditions.

A2 Key scientific theories

- General aspects, scientists involved and a timeline of important developments.
- Theories:
  - Big Bang theory of the origin of the Universe
  - giant impact theory ('The Big Splash').
- Theories with supporting evidence:
  - Darwin's theory of evolution
  - atomic structure and particle theory
  - the periodic table of elements
  - plate tectonics
  - germ theory
  - Einstein's theory of general relativity
  - Einstein's theory of special relativity
  - Newton's law of gravity
  - Chicxulub impact and the extinction of land dinosaurs
  - cell theory
  - particle theory of matter.

Learning aim B: Explore the processes involved in developing a scientific theory

B1 Definitions of hypothesis, validity and reliability

- Hypothesis:
  - general idea or question
  - testing through further study
  - testing by experimentation.
- Validity:
  - measure of accuracy of an experiment
  - control of all possible variables
  - reducing bias
  - improving measurement technique.
- Reliability:
  - level of consistency in the outcome of results
  - repeated experimentation
  - importance of using the same procedures and technique.

B2 Identification of the characteristic stages in theory development

- Questioning from observation.
- Hypothesis.
- Experimenting.
- Sharing findings.
- Repeated results (how results in science must be repeatable for the work to be recognised).
- The theory.
- Identifying theories where the stages are not so obvious.

B3 Data collection methods

- Correct means of collecting data (including computer automation and manual collection) that is useful to the investigation.
- Controls and placebos in medical research.
- Reducing bias.

Learning aim C: Investigate the testing of theories and peer review

C1 The scientific community and general consensus

- Scientists.
- Details of the groups of people who make up ethics committees.
- How a general consensus of opinion is arrived at within the scientific community.

C2 Scrutiny of a science investigation by other scientists

- The peer review process.
- The difficulties of promoting a theory to other scientists.
- The processes of testing the theory using correct scientific protocols.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Investigate historical scientific theories		**A.D1** Evaluate the strengths and weaknesses of a scientific theory.
A.P1 Describe a historic scientific theory.	**A.M1** Explain the main developments in the history of a scientific theory.	
Learning aim B: Explore the processes involved in developing a scientific theory		**B.D2** Evaluate the validity of collected data to test a scientific theory.
B.P2 Describe the stages in the development of a current scientific theory. **B.P3** Describe data collection methods.	**B.M2** Compare the stages in the development of different scientific theories. **B.M3** Explain the methods used to ensure reliable scientific data collection.	
Learning aim C: Investigate the testing of theories and peer review		**C.D3** Evaluate the strengths and weaknesses of peer review and its role in the acceptance of a scientific theory.
C.P4 Describe the processes by which theories are accepted by the scientific community.	**C.M4** Explain the purpose of a peer review.	

Essential information for assignments

The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.M1, A.D1)

Learning aim: B (B.P2, B.P3, B.M2, B.M3, B.D2)

Learning aim: C (C.P4, C.M4, C.D3)

This unit is assessed using a Pearson Set Assignment Brief. A set assignment must be used to assess learners.

Further information for teachers and assessors

Resource requirements

There are no special resources needed for this unit.

Essential information for assessment decisions

Learning aim A

For Distinction standard, learners need to look at the strengths and weaknesses of a theory, using either a theory they have already studied or another theory. They must then evaluate these and come to some conclusion. Simple descriptions of what happened and when, and any problems, are not enough for this level of work.

For Merit standard, learners must focus on one particular theory and research information regarding important events in its development. As a case study, the theory of evolution is well documented and provides a basis for developing a timeline for other theories. Learners should produce notes for every date presented and explain the main developments.

For Pass Standard, learners need to give a description of a historic theory. This should include general aspects of the theory, scientists involved and a timeline to show how the theory evolved over time.

Learning aim B

For Distinction standard, learners need to evaluate the validity of some data. They will not be expected to know if, for example, the statistical techniques used were correct but they should look for the method of how the data was obtained so they can evaluate its validity. The assessor should be looking for the learners to have identified whether enough data whether collected, were the correct controls were in place, etc.

For Merit standard, learners are required to compare the stages in the development of different theories. At this level, more than two theories in a comparison could cause problems. Learners could draw up a chart or table showing the stages in the development of the two theories and add comments to show how these compare. Learners are required to explain methods for reliable data collection, which may have also been covered in the Pass criteria where repeat results are used, and controls, methods to reduce bias, blind trials, etc. are given.

For Pass standard, learners are required to describe each of the stages identified in theory development, so the assessor can see the learner has understood the process for developing a scientific theory. This will show it is not a haphazard process. They are required to produce a description of data collection methods. This does not involve details of statistical techniques or how to plot different types of graphs. The learners will be expected to describe why data is collected in different ways and by different methods, the necessity of repetition, controls, etc. Both computer-collected data and manually collected data must be covered.

Learning aim C

For Distinction standard, learners will evaluate the strengths and weaknesses of the peer review process, which will follow on from the Merit criteria. The evaluation should balance the facts that experts will review the theory and that testing of the theory often happens after publication, and sometimes testing is not carried out. Learners must identify the various stages in the development of peer review to meet the criteria for Distinction standard. This will involve research, journal publication, editor review, scientific review and the criteria used in this review. Mention should also be made of the possible bias involved in the journal's reasons for publication, for example, as well as the many valid research papers that do not get publicity. Work should then focus on the eventual acceptance of a theory after all the stages have been assessed in the peer review process.

For Merit standard, learners can explain that peer review is undertaken, usually anonymously, by scientists who are qualified and carrying out research in the same field as the paper submitted for review. The learners can then show why such procedures are needed. For example, the peer reviewers work in the same field so they should be able to understand the new ideas being put forward and give opinions on feasibility.

For Pass standard, the process of scrutiny needs to be described here. The learners must show that any scientific theory undergoes certain processes before it is accepted by the scientific community. A description of the processes is needed rather than an explanation of why they occur.

Assessment controls

Time: this assignment has a recommended time period. This is for advice only and can be adjusted depending on the needs of learners.

Supervision: you should be confident of the authenticity of learner's work. This may mean that learners be supervised.

Resources: all learners should have access to the same types of resources to complete the assignment.

Research: learners should be given the opportunity to carry out research outside of the learning context if required for the assignment.

Links to other units and other curriculum subjects

This unit links to:

- Unit 3: Energy and Our Universe
- Unit 17: Understanding Human Behaviour
- Unit 20: Exploring Our Universe
- Unit 21: Electronics in Action.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers
- work experience
- visits to appropriate organisations.

Opportunities to develop transferable skills

In completing this unit, learners will have the opportunity to develop research and planning skills and improve their understanding of scientific procedures and techniques.

Unit 12: The Living Body

Level: **2**
Unit type: **Internal**
Guided learning hours: **30**

Unit in brief

This unit looks at how the main body systems work and how they are controlled by nerves and hormones.

Unit introduction

Knowledge of the human body systems is essential for employees who want to work in many science sectors, such as medical science, sports science, food science, nutrition, beauty therapy sciences, and health and social care. There have been many advances in the study of human body systems, such as 'magnetic resonance imaging' (MRI) scanning of the human body, and in support for human body systems, such as advanced programmable digital hearing aids.

This unit looks at the body systems in terms of their regulatory and coordinating roles. The emphasis is on the link between the structure and its function and understanding the regulatory and coordination functions; cellular details are not required. All the systems in the body are seen as being interconnected. Coordination is through the nervous and endocrine systems.

Learners will be encouraged to see the body functioning as one whole entity rather than a series of systems to be considered in isolation.

This unit will be delivered through a mixture of theoretical and practical learning. Learners will be encouraged to acquire laboratory skills, such as setting up practical experiments that use biological molecules such as enzymes, and carrying out measurements to ascertain data in order to be able to compile reports and present information.

Learning aims

In this unit you will:

A Develop a knowledge of the structure and function of individual body systems

B Develop a knowledge of how body systems are coordinated.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Develop a knowledge of the structure and function of individual body systems	**A1** Digestive system **A2** Respiratory system **A3** Circulatory system **A4** Renal system **A5** Reproductive system	Learners could produce a series of booklets or web pages providing information about the five body systems in the unit content.
B Develop a knowledge of how body systems are coordinated	**B1** Nervous system **B2** Endocrine glands and hormones **B3** Control of functions by the nervous system and hormones	Learners could be given the role of a hospital technician who has been asked to produce an informative booklet that could be given to patients.

Content

Learning aim A: Develop a knowledge of the structure and function of individual body systems

A1 Digestive system

- The structure and function of the digestive system in terms of:
  - mechanical and chemical digestion
  - absorption
  - enzymes as catalysts that help in the digestion and absorption of nutrients.

A2 Respiratory system

- The respiratory system described in terms of the main functions of the structures that enable the exchange of gases:
  - between the lungs and atmosphere
  - between the lungs and blood stream.

A3 Circulatory system

- The structure and function of the circulatory system in terms of maintaining cell and body functions:
  - the heart as the pump; atria and ventricles
  - blood vessels including aorta, arteries, veins, superior and inferior vena cava, pulmonary artery, pulmonary vein
  - oxygenated blood, deoxygenated blood
  - circulatory system as transport system including oxygen, nutrients, hormones.

A4 Renal system

- The renal system described in terms of the main functions of the structures in regulating:
  - fluid balance
  - salt balance
  - pH levels.

A5 Reproductive system

- The structure and function of the reproductive system in terms of:
  - sperm production
  - ovulation
  - fertilisation.

Learning aim B: Develop a knowledge of how body systems are coordinated

B1 Nervous system

- The nervous system as a coordinator of the body:
  - simple spinal reflex arc as an instant reaction to possible danger
  - automatic regulation of visceral activities.

B2 Endocrine glands and hormones

- Endocrine/hormone-producing glands in terms of the regulatory functions of the hormones they produce:
  - pituitary gland
  - thyroid gland
  - adrenal gland
  - pancreas
  - testes
  - ovaries.

B3 Control of functions by the nervous system and hormones

- Fear, fight, flight response:
  - heart rate and blood pressure
  - digestive system
  - metabolic rate
  - sweating
  - timescales of responses to nervous and endocrine controls.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Develop a knowledge of the structure and function of individual body systems		
A.P1 Outline digestion by enzymes and mechanical processes and absorption. **A.P2** Describe the functions of the main respiratory structures. **A.P3** Describe how the circulatory system transports materials to the cells. **A.P4** Outline how the renal system regulates fluid in the body. **A.P5** Describe the functions of the components of the male and female reproductive systems.	**A.M1** Explain how the components of a system are specialised to carry out their function.	**A.D1** Evaluate the impact on the human body if one of the systems malfunctions.
Learning aim B: Develop a knowledge of how body systems are coordinated		
B.P6 Describe how the nervous system controls and coordinates a body system. **B.P7** Describe how a chosen endocrine gland regulates a body system.	**B.M2** Compare and contrast the way in which the nervous system and the endocrine system coordinate body functions.	**B.D2** Explain how the nervous and endocrine systems can work together to regulate body functions.

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is also further information on our website.

There is a maximum number of two summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.P2, A.P3, A.P4, A.P5, A.M1, A.D1)

Learning aim: B (B.P6, B.P7, B.M2, B.D2)

Further information for teachers and assessors

Resource requirements

There are no special resources needed for this unit.

Essential information for assessment decisions

Learning aim A

For Distinction standard, learners are required to choose one of the body systems in this learning aim. For example, they might choose the renal system and its role in controlling pH values. Learners should be able to evaluate what happens if this system does not function correctly, i.e. there could be a change in body fluid pH values, and the subsequent effect, for example on cell functions due to biochemical processes being sensitive to pH values.

For Merit standard, learners can choose a system from those studied. They will need to explain how the various parts of the system are specialised for their function. For example, the learner may choose the respiratory system and highlight the very large internal surface area and blood supply of the lungs and relate this to the efficient exchange of gases.

For Pass standard, learners have to identify the main components of the digestive system and outline mechanical and enzyme-mediated digestion. Learners must include mastication and peristalsis and an outline of the role of enzymes as digestive catalysts. Learners must provide a list of enzymes, their sources (including salivary glands, pancreas, liver and gall bladder) and their functions.

Learners must use annotated diagrams in their description of the structures of the respiratory system and their functions. The chemistry of respiration and the muscles involved in ventilation are not required but learners must include the airways and alveoli that are involved in gaseous exchange between the lungs and the environment and between the lungs and the blood vessels.

Learners need to describe the structure of the circulatory system in terms of its function as a transport system. It is the means by which materials are transported around the human body to the cells that must be described. This includes the role of the heart as a pump and the blood vessels. Detail of the structure of blood vessels is not required.

Learners will need to know the structure of the renal system and its role in regulating fluid in the body. In discussing the regulation of fluid, the learner should also mention the salt balance and pH levels as they are part of this regulatory system. Details of the functions of renal tubules are not required.

Learners are required to identify the main components of the male and female reproductive systems and describe their functions. Diagrams with correct labelling should be used but there is no requirement for detailed cellular information. There is no requirement for details of ovarian/menstrual cycles or for sperm production. It will be sufficient to describe each structure that is involved with the male/female systems.

Learning aim B

For Distinction standard, learners must explain how the functions of the nervous and endocrine systems complement each other in regulating a body function. They should look in detail at one body function, such as respiration, circulation or digestion, but they should also mention other body functions and the regulation by both systems.

For Merit standard, learners need to compare and contrast the coordinating functions of the nervous and endocrine systems. One example could be fast reactions of the nervous system in a reflex action and the release of adrenaline for a longer, more sustained reaction to a stimulus. Learners need to explain why two systems are needed in response to a stimulus. One example will not be sufficient to gain this criterion.

For Pass standard, learners can choose which body system they want to use to show how the nervous system controls the functions of one of the systems in learning aim A. As an example, the learner could describe the effects of the nervous system on secretions of the salivary glands and movements of the alimentary canal. A simple diagram of the link between the salivary glands and the CNS with some explanation will be sufficient.

Learners are required to produce an annotated diagram of a spinal reflex arc. It is essential the learner identifies the fast part of the reaction between the stimulus, receptor to the CNS and back to the muscles. They should also be aware of transmissions to the brain, so coordination of reaction is identified and either the reaction is continued or not.

Learners need to identify correctly the main hormones produced by each of the glands listed in the unit content. For one of the glands they must describe how it is involved in the regulatory process. For instance, the thyroid gland produces hormones that increase the reactivity of the nervous system, resulting in increased metabolism, blood flow and heart rate.

Links to other units and other curriculum subjects

This unit links to:

- Unit 1: Principles of Science
- Unit 7: Health Applications of Life Science
- Unit 16: Science in Medicine
- Unit 17: Understanding Human Behaviour.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers
- work experience.

Opportunities to develop transferable skills

In completing this unit, learners will have the opportunity to develop communication skills.

Unit 13: Monitoring the Environment

Level: **2**
Unit type: **Internal**
Guided learning hours: **30**

Unit in brief

This unit provides learners with the opportunity to further explore the environment, its ecosystems and the steps taken to manage and protect them.

Unit introduction

Human activities that affect the environment such as global warming and pollution are high on the national and international agenda, with regular international environmental sustainability conferences taking place where global agreements have been made. Measures and new technologies needed to counteract global warming and pollution, such as energy efficiency, environmentally-friendly energy usage and production and recycling, are seen as vital in this process. It is recognised that environmental monitoring is an essential part of measuring the progress of environmental sustainability.

Knowledge and understanding of the science behind how the environment operates is becoming increasingly important as governments, organisations and individuals see the need to address the environmental issues that confront us today. This awareness ensures that management, including the monitoring of the environment and promotion of sustainability, is more effectively achieved.

In this unit, learners will study how the components of ecosystems function by interrelating with each other to maintain balance. They will then consider how this balance may be affected by human activities that result in various forms of environmental pollution and the generation of excessive waste. Knowing how ecosystems function and the effect of human influence should give learners a better understanding of the outcomes of their practical investigations. Learners will develop knowledge of techniques and vocational practical skills in order to work safely and competently in any relevant environmental setting or laboratory. Competence will be achieved through carrying out practical environmental investigations that monitor and analyse biological, chemical and physical aspects of the environment. Skills involved include carrying out risk assessments, handling laboratory apparatus, collecting samples safely, following techniques and procedures, recording and analysing data, and reporting on monitoring activities. Using the knowledge and skills acquired, learners will then review the strategies that are in place to help protect and manage these ecosystems. The complementary roles played by governmental and non-governmental bodies in the management and protection of the environment at local, national and global level should be considered.

Learning aims

In this unit you will:

A Investigate ecosystems

B Measure features of an ecosystem

C Explore environmental protection.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Investigate ecosystems	**A1** Definition of terms **A2** Ecosystems **A3** Changes to ecosystems	An illustrated report on the structure of an ecosystem, its energy and how human activity affects the ecosystem.
B Measure features of an ecosystem	**B1** Measurement of features of an ecosystem	Observation report, practical scientific report of investigation, pro forma and written report on the investigation.
C Explore environmental protection	**C1** Role of government and public bodies **C2** Role of other organisations in raising awareness of specific environmental issues	A report on how government departments, public bodies and other organisations such as charities contribute to protecting the environment.

Content

Learning aim A: Investigate ecosystems

A1 Definition of terms

- Terms:
  - flora
  - fauna
  - populations
  - biodiversity
  - producers
  - primary, secondary and tertiary consumers
  - food chains and food webs
  - habitat.

A2 Ecosystems

- The interrelationships between producers, primary and secondary consumers.
- Examples of ecosystems:
  - local to learners
  - in tropical rainforests
  - polar regions
  - desert regions.

A3 Changes to ecosystems

- How ecosystems may change as a result of the following changes to the environment:
  - food demands* of increasing populations
  - energy demands of increasing populations
  - increasing volume of waste, causing increased use of landfill
  - different effects of lifestyles on the environment
  - how deforestation* changes habitats for animals, affects global warming and influences water use and erosion
  - climate change linked to increased amounts of carbon dioxide in the air
  - acid rain, resulting from burning of fossil fuels, and its effects
  - overuse of fertilisers*, resulting in growth of algae, deoxygenation of water and reduced fish populations.

* This builds on the content in *Unit 4: Biology and Our Environment*.

Learning aim B: Measure features of an ecosystem

B1 Measurement of features of an ecosystem

- Soil composition in terms of:
  - water, organic matter, air and a mineral component
  - soil analysis, e.g. description of how a known mass mixed with a known volume of water settles out in a measuring cylinder.
- Water analysis:
  - pH, suspended solids, dissolved nitrates and dissolved chlorides.
- Measurement of climatic aspects:
  - rainfall, temperature, humidity, wind speed.
- Estimation of biodiversity:
  - use of quadrats, trapping, identification of species, recording percentage cover.
- Estimation of particulates in the air.

Learning aim C: Explore environmental protection

C1 Role of government and public bodies

- Government department and agencies with responsibility for the environment (e.g. UK Department for Environment, Food and Rural Affairs (DEFRA), Environmental Agency):
  - responsible for policy and regulations on the environment and related matters
  - responsible for rivers, pollution and flooding
  - responsible for local air quality reports and for regulating less seriously polluting processes.

C2 Role of other organisations in raising awareness of specific environmental issues

- Examples of organisations:
  - Friends of the Earth
  - Greenpeace
  - International Union for Conservation of Nature (IUCN)
  - public/independent environmental organisation for local region (e.g. Natural England)
  - World Wide Fund for Nature (WWF).

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Investigate ecosystems		**A.D1** Evaluate the scale and scope of specific human activities affecting an ecosystem.
A.P1 Describe how energy is transferred through an ecosystem.	**A.M1** Explain how human activities have influenced ecosystems.	
Learning aim B: Measure features of an ecosystem		**B.D2** Evaluate the reliability of an investigation of an ecosystem.
B.P2 Correctly demonstrate techniques used in monitoring an ecosystem. **B.P3** Collate and present the results of an investigation of an ecosystem.	**B.M2** Analyse and present conclusions from an investigation of an ecosystem.	
Learning aim C: Explore environmental protection		**C.D3** Select and justify a strategy for improving the quality of the environment on behalf of an agency.
C.P4 Describe the role of different types of agencies in environmental protection.	**C.M3** Explain how a specific agency is engaged in environmental protection.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is also further information on our website.

There is a maximum number of three summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.M1, A.D1)

Learning aim: B (B.P2, B.P3, B.M2, B.D2)

Learning aim: C (C.P4, C.M3, C.D3)

Further information for teachers and assessors

Resource requirements

For this unit, learners must have access to a suitable ecosystem for investigation.

Essential information for assessment decisions

Learning aim A

For Distinction standard, learners must evaluate the effect of specific human activities on an ecosystem that may have been covered for Merit standard. Learners are only required to evaluate one ecosystem, although they must refer to the scale and scope of specific human activities.

For Merit standard, learners are required to consider human activities and an ecosystem they have studied. Learners should show knowledge of more than one ecosystem in order to explain human activities. It will not be sufficient to say humans cut down trees or pollute water. Learners need to explain the impact of these human activities.

For Pass standard, learners should use one ecosystem to describe how energy is transferred through that system. They will need to consider the points listed in the unit content under A2 and A3. These points can be used to explain energy transfer through the ecosystem chosen. It is not expected that every point listed in the content will be used but those relevant to energy transfer should be included.

Learning aim B

For Distinction standard, learners will evaluate the reliability of an investigation into an ecosystem. It is possible for learners to carry out the evaluation using a published piece of research but this should not be the first choice for this assessment criterion. Learners must provide an evaluation of the reliability of the work and not just an account of what was done during the investigation.

For Merit standard, learners will use the results collected from the practical work for Pass standard. This will form the basis of the conclusions. The investigation needs to involve only one ecosystem but the conclusions must be based on the results collected. Learners must show evidence of analysis of their results in order to come to reasonable conclusions.

For Pass standard, learners are required to use correct techniques to monitor an ecosystem. The techniques used should be discussed with learners, so they know in advance what techniques they will be assessed on. Therefore an observation record can be used by the assessor when the learner is using the techniques required. The observation could be carried out by a suitably qualified person, possibly when learners are on a field trip. It is not expected that every technique listed in the unit content under B1 will be covered but at least one technique from each category should be observed. Learners need to present both their workbook (laboratory notebook) and the results that have been collated and presented as charts, diagrams, graphs, etc. The collated set of results must be based on the results of the investigation they carried out. They are not required to write up the apparatus, method or conclusions.

Learning aim C

For Distinction standard, learners will carry out extensive research to come up with a strategy that an agency might consider in order to improve the quality of an aspect of the environment. It would make sense for learners to build on one of the agencies already mentioned in previous assessment criteria. Learners must select a suitable strategy and also justify it.

For Merit standard, learners are required to explain one of the named agencies and its role in environmental protection. Learners can choose any agency, for example governmental, political, non-political. Learners must include sufficient detail to explain what the chosen agency does and its role in protecting the environment.

For Pass standard, learners must describe the role of different types of agencies that are involved in environmental protection, just listing them is not sufficient. A description of their hierarchy is not required; it is the agencies' role in protecting the environment that has to be described. For example, details of the boats Greenpeace uses and how they have been sunk are not relevant. Learners would need to describe Greenpeace's role in protecting whales etc. from overfishing by some nations.

Links to other units and other curriculum subjects

This unit links to:

- Unit 1: Principles of Science
- Unit 2: Chemistry and Our Earth
- Unit 3: Energy and Our Universe
- Unit 4: Biology and Our Environment
- Unit 8: Scientific Skills
- Unit 14: Growing Plants for Food
- Unit 19: Chemical Analysis and Detection.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers and interview opportunities
- work experience
- business material as exemplars
- visits to appropriate business organisations.

Opportunities to develop transferable skills

In completing this unit, learners will have the opportunity to develop skills and techniques useful for investigating environmental control and protection.

Unit 14: Growing Plants for Food

Level: **2**
Unit type: **Internal**
Guided learning hours: **30**

Unit in brief

This unit looks at the factors that affect the production of plants for food and how the yield of food could be improved.

Unit introduction

It is important to have a knowledge and understanding of the structure and function of plants and their role as sources of food for both animals and humans. This is particularly important if learners want to progress into a career in food science, manufacturing, environmental management, animal management or land-based industries.

Technicians/assistant practitioners, working within this field of study, need an underpinning knowledge that includes the current issues facing society, such as global warming, genetic engineering, food distribution, plant production for fuel usage and fair trade.

In this unit learners will be asked to think about where all our food comes from before it reaches the shops, how the hundreds of thousands of tomatoes or apples are produced each year, and how producers get them all uniform in colour and shape.

This unit builds on some of the basic concepts in *Unit 1: Principles of Science* and *Unit 2: Chemistry and Our Earth* in relation to acids and pH, simple molecules, chemical formulae and factors affecting chemical reactions.

The unit explores how plants store food and their relationship to the environment and country where they are grown. This theme is further explored by investigating the relationship between food production, the population it supports and economic factors. This will mean topical subjects, such as genetically modified crops and the use of organic and inorganic fertilisers, can be discussed using knowledge researched for this unit. The unit will help learners understand plant breeding and the technology used.

This unit links closely with environmental issues and global issues related to sustainable development and the environment, and with the use of inorganic fertilisers and their effects on ecosystems.

Learning aims

In this unit you will:

A Investigate plant growth conditions

B Investigate the relationship between food production and population size

C Explore plant breeding for commercial success.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Investigate plant growth conditions	**A1** Factors that affect plant growth **A2** Growth rates of a plant under optimal conditions **A3** Monitoring plant growth under different conditions	Learners carry out practical investigations to determine the growth rates of selected salad crops under different conditions.
B Investigate the relationship between food production and population size	**B1** Food production issues **B2** Collapse of food production **B3** Political and economic issues	Learners produce a report on the way that external factors affect food production in selected countries.
C Explore plant breeding for commercial success	**C1** Selective breeding of food plants **C2** Genetic modification of food crops **C3** The effects of genetic modification of food crops on food production and on humans and animals **C4** Plant breeding technologies	Learners will investigate the genetic modification of plants by traditional breeding and by new techniques that manipulate genetic material. These and their purposes will be discussed in a report in which their benefits and drawbacks will be evaluated.

Content

Learning aim A: Investigate plant growth conditions

A1 Factors that affect plant growth

- Light, temperature, water, growth media, pH, fertiliser, e.g. organic and artificial, chemical pesticides, weed competition.

A2 Growth rates of a plant under optimal conditions

- Optimal conditions, e.g. light, water, carbon dioxide.

A3 Monitoring plant growth under different conditions

- Different conditions, e.g. light, carbon dioxide, water, minerals and pH of soil.

Learning aim B: Investigate the relationship between food production and population size

B1 Food production issues

- Issues relating to:
  - population and the increasing demand for available food
  - climate change and how changing temperatures and rainfall influence what can be grown and where
  - market and retail influences, including personal preference and the competition between retailers and how this influences what is sold.

B2 Collapse of food production

- Causes:
  - climate change
  - lack of fertilisers
  - water
  - competition for agricultural land for other uses
  - removal of eco-stability due to logging, planting unsuitable crops and poor farming practices.

B3 Political and economic issues

- Relevant international, regional or national policies.
- Fair trade.
- Cash crops.
- Biofuels.
- Food crops.

Learning aim C: Explore plant breeding for commercial success

C1 Selective breeding of food plants

- Technology used in plant breeding and growing, e.g. polytunnels, cloning, automated irrigation.
- The effect of the technology involved on the environment.
- Time span in terms of plant breeding takes time and is not an immediate solution to famine problems.
- The loss of some species that may be valuable in the future and the need for 'seed banks'.

C2 Genetic modification of food crops

- Gene transfer and manipulation.
- Polyploidy in food crops.
- Chemically and physically induced mutations.

C3 The effects of genetic modification of food crops on food production and on humans and animals

- The loss of different species.
- Interbreeding between modified and other species, which may cause short-term and long-term problems.
- The varying attitudes of people, e.g. consumers, producers and regulators to modified crops and the possible reasons for this.
- The advantages and disadvantages of genetic alterations.

C4 Plant breeding technologies

- To produce:
  - uniform and disease-resistant food crops
  - plug plants for nurseries and gardeners
  - commercially valuable plants.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Investigate plant growth conditions		**A.D1** Compare the optimum plant growth conditions found in investigations with those found in a farmer's field.
A.P1 Investigate the different conditions that give optimal growth for plants from primary data. **A.P2** Describe how plant growth is monitored. **A.P3** Compare primary data for plant growth rates with secondary data.	**A.M1** Explain results from plant growth investigations in terms of optimum growing conditions for the plants grown.	
Learning aim B: Investigate the relationship between food production and population size		**B.D2** Evaluate the impact of policy and economics on food production.
B.P4 Explain how factors affect food production.	**B.M2** Compare how different countries have tried to increase their food production.	
Learning aim C: Explore plant breeding for commercial success.		**C.D3** Evaluate the effectiveness of plant breeding technologies.
C.P5 Describe the technology used in plant breeding. **C.P6** Explain how the genetic modification of plants has altered food production.	**C.M3** Explain how plant breeding technologies have affected variation in major food crops.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is also further information on our website.

There is a maximum number of three summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.P2, A.P3, A.M1, A.D1)

Learning aim: B (B.P4, B.M2, B.D2)

Learning aim: C (C.P5, C.P6, C.M3, C.D3)

Further information for teachers and assessors

Resource requirements

For this unit, learners must have access to facilities to enable them to grow plants from seed under a variety of conditions. This is likely to take several weeks and the plants will require regular care, including over holidays.

Essential information for assessment decisions

Learning aim A

For Distinction standard, learners must carry out research on optimal plant growth conditions, but to achieve this criterion the findings must be applied to a real-life situation. Any crop can be used as an example to provide evidence for this criterion. The importance lies in the learner realising that when growing crops in a field these optimal conditions are rarely met and that a variety of other uncontrollable features, for example the weather, influences growth.

For Merit standard, learners need to have carried out research on optimal plant growth conditions and to explain how closely their results reflect those under the optimum conditions usually quoted for plants to grow.

For Pass standard, learners must identify factors that affect plant growth and investigate them practically. They must produce a report on their work and results.

Learners are required to research how plant growth is monitored and to describe this. They should include in their description how they monitored plant growth in their own experiments, as well as how it is done in plant research laboratories and commercial nurseries.

Learners need to compare plant growth rates from their experimental work with published growth rates. This requires analytical skills to be shown. This will mainly be a descriptive exercise but comparisons between growth graphs, for example, could be used.

Learning aim B

For Distinction standard, learners will need to establish what policies and economic ideas are involved in food production. Then they will evaluate how these policies and economic ideas impact on food production. One area they may look at is the ability of some countries to pay for imported artificial fertilisers and thereby maximise yield, whereas another country might have to rely on an insufficient supply of organic fertiliser. There may be economic reasons why a country cannot produce the amount of food it needs, even if it has more favourable conditions.

For Merit standard, learners must compare the approaches used in different countries to increase food production. They must consider the extent to which food production has increased as a result of the different approaches.

For Pass standard, learners must identify the main factors that affect the production of food crops in a selected country and explain how food production is affected. For example, they might identify the availability of fertilisers and then explain why quality, quantity and source of fertiliser affect the amount of food produced. Learners will be expected to include relevant factors (for example the ability to control market forces, access to fertilisers or water, availability of suitable land). Learners should identify the reasons why some countries cannot feed their population, including physical conditions, such as drought, and also social and political factors.

Learning aim C

For Distinction standard, learners need to evaluate the effectiveness of the plant breeding technologies considered by them in this learning aim. They must look at the disadvantages and advantages of using the plant breeding technologies that have been developed. Learners are required to evaluate whether advantages outweigh disadvantages when using these technologies to produce food for a country's population.

For Merit standard, learners need to focus on the plant breeding technologies that have affected variation in major food crops. They must explain the technologies used and the variation that has resulted. It would not be sufficient only to provide lists of plant breeding technologies. The requirement is for an explanation of how the technologies have affected major food crops.

For Pass standard, learners need to describe how breeding plants now requires high-technology systems where optimum growth conditions can be provided, pests and diseases excluded and maximum yields guaranteed. Learners must describe at least two examples of technology used in plant breeding. Lists of methods would not be sufficient to meet this criterion.

Learners must explain how genetic alterations are used to improve food production. It is the application of genetic modification that learners are being asked to explain. They do not need to give detailed descriptions of the techniques of genetic manipulation. Learners must show they are aware that genetic modification can give properties to plants they did not previously possess. This is linked to altered food production in terms of desirable characteristics such as resistance to pests, better crop yields, and better resistance to drought/wet conditions.

Links to other units and other curriculum subjects

This unit links to:

- Unit 1: Principles of Science
- Unit 4: Biology and Our Environment.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers
- work experience.

Opportunities to develop transferable skills

In completing this unit, learners will have the opportunity to demonstrate numerical, communication and practical skills.

Unit 15: Investigating a Crime Scene

Level: **2**
Unit type: **Internal**
Guided learning hours: **30**

Unit in brief

This unit provides learners with the opportunity to apply scientific skills to investigate a crime scene in a forensic context.

Unit introduction

Forensic science is an important science field and involves many important scientific skills in observation, collecting, measuring and recording data, and analysis. These are carried out to a high level of accuracy and with a need to limit errors. These skills are needed at many different crime scenes, such as road accidents, burglaries and murder scenes.

Forensic science produces scientific evidence that can be presented in a court. It involves many disciplines, for example biology, physics, chemistry, engineering, dentistry, anthropology and entomology. In order to yield valid and useful evidence, the science must be accurate and reliable.

In this unit, learners will take on the identity of someone employed within the forensic science industry or a forensic science organisation. In a criminal investigation, scenes of crime officers (SOCOs) process the crime scene and collect evidence from the scene, victim and/or suspects. The evidence is then sent to a laboratory, where several forensic scientists examine and analyse it. Both SOCOs and scientists may be required to give evidence in court. Learners will be introduced to the concept of the criminal justice system and expert witness testimony. They will have the opportunity to learn how to process a crime scene, taking into account different aspects of health and safety, handling and preservation of the evidence found, and teamwork. They will learn how to analyse the evidence, using a number of different biological, physical and chemical techniques. It is intended that the unit will build on aspects of the applied biology, applied chemistry and applied physics core units and will extend learners' knowledge of a range of practical applications. The aim of this unit is to further develop learners' scientific knowledge, understanding and skills in a forensic science context.

Learning aims

In this unit you will:

A Understand the role of crime scene investigation and forensic science and their relevance to solving cases of crime

B Process the information at a crime scene

C Analyse evidence collected from a crime scene.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand the role of crime scene investigation and forensic science and their relevance to solving cases of crime	**A1** Key stages in forensic science investigations **A2** Types of crime **A3** Types of job involved in forensic science **A4** The court system **A5** Types of evidence	A report outlining key terms and showing links between organisations. An explanation of the roles involved in the investigation of a crime scene and an evaluation of the different types of evidence used to bring about a conviction.
B Process the information at a crime scene	**B1** Types of evidence found at a crime scene **B2** Investigating a crime scene **B3** Taking samples from the crime scene	A report consisting of a plan, observation records of collecting a wide range of types of evidence, photographs and sketches, records of evidence collected, and analysis records. An explanation and evaluation of the steps involved in investigating a crime scene, discussing potential errors.
C Analyse evidence collected from a crime scene	**C1** Crime scene analysis techniques **C2** Outcomes of the analysis to draw conclusions	A report consisting of the presentation and analysis of the evidence from a crime scene, including a witness statement, to draw conclusions. Evaluation of the validity of the evidence. (Learning aim C could be combined with learning aim B for the assessment activity.)

Content

Learning aim A: Understand the role of crime scene investigation and forensic science and their relevance to solving cases of crime

A1 Key stages in forensic science investigations

- Scene of crime:
  - (collection and recording of evidence) where evidence is collected and recorded.
- Forensic science analysis:
  - biological, chemical and physical techniques used to analyse evidence.
- Interpretation of analysis:
  - biological, chemical and physical results.
- Role of forensic science in law and solving cases of crime, forensic science and the law and criminal justice system.

A2 Types of crime

- Forensic science as science, which is used as evidence in court for cases of:
  - murder
  - assault
  - robbery
  - drug crime
  - fraud
  - arson.
- Other situations where science contributes to legal action:
  - pollution
  - food standards
  - Trading Standards.

A3 Types of job involved in forensic science

- Roles:
  - forensic scientist
  - forensic analyst
  - scenes of crime officer
  - pathologist
  - toxicologist
  - odontologist
  - detective
  - police officer
  - archaeologist.

A4 The court system

- Types of court – as applicable to the region:
  - e.g. in UK magistrates' court, county court, judge and jury, prosecution, defence, victim, accused, the trial process, rules of evidence.
- The need for enough valid and reliable evidence to be able to bring about a successful conviction.

A5 Types of evidence

- Types:
  - chemical, physical and biological
  - photographs and facial recognition from CCTV and mobile phones
  - interview documents
  - computer
  - expert witness testimony.
- Value placed on different types of evidence.

Learning aim B: Process the information at a crime scene

B1 Types of evidence found at a crime scene

- Different types of evidence that may be found at crime scenes and that may be used in criminal cases:
  - biological evidence, e.g. fingerprints, hair, body fluids, DNA profiling, environmental profiling (soil, seeds, pollen, pollutants), entomology, odontology, predicting the height of a person from the size of leg/arm bones
  - physical evidence, e.g. blood pattern analysis (height, direction and angle), marks and impressions (footprints, vehicle tyre prints, toolmarks, casting), electronic evidence (computer crime, CCTV, mobile phone technology), document analysis (handwriting, ink analysis)
  - chemical evidence, e.g. toxicology (drugs, alcohol, poisons, identification, weight and purity, body fluid tests), trace evidence (fibres, glass, paint and ink, components, identification and comparison), types of firearm, bullets and gunshot residue.

B2 Investigating a crime scene

- Planning to investigate the crime scene:
  - identifying the equipment and materials that will be needed
  - identifying the order in which tasks should be carried out.
- Identification of potential hazards and estimation of risks at the crime scene:
  - presence of suspect
  - chemical hazards
  - flammable material
  - explosives
  - biohazards
  - sharps.
- Securing the crime scene:
  - taping off the scene
  - preventing people from entering it
  - use of protective clothing to prevent contamination.
- Measuring the scene.
- Sketches and photographs as appropriate to the scene and resources available.
- Searching for evidence:
  - awareness of trace evidence
  - awareness of the possible variety of evidence.
- Flags to indicate the position of evidence.

B3 Taking samples from the crime scene

- Packaging: suitable packaging should be used to protect the sample from damage and contamination.
- Labelling to show:
  - where the evidence was found
  - when the evidence was found
  - by whom.
- Transporting evidence:
  - in a manner that prevents damage
  - preventing contamination
  - preserving the chain of continuity.

Learning aim C: Analyse evidence collected from a crime scene

C1 Crime scene analysis techniques

- Physical techniques:
  - size, melting point, boiling point, density, microscopy, casting techniques, matching of tyre impressions, footprints, toolmarks, fingerprints, fibres, hairs, glass fragments and paper types.
- Chemical tests:
  - use of flame tests, spot tests in a test tube, chromatography and colorimetry.
- Toxicology:
  - identification of drugs such as paracetamol, aspirin, caffeine, alcohol and poisons.
- Biological tests:
  - tests that would be needed to study blood and body fluids to identify components of blood, semen, saliva, DNA, insects, bones, teeth and artefacts, blood group analysis, identification of blood enzyme with peroxide solution.
- The use of DNA:
  - DNA profiling, DNA fingerprinting, the National DNA Database, DNA extraction and the polymerase chain reaction (PCR) process.
- Entomology:
  - an understanding of the life cycle of insects and how the insect population may be used to indicate time and location of death.
- Anthropology/odontology:
  - how the size of particular bones and structure and layout of teeth may be used to identify the age, sex and lifestyle of decayed corpses.
- Blood pattern analysis:
  - the blood splatter pattern and volume may give useful information about the direction and force of a blow to a person.

C2 Outcomes of the analysis to draw conclusions

- Record the outcomes of the analysis appropriately and draw appropriate conclusions, to enable conclusions from analysis to be presented as reliable evidence in a court.
- Statement of witness:
  - personal identification
  - date and time of the investigation
  - details of steps to secure the crime scene
  - location of evidence
  - analysis of evidence
  - factual conclusions.
- Assess whether there is sufficient evidence to convict.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Understand the role of crime scene investigation and forensic science and their relevance to solving cases of crime		
A.P1 Describe the key stages and the types of jobs relating to forensic investigation. **A.P2** Describe how different types of evidence are used in forensic investigation.	**A.M1** Explain the role of forensic investigation and analysis in solving criminal cases. **A.M2** Explain the different types of evidence used in convicting a criminal.	**A.D1** Evaluate the usefulness of different types of evidence in convicting a criminal.
Learning aim B: Process the information at a crime scene		
B.P3 Plan the processing of a crime scene, including an assessment of the potential health and safety risks. **B.P4** Explain why the steps are taken to secure and record details of the crime scene. **B.P5** Collect and identify different types of evidence from the crime scene.	**B.M3** Discuss potential errors in processing a crime scene.	**B.D2** Evaluate the effectiveness of processing a specific crime scene.
Learning aim C: Analyse evidence collected from a crime scene		
C.P6 Conduct analyses on different types of evidence from the crime scene and draw conclusions. **C.P7** Present the results of the analysis with interpretation. **C.P8** Prepare an outline of a statement of witness, based on the collection and analysis of evidence from the crime scene.	**C.M4** Link conclusions from analysis of different types of evidence. **C.M5** Write a detailed statement of witness, based on the processing of a crime scene and the analysis of the evidence.	**C.D3** Evaluate whether the evidence collected and analysed would be sufficient to bring about a successful prosecution.

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is also further information on our website.

There is a maximum number of two summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.P2, A.M1, A.M2, A.D1)

Learning aim: B (B.P3, B.P4, B.P5, B.M3, B.D2)

Learning aim: C (C.P6, C.P7, C.P8, C.M4, C.M5, C.D3)

Further information for teachers and assessors

Resource requirements

For this unit, learners must have access to an area where a simulated crime scene may be set up. Laboratory facilities for analysing evidence are required.

Essential information for assessment decisions

Learning aim A

For Distinction standard, learners must produce an evaluation of the usefulness of different types of evidence. They should be able to argue why some types of evidence are virtually conclusive, providing appropriate care has been taken during the collection and analysis of the evidence, whereas other types of evidence are not at all conclusive.

For Merit standard, learners must explain the role of forensic investigation and analysis in solving crime cases. They should be able to explain the different types of evidence in securing convictions. A case study could be provided for this.

For Pass standard, learners could produce a poster or presentation that describes the key stages involved in a forensic investigation. This would also include a description of the role of individuals and organisations within forensic investigations. Learners must produce a description of the type of evidence that could be recovered from a crime scene.

Learning aim B

For Distinction standard, learners need to reflect on their own effectiveness in processing the crime scene. They should identify what they did well and aspects that have not gone well and justify the consequences that their actions would have in relation to the reliability/validity of the evidence collected.

For Merit standard, learners should discuss potential errors in processing a crime scene. They must identify the consequences of following or not following some aspects of good practice.

For Pass standard, learners must be able to suggest the precautions necessary to minimise the risks from identified potential hazards as part of a plan for processing a crime scene. This would include the need to be dressed appropriately to avoid contaminating evidence, the requirement to take photographs of the evidence before it is moved and the steps necessary to ensure that evidence is packaged and labelled appropriately. They must also plan the other aspects of processing a crime scene, such as what materials and equipment to prepare and the anticipated stages of the process.

Learners must describe the steps taken to secure and record details from the crime scene. This should include taping off the scene of the crime, preventing people from entering the crime scene and the use of protective clothing. They need to explain why these steps are taken to secure the crime scene and why they are important. A detailed observation report would be useful that includes observation of learners taking photographs of where evidence was found, marking out the area of the crime scene and taking steps to exclude members of the public. Steps should be taken to ensure that the crime scene is not contaminated by material from outside. At least three different types of evidence should be made available for learners to collect for analysis at the simulated crime scene and learners must be observed using handling techniques that minimise possible contamination and transportation damage, labelling evidence carefully and identifying the different types of evidence.

Learning aim C

For Distinction standard, learners should be able to assess whether the evidence collected and analysed is conclusive or whether more evidence from other sources, for example interviews, testimony from other expert and non-expert witnesses, would be required. Would other analytical techniques, to which the centre does not have access, give more information? Was there any possibility that the reliability of the results could have been compromised by poor technique, such as the introduction of cross-contamination? Was the analysis, although limited, accurate and reliable? Learners will have to justify the conclusions drawn from their analysis.

For Merit standard, learners should be able to link conclusions that have been drawn from analysis of different types of evidence. Perhaps the analysis will link one of the suspects to several types of evidence or perhaps there will be no obvious links between the conclusions drawn from the analysis. Learners should produce more detailed descriptions than the listing for Pass standard in relation to their statements of witness.

For Pass standard, there must be appropriate documentation to record the analysis undertaken, linking the samples to the results clearly with interpretation and drawing of conclusions. Learners could be given a simple pro forma to record and present the results or design their own documentation. A formal statement of witness should be prepared by the learner with facts from the crime scene processing and from the analysis of evidence. This should include information about the day and time of the investigation, a description of the crime scene, a list of the evidence collected, the analysis carried out and justifiable conclusions drawn.

Links to other units and other curriculum subjects

This unit links to:

- Unit 1: Principles of Science
- Unit 2: Chemistry and Our Earth
- Unit 5: Applications of Chemical Substances
- Unit 7: Health Applications of Life Science
- Unit 8: Scientific Skills
- Unit 19: Chemical Analysis and Detection.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers and interview opportunities (e.g. from police and/or forensic service)
- work experience
- visits to appropriate organisations (e.g. forensic science laboratory).

Opportunities to develop transferable skills

In completing this unit, learners will have the opportunity to develop scientific knowledge and skills related to forensic investigation.

Unit 16: Science in Medicine

Level: **2**
Unit type: **Internal**
Guided learning hours: **30**

Unit in brief

This unit looks at the science behind the diagnosis and treatment of illness and at some of the factors that affect access to healthcare.

Unit introduction

Medical science is an important field of study and medical scientists in their different roles need to have many scientific skills, such as observation, analysis, diagnosis, laboratory techniques, keeping logs and report writing. A lot of the work is now automated but interpretation of results by a qualified person is still needed.

In this unit, learners will investigate the diagnosis and treatment of diseases or conditions that occur when human body systems malfunction. Learners will look at different options for treatment and the factors that influence the choice and availability of treatment.

The influence of 'ethical judgements and decisions' will be introduced so learners can contribute to contemporary and medically-related discussions.

Learning aims

In this unit you will:

A Explore the scientific procedures used in diagnosing illness

B Investigate the scientific principles of treating illnesses and health conditions

C Know the factors affecting treatments.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Explore the scientific procedures used in diagnosing illness	**A1** Physical and visual examination **A2** Laboratory tests **A3** Genetic investigations	Learners could be asked to produce a reference manual that would enable new colleagues to find out about diagnostic procedures.
B Investigate the scientific principles of treating illnesses and health conditions	**B1** Medicines and their uses **B2** Other therapies	Learners could produce a portfolio of case studies that shows their knowledge and understanding of the range of approaches available for treating specific illnesses and conditions.
C Know the factors affecting treatments	**C1** Risk factors associated with treatments **C2** Considerations involving ethics, cultural norms and religious considerations **C3** Cost of treatments	Case studies could be used to consider the range of factors that influence choice of treatment and a range of conditions and illnesses.

Content

Learning aim A: Explore the scientific procedures used in diagnosing illness

A1 Physical and visual examination

- Physical diagnosis using external appearances, including rashes and swelling.
- Normal range of body temperature measurements and the significance of deviations from the norm.
- Blood pressure measurements and the significance of deviations from norms.
- Body scans using:
  - X-rays
  - computerised tomography (CT) scans
  - magnetic resonance imaging (MRI) scans.
- Endoscopy procedures, e.g. gastroendoscopy.

A2 Laboratory tests

- Biological diagnosis (pathology) of microbiological organisms causing disease:
  - bacteria
  - viruses
  - parasites.
- Haematology, including the cellular structure of blood and abnormalities, e.g. leukaemia.
- Chemical analysis of:
  - blood, including blood cholesterol levels
  - sputum
  - urine, including urine sugar levels
  - faeces.
- Cytology (cell appearance) used in cervical smear tests.

A3 Genetic investigations

- DNA analysis.
- Family history.
- Counselling for genetically controlled diseases.

Learning aim B: Investigate the scientific principles of treating illnesses and health conditions

B1 Medicines and their uses

- Analgesics.
- Anti-inflammatories.
- Antibiotics.
- Antihistamines.
- Chemical replacement treatments involving drugs, e.g. insulin.
- Other groups of drugs used for various treatments:
  - cytological chemotherapy
  - antidepressants
  - stimulants
  - sedatives
  - heart drugs.

- Drug formulations, e.g. cream, ointment, patch, tablet, capsule, oral liquid, injection liquid.
- Administration of therapeutic drugs by various routes:
  - topical
  - oral
  - inhalation
  - intravenous injection
  - subcutaneous injection.

B2 Other therapies

- Surgery, e.g. appendectomy.
- Radiotherapy for cancer.
- Laser therapy, e.g. short-sightedness and removal of skin blemishes.
- Physiotherapy, e.g. for muscular sports injuries.
- Replacement therapies, e.g. blood and plasma transfusions, organ transplants.
- Vaccination as preventive therapy.
- Complementary and alternative therapies, e.g. osteopathy, acupuncture.

Learning aim C: Know the factors affecting treatments.

C1 Risk factors associated with treatments

- Side effects.
- Age.
- Allergies.
- Addictive properties.
- Antagonistic treatment regimes.
- Anaesthesia.
- Surgical procedures.

C2 Considerations involving ethics, cultural norms, and religious considerations

- Judgements of benefits and drawbacks for the individual including, for example, age, domestic circumstances, other medical or physical conditions, ethical and religious considerations.
- Continuation of life support.
- Abortion.
- Contraception.
- Blood transfusion.

C3 Cost of treatments

- Financial considerations about cost of treatment:
  - funding healthcare, e.g. government, private, insurance, charity, employer
  - allocation of resources, e.g. availability of resources, waiting lists, private medicine.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Explore the scientific procedures used in diagnosing illness		**A.D1** Evaluate the advantages and disadvantages of using laboratory and physical procedures to diagnose illness.
A.P1 Describe laboratory and physical procedures used to diagnose illness.	**A.M1** Explain the scientific principles underlying the laboratory and physical procedures used to diagnose illness.	
Learning aim B: Investigate the scientific principles of treating illnesses and health conditions		**B.D2** Evaluate the effectiveness of the use of medicines and other therapies in the treatment of illnesses.
B.P2 Describe the scientific principles and methods of delivery of medicines used to treat given illnesses. **B.P3** Describe the scientific principles of other therapies used to treat given illnesses.	**B.M2** Explain the use of medicines and other therapies in the treatment of illnesses.	
Learning aim C: Know the factors affecting treatments		**C.D3** Discuss why some individuals may choose not to take advantage of all types of available treatment.
C.P4 Identify general risks of specified treatments and the factors affecting patient choice. **C.P5** Describe the factors affecting the choice and availability of treatments to patients.	**C.M3** Explain the relationship between available treatments and what is offered to patients.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is also further information on our website.

There is a maximum number of three summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.M1, A.D1)

Learning aim: B (B.P2, B.P3, B.M2, B.D2)

Learning aim: C (C.P4, C.P5, C.M3, C.D3)

Further information for teachers and assessors

Resource requirements

Learners will need access to results from diagnostic procedures, such as images from X-ray and other procedures and the results of laboratory tests. Where possible these should be authentic but the names of people and institutions must not be seen. It would be useful to have the facility to measure blood pressure and body temperature.

Essential information for assessment decisions

Learning aim A

For Distinction standard, learners are required to evaluate the use of laboratory, physical and genetic diagnostic procedures for specific purposes. It is not sufficient for learners just to list techniques and state that one is, for example, cheaper than another. The learner needs to show that they appreciate the drawbacks and limitations of techniques as well as the benefits. They should be able to compare techniques that could be used for a diagnosis, for example X-rays compared with a CT scan, showing that they appreciate the dangers of constant exposure to X-rays and the limitations X-rays have in soft tissue diagnosis.

For Merit standard, learners are required to explain the principles behind laboratory, physical and genetic diagnostic procedures. Again, details of how devices work are not required, it is the scientific principles that are important. For example, learners should be able to explain how an X-ray machine produces an image as opposed to a CT scanner, but they do not need to explain how the X-rays are generated.

For Pass standard, learners are required to describe physical and laboratory diagnostic procedures, as identified in the content for this learning aim. The descriptions should include what the procedure involves, although detailed descriptions of how the procedure works are not required. The focus is on the principles needed and the diagnosis with which the procedure can help the physician.

Learning aim B

For Distinction standard, learners have to use examples to evaluate the effectiveness of treatments for at least two illnesses or conditions. The treatments must include medicines and other approaches.

For Merit standard, learners must explain how the treatments for two different illnesses or conditions involve a range of approaches, including medicines and other therapies. Depending on the conditions or illnesses being considered, their account could consider the choice of medicines and routes of administration, why combinations of drugs may be used, how and why other therapies may be used with medicines, how the approach taken may be different during the stages of treatment, or other relevant features of the treatment. Learners must explain why the chosen approaches are used.

For Pass standard, learners must identify medicines that can be used to treat at least three different illnesses or conditions and describe the scientific principles behind their use, including routes of administration. For example, the learner could briefly describe asthma and then describe how this can be managed using beta agonists (e.g. salmeterol), steroids (e.g. beclomethasone) or mast cell stabilisers (e.g. sodium cromoglycate). They would need to describe briefly how each medicine worked and which was the most common treatment. They must use correct terminology (e.g. intravenous injections, oral administration) but the scientific principles do not need to include the molecular structures of drugs. Learners must describe the scientific principles of other therapies used to treat at least three illnesses or conditions. This could include conditions for which the use of medicines is described by the learner.

Learning aim C

For Distinction standard, learners must discuss why individuals choose a particular approach to the treatment of their illness or condition from the range of options available. At least two illnesses or conditions must be considered. The discussion must include factors affecting access to treatment (e.g. geographical area and availability of finances) as well as factors relating to the individual's preferences. Learners should not make judgements about whether the patient is right or wrong in the decisions they make.

For Merit standard, learners need to discuss the range of treatments available for at least two illnesses or conditions. They must explain how different relevant factors influence what treatments can be offered. Learners are not expected to judge whether such things are right or wrong but just to explain what happens.

For Pass standard, learners must identify general risks associated with some named treatments for at least two illnesses or conditions. They must also identify the other factors that can affect the availability of treatments and the patient's choice of treatment for the illnesses or conditions.

Links to other units and other curriculum subjects

This unit links to:

- Unit 1: Principles of Science
- Unit 3: Energy and our Universe
- Unit 4: Biology and our Environment
- Unit 6: Applications of Physical Science
- Unit 7 Health Applications of Life Science
- Unit 12: The Living Body.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers, particularly if they can bring equipment or diagnostic results
- visits to appropriate organisations.

Opportunities to develop transferable skills

In completing this unit, learners will have the opportunity to develop communication skills and the ability to consider ethical dimensions.

Unit 17: Understanding Human Behaviour

Level: **2**
Unit type: **Internal**
Guided learning hours: **30**

Unit in brief

This unit is an introduction to the study of human behaviour and the methods by which it is investigated and influenced.

Unit introduction

Psychology has been said to be an applied science and is closely linked to human biological sciences. Psychologists use many skills that are part of scientific methods to investigate human behaviour. There are many specialisms in psychology and many psychologists are employed in healthcare, social services and education.

The study of human behaviour gives insights that help in understanding human nature. In this unit, learners will explore how psychology tries to explain behaviour, the different types of psychological approach used and the different jobs in psychology.

One of the key questions in psychology is whether our behaviour is learned or innate. No definitive answer has been forthcoming, despite various studies dating back at least 70 years, so this is an area where learners can carry out a literature search and weigh up the evidence to make up their own mind.

Learners will look to see if there are any biological explanations for certain behaviours, such as developmental problems due to the brain, nervous system or hormones malfunctioning. Inheritance might also be a factor via the transmission of genes.

Social explanations for other behaviours will look at role models, families and other influences. Learners will be looking for evidence to support these various theories. Learners will be asked to explore one aspect of behaviour, and to carry out research on how this type of behaviour has been investigated by different psychologists.

Learning aims

In this unit you will:

A Explore different ways to understand human behaviour

B Investigate biological influences on behaviour

C Investigate social influences on behaviour.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Explore different ways to understand human behaviour	**A1** Different approaches in psychology **A2** Understanding human behaviour	Learners could use case studies to explain the approaches available for the study of human behaviour and the methods by which it can be modified.
B Investigate biological influences on behaviour	**B1** Biological influences **B2** Methods of investigating biological influences on behaviour	Learners can prepare a booklet for display in the waiting room of a behavioural psychology clinic. This booklet is to help clients understand their consultation better by describing the influences of the brain and hormones on behaviour and the degree to which behaviour is inherited, including how twin/adoption studies have helped our understanding.
C Investigate social influences on behaviour	**C1** Social influences **C2** Learning behaviour	Learners could prepare a script and storyboard for a television programme or a presentation to look at examples of learned behaviours and of social learning theory.

Content

Learning aim A: Explore different ways to understand human behaviour

A1 Different approaches in psychology

- Biological approach.
- Cognitive approach.
- Social psychology.
- Behavioural approach.

A2 Understanding human behaviour

- Origins of behaviour.
- Outcomes and patterns of behaviour.
- Treatment and changing behaviour.
- Whether behaviour is innate (nature) or learned (nurture).

Learning aim B: Investigate biological influences on behaviour

B1 Biological influences

- How the brain can influence behaviour (brain lateralisation, gender).
- Hormones and the nervous system (gender, fight or flight, relationships).
- Genes and evolutionary psychology (gender, individual differences, survival behaviours).
- Development (effect of illness, autism).
- Aggression.
- Stress.

B2 Methods of investigating biological influences on behaviour

- Experiments.
- Longitudinal studies.
- Twin studies.
- Adoption studies.
- Brain scans.

Learning aim C: Investigate social influences on behaviour

C1 Social influences

- Role models (Bandura).
- Families.
- Television, internet and games.

C2 Learning behaviour

- Conditioning.
- Social learning, e.g. obedience, group behaviour.
- Social learning theory (SLT).

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Explore different ways to understand human behaviour		**A.D1** Evaluate the limitations and benefits of methods used in different approaches to understanding changes in human behaviour.
A.P1 Describe four different approaches to understanding human behaviour. **A.P2** Describe a way in which human behaviour can be changed.	**A.M1** Compare and contrast the different approaches to understanding human behaviour. **A.M2** Explain a way in which human behaviour can be changed.	
Learning aim B: Investigate biological influences on behaviour		**B.D2** Evaluate how behaviour can be considered innate, using examples.
B.P3 Describe how the nervous system influences behaviour. **B.P4** Describe different methods to investigate biological influences on behaviour. **B.P5** Describe how genetics affects behaviour, using an example.	**B.M3** Explain, using relevant examples, how the nervous system influences behaviour. **B.M4** Explain advantages and disadvantages of different methods of investigating biological influences on behaviour. **B.M5** Explain why studies of twins and adoption are useful to investigate behaviour.	
Learning aim C: Investigate social influences on behaviour		**C.D3** Evaluate whether behaviour can be considered learned, using examples.
C.P6 Describe how social influences affect our behaviour. **C.P7** Describe social learning theory.	**C.M6** Explain how behaviour can be learned from others, using examples. **C.M7** Explain how social learning theory can explain behaviour, using examples.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is also further information on our website.

There is a maximum number of three summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.P2, A.M1, A.M2, A.D1)

Learning aim: B (B.P3, B.P4, B.P5, B.M3, B.M4, B.M5, B.D2)

Learning aim: C (C.P6, C.P7, C.M6, C.M7, C.D3)

Further information for teachers and assessors

Resource requirements

There are no special resources needed for this unit.

Essential information for assessment decisions

Learning aim A

For Distinction standard, learners will build on their work for the Pass and Merit criteria and consider the benefits and disadvantages of how different approaches view the nature/nurture debate. Learners must use examples to construct their argument.

For Merit standard, learners must demonstrate their understanding of the different approaches to understanding behaviour by comparing and contrasting the methodologies that each approach uses. They must explain how behaviour can be changed, for example how the phobia was treated.

For Pass standard, learners must describe each of the four different approaches used in psychology to understand human behaviour: biological, cognitive, social and behavioural. They must describe one example of how human behaviour can be changed, for example in relation to a phobia.

Learning aim B

For Distinction standard, learners must consider whether behaviour could be considered innate or whether some or all behaviours are learned. They should look at evidence from the study of genetic, brain-based and hormonal influences on our behaviour and they should consider whether or not these studies confirm that a behaviour is innate.

For Merit standard, learners must use relevant examples to explain how the nervous system affects our behaviour.

Learners must extend the account of methods used to study behaviour by explaining the advantages and disadvantages of the methods considered. They must provide details of the methods in support of their explanation.

Learners must explain what is involved in studies of twins and adoptees and why they are useful in studies of behaviour. A description of what happened is not sufficient; the explanation must include the importance of such studies.

For Pass standard, learners must use one aspect of behaviour (e.g. aggression or stress) to describe how the nervous system affects our behaviour. This could relate to the brain or to hormone responses. They must also describe how genetics affects behaviour. If no example is given then an explanation alone would not meet the criterion.

Learners are required to describe the different methods used in investigating biological influences on behaviour. A list is not sufficient and each method given must be described accurately.

Learning aim C

For Distinction standard, learners must give an evaluation of how behaviour could be considered learned, with at least two examples from social learning theory. These examples should come from case studies. Learners should consider the strengths and weaknesses of each study and describe, with reasons, how each case study could have been improved. The learner must evaluate the work and not just give an explanation.

For Merit standard, learners are required to use two examples to explain learned behaviour. If no example or only one example is given, then the criterion will not be met.

Learners must extend their description of social learning theory, using their three examples to explain how the theory is used in explaining behaviour.

For Pass standard, learners are required to use three examples to describe how social influences affect our behaviour. They must state what is meant by social learning theory and then describe it, using their examples.

Links to other units and other curriculum subjects

This unit links to:

- Unit 1: Principles of Science
- Unit 12: The Living Body.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers
- work experience.

Opportunities to develop transferable skills

In completing this unit, learners will have the opportunity to develop research and communication skills and the ability to deal with sensitive issues correctly.

Unit 18: Designing and Making Useful Devices in Science

Level: **2**
Unit type: **Internal**
Guided learning hours: **30**

Unit in brief

This unit looks at how scientific devices work and the different stages involved in the planning, designing, building and testing.

Unit introduction

Continued advances in materials and electronics have enabled designers to make many changes to the technological equipment that we use in daily life, such as cameras, mobile phones, computers and medical equipment. The result has been equipment that is typically lighter, smaller, cheaper and more versatile. Designers are also thinking about how sustainable the equipment is and how easy it is to recycle.

This unit allows learners to develop their knowledge and skills by attempting to make some products and build some scientific devices using basic principles employed by the designers, scientists and engineers who work in the manufacturing industries. Learners will learn about the simplicity of the design process and appreciate the essential science involved.

Learners will realise the importance of time considerations, costs and availability of materials during the planning, designing, building and testing you encountered before creating an effective product. They will gain useful knowledge and understanding of the way in which devices work, in particular batteries, microbalances and hydrometers and polarimeters for measuring sugar solutions.

In addition, this unit can help to give learners some basic industrial skills that could provide a foundation for work as a designer in this or a related field.

The aim of this unit is to enable the learner to apply many of the fundamental concepts that they have learned in *Unit 1: Principles of Science*, *Unit 3: Energy and Our Universe* and *Unit 6: Applications of Physical Science*, such as those to do with forces, light waves, chemical energy and electricity.

Learning aims

In this unit you will:

A Design and build a hydrometer

B Design and build a polarimeter

C Design and build a cell

D Design and build a microbalance.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Design and build a hydrometer	**A1** Consider equipment, materials, health and safety **A2** The planning stage **A3** Construction, testing and evaluation	Description and relevant explanations of the initial consideration of equipment and materials. Detailed completion of a 'risk assessment', calibration plan for equipment and clear assessment of the suitability of specific materials. Report on how the device was built, changes to the outline plan and evaluation of its performance.
B Design and build a polarimeter	**B1** Consider equipment, materials, health and safety **B2** The planning stage **B3** Construction, testing and evaluation	Description and relevant explanations of the initial consideration of equipment and materials. Detailed completion of a 'risk assessment', calibration plan for equipment and clear assessment of the suitability of specific materials. Report on how the device was built, changes to the outline plan and evaluation of its performance.
C Design and build a cell	**C1** Consider equipment, materials, health and safety **C2** The planning stage **C3** Construction, testing and evaluation	Description and relevant explanations of the initial consideration of equipment and materials. Detailed completion of a 'risk assessment', calibration plan for equipment and clear assessment of the suitability of specific materials. Report on how the device was built, changes to the outline plan and evaluation of its performance.

Learning aim	Key content areas	Assessment approach
D Design and build a microbalance	**D1** Consider equipment, materials, health and safety **D2** The planning stage **D3** Construction, testing and evaluation	Description and relevant explanations of the initial consideration of equipment and materials. Detailed completion of a 'risk assessment', calibration plan for equipment and clear assessment of the suitability of specific materials. Report on how the device was built, changes to the outline plan and evaluation of its performance.

Content

Learning aim A: Design and build a hydrometer

A1 Consider equipment, materials, health and safety

- Specific properties of materials, e.g. density.
- Implications of costs.
- Flexibility.
- Shape.
- Health and safety.

A2 The planning stage

- Calibration.
- Pre-testing.
- Suitability of materials.
- Outline planning and drawings.

A3 Construction, testing and evaluation

- Testing the device.
- Evaluating effectiveness for measuring the concentration of sugar solutions.
- Making improvements.

Learning aim B: Design and build a polarimeter

B1 Consider equipment, materials, health and safety

- Specific properties of materials, e.g. transparency.
- Implications of costs.
- Flexibility.
- Shape.
- Polarising film.
- Health and safety aspects.

B2 The planning stage

- Calibration.
- Pre-testing.
- Suitability of materials.
- Outline planning and drawings.

B3 Construction, testing and evaluation

- Testing the device.
- Evaluating effectiveness for measuring the concentration of sugar solutions.
- Making improvements.

Learning aim C: Design and build a cell

C1 Consider equipment, materials, health and safety

- Specific properties, e.g. malleable, ductile, brittle, porous, conductive, non-conductive.
- Acids/alkalis (fruit or chemical solutions).
- Sandpaper.
- Coins.
- Voltmeter.
- LED.
- Copper and zinc sulphate solutions.
- Health and safety aspects.

C2 The planning stage

- Producing results tables.
- Outline planning and drawings.

C3 Construction, testing and evaluation

- Construction using materials from planning stage.
- Testing and evaluating effectiveness and making improvements.

Learning aim D: Design and build a microbalance

D1 Consider equipment, materials, health and safety

- Specific properties, e.g. malleable, ductile, brittle, porous.
- U-shaped metal.
- Small squares of graph paper.
- Scissors.
- Straws.
- Base.
- Pin.
- Clamp and stand (or equivalent).
- Health and safety aspects.

D2 The planning stage

- Calibration.
- Retesting.
- Suitability of materials:
  - paper
  - card
  - plastics
  - metal
  - wood
  - tape.
- Outline planning and drawings.

D3 Construction, testing and evaluation

- Construction using materials from the planning stage.
- Testing and evaluating effectiveness and making improvements.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Design and build a hydrometer		**A.D1** Evaluate the hydrometer, commenting on its performance and suggesting improvements to the finished product.
A.P1 Design, construct, calibrate and test a working hydrometer to accurately measure the concentration of a sugar solution, recording primary data.	**A.M1** Explain how scientific principles influenced the design considerations of the hydrometer.	
Learning aim B: Design and build a polarimeter		**B.D2** Evaluate the polarimeter, commenting on its performance and suggesting improvements to the finished product.
B.P2 Design, construct, calibrate and test a working polarimeter to accurately measure the concentration of a sugar solution, recording primary data.	**B.M2** Explain how scientific principles influenced the design considerations of the polarimeter.	
Learning aim C: Design and build a cell		**C.D3** Evaluate the cells, commenting on their performance and suggesting improvements to the finished products.
C.P3 Design, construct and test different working cells, recording primary data.	**C.M3** Explain how scientific principles influenced the design considerations of different cells.	
Learning aim D: Design and build a microbalance		**D.D4** Evaluate the microbalance, commenting on its performance and suggesting improvements to the finished product.
D.P4 Design, construct and test a working microbalance, recording primary data.	**D.M4** Explain how scientific principles influenced the design considerations of the microbalance.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is also further information on our website.

There is a maximum number of four summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.M1, A.D1)

Learning aim: B (B.P2, B.M2, B.D2)

Learning aim: C (C.P3, C.M3, C.D3)

Learning aim: D (D.P4, D.M4, D.D4)

Further information for teachers and assessors

Resource requirements

For this unit, learners must have access to suitable and sufficient equipment and components to construct and test the four devices (hydrometer, polarimeter, battery and microbalance). This should also include text/video/internet access for additional guidance.

Essential information for assessment decisions

Learning aim A

For Distinction standard, learners need to comment on the performance of their hydrometer in terms of its accuracy to measure the concentration of a sugar solution, evaluate their final product and make valid suggestions for improving it. This could be done by making a comparison with hydrometers on general sale, e.g. for measuring the sugar levels for wine-making.

For Merit standard, learners need to explain how scientific principles influenced their design for the hydrometer, which has shown to be fit for purpose from the testing in A.P1. The choice of materials must also be explained, as well as any safety considerations.

For Pass standard, learners must provide a suitable design for the hydrometer, which could be based on secondary evidence, choosing suitable materials to make it. Learners need to build the hydrometer from their design and calibrate it. They need to demonstrate that it functions correctly by testing it and recording appropriate primary data.

Learning aim B

For Distinction standard, learners need to evaluate their final product and make valid suggestions for improving it. Comments are expected on the performance of their polarimeter in terms of its accuracy to measure the concentration of a sugar solution. They could compare their polarimeter with polarimeters on sale from scientific suppliers.

For Merit standard, learners need to explain how scientific principles influenced their design for the polarimeter to produce their working model, which has shown to be fit for purpose from the testing in B.P2. A detailed understanding of polarisation is not expected. The choice of materials must also be explained, as well as any safety considerations.

For Pass standard, learners must provide a suitable design for a polarimeter, choosing suitable materials to make it. Learners need to build the polarimeter from their design and calibrate it. They need to demonstrate that it functions correctly by testing it and recording appropriate primary data.

Learning aim C

For Distinction standard, learners need to evaluate their final products and make valid suggestions for improving them. This could be done by making a comparison with cutaway diagrams or cells on general sale. Learners should also consider the suitability of using electrolytes or fruit, as opposed to freshly made solutions or ripe fruit, and the properties of the materials used in construction.

For Merit standard, learners need to explain how scientific principles influenced their design for the cells, which have shown to be fit for purpose from the testing in C.P3. Learners must explain their choices of materials, such as concentration of electrolytes (from either fruit or other substances), combinations of metal electrodes and thicknesses of electrodes or other valid points. Learners should also explain any safety considerations.

For Pass standard, learners must provide a suitable design for two different types of cell, which could be based on secondary evidence, choosing suitable materials to build them. They need to demonstrate that their cells function correctly by testing them and recording appropriate primary data.

Learning aim D

For Distinction standard, learners need to comment on the performance of their microbalance, evaluating their final product and making valid suggestions for improving it. This could be done by making a comparison with cutaway diagrams or microbalances on general sale, taking into account the properties of the materials used in the construction of the microbalance.

For Merit standard, learners need to explain how scientific principles influenced their design for the microbalance, which has shown to be fit for purpose from the testing in D.P4. The choice of materials should be explained, as well as any safety considerations.

For Pass standard, learners must provide a suitable design for a microbalance, choosing suitable materials to make it. Learners need to build the microbalance from their design. They need to demonstrate that it functions correctly by testing it and recording appropriate results. This can be tested by measuring the mass of the paper with the constructed microbalance and also with a commercial balance, and comparing the primary data. The accuracy of measurement should be to acceptable standards and the device should be well calibrated. There should be a full list of measurements of other useful items.

Links to other units and other curriculum subjects

This unit links to:

- Unit 1: Principles of Science
- Unit 3: Energy and Our Universe
- Unit 6: Applications of Physical Science
- Unit 9: Practical Scientific Project
- Unit 21: Electronics in Action.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers and demonstrations
- work experience in manufacturing and production industry
- visits to appropriate business organisations including further education colleges.

Opportunities to develop transferable skills In completing this unit,

Learners will have the opportunity to develop their planning skills with additional opportunities for detailed research activities. Learners will be able to develop further their understanding of the process for planning prior to development of manufactured products and appreciate the need for detailed scientific testing.

Unit 19: Chemical Analysis and Detection

Level: **2**
Unit type: **Internal**
Guided learning hours: **30**

Unit in brief

This unit enables learners to build on knowledge and concepts learned in *Unit 1: Principles of Science*, *Unit 2: Chemistry and Our Earth* and *Unit 5: Applications of Chemical Substances* and apply these to the detection and analysis of chemical substances.

Unit introduction

Chemical analysis and detection is an important and growing field in science and related sectors. The identification of unknown solids and solutions is a vital part of analytical chemistry carried out, for example, in the pharmaceutical and food industries, sports science, pathology, and environmental and forensic laboratories. Chemical analysis is used, for example, to test athletes for the presence of drugs, to check that food is fit to eat, and to check for pollutants in the water that we drink.

In this unit, learners will learn how to identify unknown compounds, using more than one type of analytical technique. The teacher may present the unit with a forensic slant or from an environmental health standpoint. The teacher may cover examples of scenarios where it is important to identify unknown substances. For example, on the bench is a crucible that contains a white powder and a beaker that holds a clear liquid. Neither is labelled. Are they as innocent as they look? Is the powder common salt or a cyanide? Is the liquid just water or a corrosive acid? They will learn techniques that will allow them to gain an insight into the identification of these unknown chemicals. Testing for inorganic substances uses a wide range of practical work to identify cations, anions and gases, and develops previous knowledge from *Unit 1: Principles of Science*, *Unit 2: Chemistry and Our Earth* and *Unit 5: Applications of Chemical Substances* of the periodic table, atomic structure and bonding. pH is also used in the identification and classification of chemicals.

Learners can identify a wide selection of chemicals from the laboratory and from home, and classify them as either acidic or basic. Even tap, distilled and bottled water from different areas can show variations in pH. Many materials are mixtures and chromatography is a technique that learners can use to separate and identify the different components of substances, such as marker pen fluids, different coloured inks and plant materials. This unit aims to develop learners' knowledge and skills in chemical analysis and detection and build on the basic chemistry concepts that learners have learned in *Unit 1: Principles of Science*, *Unit 2: Chemistry and Our Earth* and *Unit 5: Applications of Chemical Substances*

Learning aims

In this unit you will:

A Classify substances on the basis of pH

B Use chemical tests to identify ions and gases

C Carry out quantitative analysis on substances

D Carry out chromatographic separations.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Classify substances on the basis of pH	**A1** Terminology **A2** Chemical techniques for measuring pH and acidity **A3** Solutions to test	A practical report/pro forma that can also include observation records for pH tests on household and laboratory solutions. A comparison of the pH of a strong and weak acidic solution. Evaluation of the techniques with identification of potential sources of error.
B Use chemical tests to identify ions and gases	**B1** Carrying out tests for gases **B2** Structure of ionic inorganic compounds **B3** Flame tests for cations **B4** Testing for anions **B5** Testing for unknown substances **B6** Writing equations	A report that can include a practical work report/log with suitable pro forma and observation records in relation to practical work on known substances. This should also include planning, recording of results, balanced equations and deductions from the analysis of unknown substances.
C Carry out quantitative analysis on substances	**C1** Calculations involving concentration and mass **C2** Preparation of soluble salts **C3** Acid-base titrations	A report that includes observation records and written reports for carrying out preparations and titration. This should also include results and appropriate calculations.
D Carry out chromatographic separations	**D1** Chromatographic techniques **D2** Carrying out chromatographic techniques **D3** Interpreting chromatographs	A report that can include observation records of carrying out chromatographic separations, results, copies of chromatographs and written details of the practical work and analysis of the results.

Content

Learning aim A: Classify substances on the basis of pH

A1 Terminology

- Definitions and terminology relating to acids and alkalis:
  - acid, acidic, alkali, alkaline
  - weak acid/alkali, strong acid/alkali
  - neutral
  - pH as a measure of the concentration of H^+ ions.

A2 Chemical techniques for measuring pH and acidity

- Chemical indicators:
  - red cabbage juice
  - litmus paper
  - universal indicator (solution and paper).
- pH meters.
- Use and calibration of pH meters.
- Sources of error in techniques for measuring pH (chemical and pH meter).
- Recognise that the greater the concentration of a strong acid, the lower the pH:
  - comparison of the pH of ethanoic acid and hydrochloric acid of the same concentration
  - draw conclusions about the concentration of hydrogen ions in each solution.

A3 Solutions to test

- Familiar/household solutions:
  - tea, coffee, soft drinks, lemon juice, orange juice, vinegar, wine, water, bleach, milk, soap, washing-up liquid, salt, baking soda, washing powder, washing liquids.
- Laboratory solutions:
  - sodium hydroxide, hydrochloric acid, ethanoic acid, sodium chloride.

Learning aim B: Use chemical tests to identify ions and gases

B1 Carrying out tests for gases

- Tests for the following gases:
  - Hydrogen: squeaky pop test
  - oxygen: relights a glowing splint
  - carbon dioxide: makes limewater turn milky.

B2 Structure of ionic inorganic compounds

- Cations.
- Anions.
- Recognition and use of formulae of ions and ionic compounds:
  - writing formulae of ionic compounds
  - naming ions and ionic compounds from formulae.

B3 Flame tests for cations

- Flame test colours for:
  - sodium
  - potassium
  - lithium
  - calcium
  - barium
  - copper.

B4 Testing for anions

- Testing for carbonate ions with acid:
  - effervescence
  - evolution of carbon dioxide (testing with lime water).
- Testing for chloride ions, bromide ions and iodide ions with dilute nitric acid and silver nitrate solution:
  - observation of precipitate formed
  - silver chloride white, silver bromide cream, silver iodide yellow.
- Testing for sulfate ions with dilute hydrochloric acid and barium chloride solution:
  - formation of white precipitate of barium sulfate.

B5 Testing for unknown substances

- Carrying out a test on an unknown substance:
  - planning how to undertake testing
  - naming a substance, once the anion and cation are identified
  - understanding cross-contamination and false positives.

B6 Writing equations

- Types of equation:
  - word equations
  - balanced symbol equations
  - ionic equations.

Learning aim C: Carry out quantitative analysis on substances

C1 Calculations involving concentration and mass

- Calculation of concentration of solutions in g dm^{-3}.
- Evaporation of a solution to dryness to determine the mass of solute in a given mass of solution.
- The amount of a substance can be measured in grams, numbers of particles or number of moles of particles.
- Conversion of masses of substances into moles of particles of the substance and vice versa using number of moles (n) = mass of substance (m/relative molecular mass (M_r).
- Conversion of concentrations in g dm^{-3} into mol dm^{-3} and vice versa.

C2 Preparation of soluble salts

- Soluble salts prepared from an acid and an insoluble reactant:
  - excess of the reactant can be added to ensure that all the acid is used up
  - the excess reactant can be removed by filtration
  - the solution remaining is only salt and water
  - the salt can be obtained by crystallisation.
- Soluble salts prepared from an acid and a soluble reactant:
  - titration must be used to determine the exact amount of the soluble reactant that reacts with an acid
  - the acid and the soluble reactant can then be mixed in the correct proportions
  - the solution remaining after reaction and evaporation/crystallisation is only salt and water.

C3 Acid-base titrations

- Acid-base titrations are neutralisation reactions where hydrogen ions (H^+) from the acid react with hydroxide ions (OH^-) from the base.
- Carry out simple acid-base titrations using burette, pipette and suitable acid-base indicators.
- Carry out an acid–base titration to prepare a salt from a soluble base.
- Carry out simple calculations using the results of titrations to calculate an unknown concentration of a solution or an unknown volume of solution required.

Learning aim D: Carry out chromatographic separations

D1 Chromatographic techniques

- Carrying out chromatographic separations on mixtures of substances/extracts using non-instrumental techniques:
  - paper chromatography
  - thin-layer chromatography
  - column chromatography.

D2 Carrying out chromatographic techniques

- Separating substances using chromatography.
- Substances to separate, e.g.:
  - chlorophyll – leaves/grass pigments
  - inks
  - orange and lemon juice
  - a mixture of amino acids
  - caffeine from coffee
  - paracetamol.

D3 Interpreting chromatographs

- Use information from chromatographs to:
  - determine if a substance is pure
  - identify the components of a mixture
  - calculate R_f values.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Classify substances on the basis of pH		
A.P1 Carry out tests on solutions of household and laboratory substances to determine their pH.	**A.M1** Compare the pH of a weak acid and a strong acid of identical concentration and draw a conclusion about the concentration of hydrogen ions.	**A.D1** Evaluate the procedures used and the sources of error in measuring pH of solutions.
Learning aim B: Use chemical tests to identify ions and gases		
B.P2 Carry out practical tests to identify common gases. **B.P3** State the formulae of ions present in named ionic compounds. **B.P4** Devise and follow a plan to identify the cations in unknown substances correctly. **B.P5** Devise and follow a plan to identify the anions in unknown substances correctly.	**B.M2** Deduce the identity of unknown substances tested.	**B.D2** Write balanced symbol equations for tests used to identify an unknown substance.
Learning aim C: Carry out quantitative analysis on substances		
C.P6 Prepare salts from soluble and insoluble reactants. **C.P7** Carry out a titration of an acid and an alkali.	**C.M3** Use the mole concept to calculate the concentration of a solution in mol dm^{-3} and convert from g dm^{-3} to mol dm^{-3}.	**C.D3** Determine the concentration of an unknown solution using data from a titration experiment.
Learning aim D: Carry out chromatographic separations		
D.P8 Carry out chromatographic separation using different techniques.	**D.M4** Calculate an R_f value for a chromatographic separation.	**D.D4** Analyse the outcomes of a chromatographic separation.

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is also further information on our website.

There is a maximum number of four summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.M1, A.D1)

Learning aim: B (B.P2, B.P3, B.P4, B.P5, B.M2, B.D2)

Learning aim: C (C.P6, C.P7, C.M3, C.D3)

Learning aim: D (D.P8, D.M4, D.D4)

Further information for teachers and assessors

Resource requirements

For this unit, learners must have access to good laboratory facilities and a range of suitable chemicals and equipment.

Essential information for assessment decisions

Learning aim A

For Distinction standard, learners should be able to assess the accuracy of the procedures used, identify factors that introduce inaccuracy and evaluate the extent to which this affects results and conclusions. This could be done as a separate exercise or could be included in a report on the practical work.

For Merit standard, learners should be presented with two identical concentrations of a strong acid and a weak acid, e.g. 0.01 mol dm^{-3} hydrochloric acid and ethanoic acid. These should be part of the group of solutions whose pH is tested for Pass standard. Learners should be able to conclude that the difference in pH is due to there being fewer hydrogen ions in the weak acid.

For Pass standard, learners should carry out the determination of the pH value for a range of different solutions (to include strong acid, weak acid, strong alkali, weak alkali and neutral solution), using universal indicator and a pH meter.

Learning aim B

For Distinction standard, learners must write balanced symbol equations for the tests they have carried out. This must be linked to the work carried out for Merit standard.

For Merit standard, learners will be able to conclude that, for example, if the cation is lithium and the anion is chloride, the unknown substance must be lithium chloride.

For Pass standard, learners should carry out the tests to identify hydrogen, carbon dioxide and oxygen. Learners need to state the formulae of ions present in at least six different ionic compounds, from a variety of groups in the periodic table. Learners are required to devise and follow a plan of how to identify the cations in at least three inorganic substances. The plan could be in the form of a flow chart and should be devised to be carried out in a logical order. Learners are also required to devise and follow a plan of how to identify the anions in at least three inorganic substances. Again this could be in the form of a flow chart and devised to be carried out in a logical order.

Learning aim C

For Distinction standard, learners could use the results from Pass standard to calculate the concentration of the unknown solution.

For Merit standard, learners need to use the mole concept to calculate the concentration of a solution correctly. This could be one they have used at Pass standard.

For Pass standard, learners need to prepare a salt from a soluble reactant and one from an insoluble reactant. Assessors should use an observation sheet to record their observations and learners could write a brief laboratory report. They need to carry out a simple titration using an acid and an alkali. Again assessors should use an observation sheet to record their observations and learners could write a brief laboratory report.

Learning aim D

For Distinction standard, learners could sketch or photograph chromatograms and calculate R_f values.

For Merit standard, learners need to analyse the outcomes of the separations, including the analysis of unknowns and reasons why spots move different distances.

For Pass standard, learners must use chromatography to separate at least two different types of substance. They should use at least two techniques. The pigments in a propanone extract of fresh or dried leaves may be separated using paper, column or thin layer chromatography (TLC). Amino acids may be separated using paper chromatography and TLC. TLC of paracetamol and caffeine, using iodine as a locating agent, may be easily related to the pharmaceutical industry.

Links to other units and other curriculum subjects

This unit links to:

- Unit 1: Principles of Science
- Unit 2: Chemistry and Our Earth
- Unit 5: Applications of Chemical Substances
- Unit 8: Scientific Skills
- Unit 23: Further Chemistry.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers and interview opportunities
- work experience
- visits to appropriate business organisations.

Opportunities to develop transferable skills

In completing this unit, learners will have the opportunity to develop skills and knowledge in chemistry techniques that are required for qualitative and quantitative analysis.

Unit 20: Exploring Our Universe

Level: **2**
Unit type: **Internal**
Guided learning hours: **30**

Unit in brief

In this unit learners will understand about the Solar System and the Universe.

Unit introduction

There is a continued growing interest in astronomy and the exploration of our Universe. Learners will find out that our world is a very small planet in a vast Universe, and understand the apparent movement of the Sun, Moon and stars across the sky.

Knowledge of the Universe and our place within it has been developing for thousands of years but has increased significantly over the last few hundred years as a result of the advances made in scientific instruments.

This unit will provide a clear outline of our present understanding of the system of planets and other objects in orbit around our Sun, where our Solar System is in terms of its place in the Universe, and what scientific methods and instruments have helped to provide this knowledge in more recent times.

In addition, this unit will look at space exploration, our knowledge of moons and smaller objects, and give learners opportunities to discover some interesting facts and figures. There is also an opportunity to explore the vast scale of the Universe, to learn about other astronomical objects and to gain an insight into the difficulties of producing a theory that neatly explains it all.

Learners will gain an understanding of how the science involved in exploring the Universe is firmly based on established scientific principles, which are the basis for any careers linked to the space exploration industry.

Learning aims

In this unit you will:

A Explore the structure of our Solar System and the Universe

B Study methods used to explore our Universe

C Explore theories of how the Universe was formed.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Explore the structure of our solar system and the Universe	**A1** Solar System objects and key data **A2** Earth-Moon-Sun system **A3** Stars, galaxies and gravitational forces	Description of the structure of the Solar System, supported by diagrams, providing relevant positions of planets and other objects. Detailed report on the Earth-Moon-Sun system and interrelationship, with accurate facts and figures. Description of non-Solar System objects based on suitable examples of stars and galaxies. Description of the birth and death of stars, star types, galaxy formation and forces involved.
B Study methods used to explore our Universe	**B1** Optical telescopes **B2** Other electro-magnetic spectrum telescopes **B3** Manned and unmanned space missions	Diagrammatic representations of refractor/reflector telescopes with light rays shown. This could also include experimental notes from work with lenses and mirrors. Description of the operation of other telescopes and indication of the part of the electromagnetic spectrum used. Brief outline of the history of space exploration as a timeline of events, providing relevant milestones and contributions of missions to scientific development.

Learning aim	Key content areas	Assessment approach
C Explore theories of how the Universe was formed	**C1** The Big Bang theory and approximate age of the Universe **C2** Evidence to support the Big Bang theory (redshift and cosmic microwave background radiation) **C3** Limitations of the Big Bang theory	Explanation of the Big Bang theory in basic terms and outline of the evidence to support the time-scale involved. Description of the evidence for the theory and for the continued expansion of the Universe from redshift. Include how the actual origin may never be known.

Content

Learning aim A: Explore the structure of our Solar System and the Universe

A1 Solar System objects and key data

- The planets and their orbital characteristics.
- Exo-planets.
- The Sun.
- The Moon.
- Asteroids, meteors and comets.

A2 Earth-Moon-Sun system

- Lunar and solar eclipses.
- Gravitation and tides on Earth.
- Axis of rotation.
- Moon's rotation about the Earth.
- Earth's rotation about the Sun.

A3 Stars, galaxies and gravitational forces

- How stars are formed.
- Death of stars related to size.
- Influence of gravitation on stars.
- Gas clouds and nebulae.
- Galaxy types (Hubble classification).
- Galaxy types, collisions and clusters.
- Gravitational forces at the centre of galaxies (black holes).

Learning aim B: Study methods used to explore our Universe

B1 Optical telescopes

- Reflector.
- Refractor.
- Principles of both types with ray diagrams.
- Their use throughout history and in the present day.

B2 Other electro-magnetic spectrum telescopes

- Radio telescopes.
- Microwaves telescopes.
- Infrared telescopes.
- Ultraviolet telescopes.
- X-ray and gamma ray telescopes.
- Principles of the different types with ray diagrams.
- Their use throughout history and in the present day.

B3 Manned and unmanned space missions

- Apollo programme.
- International Space Station (ISS).
- NASA Space Shuttle programme.
- Future missions, coalition of inter-government and private ventures.
- Search for extra-terrestrial life (SETI project).

Learning aim C: Explore theories of how the Universe was formed

C1 The Big Bang theory and approximate age of the Universe

- Estimate of 13.7 billion years and evidence in support.
- Hubble 'deep field' evidence and implications.

C2 Evidence to support the Big Bang theory (redshift and cosmic microwave background radiation)

- Evidence for an expanding Universe (redshift showing galaxies moving away from each other).
- Cosmic microwave background radiation and the importance of its detection.

C3 Limitations of the Big Bang theory

- Dark matter.
- Dark energy.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Explore the structure of our Solar System and the Universe		
A.P1 Describe the main features of the Solar System, including its planets. **A.P2** Describe the main features of the Universe, excluding the Solar System and including different types of galaxy.	**A.M1** Explain the relationship between the bodies in the Earth-Moon-Sun system. **A.M2** Explain the life cycle of stars.	**A.D1** Explain the characteristics of galaxies and galaxy clusters.
Learning aim B: Study methods used to explore our Universe		
B.P3 Describe the different methods used to explore the Universe, including the use of different types of telescope. **B.P4** Describe how manned and unmanned space missions collect scientific data.	**B.M3** Explain why different telescopes are used to observe the Universe. **B.M4** Compare manned and unmanned space missions, in terms of scientific data collected and their limitations.	**B.D2** Analyse how the scientific data collected through observation and space missions is being used.
Learning aim C: Explore theories of how the Universe was formed		
C.P5 Describe the Big Bang theory and how it is used to obtain the age of the Universe.	**C.M5** Explain how evidence supports the Big Bang theory.	**C.D3** Evaluate evidence to support the Big Bang theory and limitations of the theory.

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is also further information on our website.

There is a maximum number of three summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.P2, A.M1, A.M2, A.D1)

Learning aim: B (B.P3, B.P4, B.M3, B.M4, B.D2)

Learning aim: C (C.P5, C.M5, C.D3)

Further information for teachers and assessors

Resource requirements

There are no special resources needed for this unit.

Essential information for assessment decisions

Learning aim A

For Distinction standard, learners need to explain the characteristics of galaxies and galaxy clusters. This explanation needs to include the influence of gravity on the galaxies in galaxy collisions and clusters and black holes at the centre of galaxies.

For Merit standard, learners need to explain each item. The Earth-Moon-Sun system should be dealt with as a series of diagrams explaining the link to eclipses, day and night and the effect of gravitation on tides. In addition, learners need to explain the life cycle of different types of star, including characteristics such as the diameters and mass of stars. Learners could use annotated diagrams or images to achieve this criterion.

For Pass standard, learners should produce a list or diagram of the eight planets, the dwarf planet Pluto, the Sun, Moon and other key features, such as the asteroid belt and some named comets. There should be some detail of the characteristics of the items given. A poster display or list, with the planets in the correct order from the Sun, will be included and a diagram should be annotated to provide a full description. A description of the impacts of collisions of comets and meteors with planets and moons should also be included for A.P1, including how the planetary objects are changed as a result of the collisions. Learners will also need to describe the features of the Universe, including nebulae, different types of galaxy and the effects of gravitation. The description can be a series of annotated diagrams or images.

Learning aim B

For Distinction standard, learners are required to analyse how the data collected by observations and space missions is useful to astronomers, to further our understanding of the nature of the Universe. This needs to include data collected by telescopes and manned and unmanned space missions. This should include an analysis of the usefulness of the scientific data collected by different instruments.

For Merit standard, learners are required to explain why different telescopes are used to observe the Universe. Learners could include details, such as an explanation using a diagram of the electromagnetic spectrum with the method of observation, for example Hubble (optical), Chandra (X-ray). There should be some inclusion of the wavelengths at which these telescopes operate. Examples of objects observed using particular wavelengths and also some mention of the measurement of distance should be included in the explanation for this criterion. Learners might also include ray diagrams to help in their explanation of why different telescopes are used in observations. In addition, learners need to compare manned and unmanned space missions, so a description of each is not sufficient here. Learners must carry out a comparison in terms of the scientific data collected and what the limitations are for each type of mission. Most learners will mention cost, problems of humans travelling vast distances and the time involved but they must also include the amount and scientific value of the data collected.

For Pass standard, learners must provide information on how we use different techniques to explore the Universe. This could be shown as a comprehensive table of the different telescopes and techniques used to explore the Universe. Learners could construct and test simple telescopes. Learners will also need to describe how manned and unmanned space missions collect scientific data. This could be shown in a comprehensive table of different space missions, showing how scientific data was collected by each one.

Learning aim C

For Distinction standard, learners are required to evaluate the evidence to support the Big Bang theory. Learners will have to look at the supporting evidence (given in C.M5) and other evidence that may not be supportive of the theory. Descriptions will not be sufficient to achieve this criterion. Learners need to evaluate the evidence that supports the Big Bang theory and then decide if the limitations are sufficient to make the idea doubtful or not.

For Merit standard, learners may complete this as part of C.P5. Assessors must make sure the learner has explained the evidence to support the Big Bang theory and not just repeated the description given in C.P5. The evidence needs to mention the redshift and cosmic microwave background radiation and its significance in the Big Bang theory.

For Pass standard, a description is required of the Big Bang theory and its use in identifying the age of the Universe. Although they are not asked to give evidence to support the theory, some learners may do so and assessors should look for sufficient evidence, which may cover assessment criterion C.M5 at this point. The description could be presented as a series of annotated diagrams but assessors should make sure the key facts are described.

Links to other units and other curriculum subjects

This unit links to:

- Unit 1: Principles of Science
- Unit 3: Energy and Our Universe
- Unit 6. Applications of Physical Science.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers
- work experience.

Opportunities to develop transferable skills

In completing this unit, learners will have the opportunity to develop research and planning skills and improve their ability to use specific science terms appropriately.

Unit 21: Electronics in Action

Level: **2**
Unit type: **Internal**
Guided learning hours: **30**

Unit in brief

This unit looks at electronic components and circuits.

Unit introduction

Almost all electrical equipment we use at home and in the workplace contains electronic components. This unit will enable learners to identify electronic components and learn about their uses in the electronics industry for safe, effective circuit design and construction. It will also help learners gain some understanding of the way in which some domestic devices operate. Learners will be provided with step-by-step guidance on the function of electronic components and use this to build the simple electronic circuits that are used as 'building blocks' for complex electronic systems.

Learners will be able to put basic electronic theory into practice by building some practical working circuits and systems that include sensors and electronic switches. Circuit testing is included as part of each practical circuit building activity, using common test equipment that a working electronics technician would encounter.

There is an emphasis on the importance of using equipment with care. This aspect will become routine in practical lessons and learners should follow industrial practice and minimise the risk of accidents and damage.

This unit builds on the investigations into electricity in *Unit 6: Applications of Physical Science*.

Learning aims

In this unit you will:

A Identify electronic components and their uses

B Build electronic circuits and systems safely

C Check, measure and test electronic circuits.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Identify electronic components and their uses	**A1** Resistors, capacitors, diodes and switches **A2** Transducers (resistive input) **A3** Transistors and integrated circuits	Production of a catalogue with photos or drawings of components and their circuit symbols with detailed descriptions of their functions. Presentations on the use and function of integrated circuits using PowerPoint and accompanying notes.
B Build electronic circuits and systems safely	**B1** Safety in circuit assembly **B2** Essential circuit calculations and transducers **B3** Integrated circuits and circuit diagrams	Scientific report for a scenario of 'electronics employer', including expected currents and voltages for a circuit, photograph of circuit, observation record. Review of the safety considerations in electronic circuit design and construction. Appraisal of circuit construction in terms of expected difficulty from following (not needed) circuit diagrams.
C Check, measure and test electronic circuits	**C1** Important circuit checks **C2** Measurements and tests **C3** Essential health and safety	Description of circuit testing procedures and confirmation of correct components from circuit diagrams reporting any changes that may have been made. Report on the operation of the circuit from measured values obtained. Explanation of safety precautions followed during circuit construction and assessment of circuit function.

Content

Learning aim A: Identify electronic components and their uses

A1 Resistors, capacitors, diodes and switches

- Fixed resistors (E24 values, colour code, tolerance, power ratings).
- Variable resistors.
- Capacitors.
- Fixed capacitors (values).
- Voltage–time graphs for charging and discharging a capacitor through a resistor.
- Diodes and LEDs (values and graphs of turn on voltages for silicon and germanium diodes).
- Switches (tilt and reed), lamps and buzzers.

A2 Transducers (resistive input)

- Light-dependent resistors (LDRs).
- Moisture detector.
- Photodetector.
- Thermistors.

A3 Transistors and integrated circuits

- Types (npn and pnp).
- Use as a switch.
- Use as a current amplifier.
- Logic gates (NOT, OR, AND, NOR, NAND).
- 555 timer (monostable and astable configurations).
- Operational amplifiers (741) and use as a comparator.
- Physical appearance and component symbols.

Learning aim B: Build electronic circuits and systems safely

B1 Safety in circuit assembly

- Risk assessments.
- First-aid procedures for shock/electric or acid burns.
- Safe handling of equipment and components.
- Wiring and cable identification.
- General safety precautions (earthing).
- Power sources, e.g. batteries, low-voltage power supply units.

B2 Essential circuit calculations and transducers

- Ohm's law ($V = IR$), series and parallel circuits, power equation ($P = VI$).
- Potential divider circuits.
- Transistor circuits (switch and amplifier) using Bipolar Junction Transistors (BJT).
- Input transducers, e.g. thermistor, LDR, moisture detector and photodetector.
- Output transducers, e.g. LED, buzzer.

B3 Integrated circuits, circuit diagrams and systems

- Logic gates, e.g. NOT, OR, AND, NOR, NAND.
- 555 timers (monostable and astable configurations).
- Operational amplifier as a comparator, using sensors and output devices.
- Block diagrams showing input/processor/output devices.
- Circuit diagrams.
- Purpose of systems, e.g. home, business, hospitals, cars.

Learning aim C: Check, measure and test electronic circuits

C1 Important circuit checks

- Check circuit diagram matches circuit layout.
- Importance of checking for good connections.

C2 Measurements and tests

- Use of Ohm's law and potential divider equations to calculate circuit values that can be measured.
- Use of meters to measure voltage and current.
- Importance of repeating measurements.

C3 Essential health and safety

- Importance of health and safety when carrying out checks, measurements and tests on circuits and systems.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Identify electronic components and their uses		**A.D1** Evaluate the advantages and disadvantages of using integrated circuits.
A.P1 Identify electronic components from symbols and their physical appearance.	**A.M1** Describe the function of electronic components.	
Learning aim B: Build electronic circuits and systems safely		**B.D2** Evaluate an electronic system and suggest improvements.
B.P2 Safely construct working electronic circuits. **B.P3** Safely construct a useful working electronic system that meets an identified purpose.	**B.M2** Calculate expected value of voltages and currents for different places in electronic circuits. **B.M3** Explain how the electronic system meets its purpose and identify any weaknesses.	
Learning aim C: Check, measure and test electronic circuits		**C.D3** Evaluate electrical measurements of voltages and currents against calculated values.
C.P4 Carry out checks and electrical measurements safely to test circuits.	**C.M4** Discuss the importance of reliability of measurements on circuits.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is also further information on our website.

There is a maximum number of three summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.M1, A.D1)

Learning aim: B (B.P2, B.P3, B.M2, B.M3, B.D2)

Learning aim: C (C.P4, C.M4, C.D3)

Further information for teachers and assessors

Resource requirements

For this unit, learners must have access to:

- electronic measuring equipment, for example low-voltage power supplies, multi-meters (or voltmeters and ammeters) to suitable scales of measurement
- a wide range of electronic components to include, for example, LEDs, diodes, capacitors and full range of resistors, input and output transducers, integrated circuit components.

Essential information for assessment decisions

Learning aim A

For Distinction standard, learners are expected to evaluate the advantages and disadvantages of integrated circuits over discrete components (include cost, size, power consumption, ease of use).

For Merit standard, learners must describe briefly the purpose of each of the components that appears in the content section. This should include their effect on circuit operation where appropriate, for example a fixed resistor limits the flow of current in a branch of a circuit. Learners should know some integrated circuits can be configured to perform different functions, for example a 555 timer may be configured as monostable for timing circuits or as astable, for example to make an LED flash or produce sound effects.

For Pass standard, learners should be able to identify all components in the content from their associated circuit symbols and physical appearance. For example, identifying the resistor value from its colour code and pin connections for integrated circuits. This could be achieved through a poster, leaflet, or an exercise from matching cards, for example.

Learning aim B

For Distinction standard, learners must evaluate a system they have built, including the circuits it contains, and provide suggestions of how to improve them. Learners could experiment with changing some components, for example resistor values, and suggest improvements to the design. More able learners may add a light-sensing building block to another circuit and test its operation. Sound reasoning and valid suggestions are required to achieve this criterion.

For Merit standard, learners should calculate selected voltages and current values for some circuits they have built. Calculations can include resistance and power rating values from measurements of voltage and current. There needs to be a sufficient number of calculations to show that learners can apply Ohm's law consistently to simple circuits. While constructing circuits for B.P2 learners should have been taught (during the delivery stage) to recognise the building blocks that are used in electronic systems, for example a current amplifier, to prepare them for building an electronic system. Learners must also explain how their system meets its purpose and identify any weaknesses. This will relate all input changes to the eventual output.

For Pass standard, learners must construct a sufficient number of working circuits to cover all the components in the content and identify all components used. Colour-coding charts and conversions to standard form for very low values (where appropriate) must be used correctly. Aspects of safety and correct handling are to be clearly demonstrated and must be evidenced by an observation record. Learners must construct a useful working electronic system, from a minimum of two smaller circuits that may have been constructed in B.P2. This could be any of the systems mentioned previously for a specific purpose. Aspects of safety and correct handling are to be clearly demonstrated and must be evidenced by an observation record.

Learning aim C

For Distinction standard, learners could measure the voltages and currents that were calculated in C.M4 to evaluate electrical measurements against calculated values to achieve C.D3. Learners should account for any differences, for example by referring to the tolerance of components.

For Merit standard, learners must discuss the importance of reliability of measurements for electric circuits, by repeating measurements and providing the evidence in their reporting of practical investigation.

For Pass standard, learners must use appropriate test equipment to measure voltages and currents at various points in their circuits after checking their circuits against circuit diagrams thoroughly. Results could then be shown on the diagrams. Vital health and safety considerations are to be proposed and evidenced by an observation record.

Links to other units and other curriculum subjects

This unit links to:

- Unit 1: Principles of Science
- Unit 3: Energy and Our Universe
- Unit 6: Applications of Physical Science
- Unit 8: Scientific Skills.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers from electrical component suppliers/manufacturers
- work experience in an electrical workshop.

Opportunities to develop transferable skills

In completing this unit, learners will have the opportunity to develop research and planning skills related to circuit construction and accuracy of measurement recording. Learners will increase their attention to detail and improve their mathematical skills by carrying out regular calculations needed to achieve expected circuit outcomes.

Unit 22: Biotechnology Procedures and Applications

Level: **2**
Unit type: **Internal**
Guided learning hours: **30**

Unit in brief

This unit looks at biotechnology from historical (but still important) techniques of plant and animal breeding to modern techniques used in food production, healthcare and forensic science.

Unit introduction

Biotechnology is the application of science and engineering principles to the processing of materials by biological agents to provide goods and services. Today, biotechnology is mostly thought of in terms of genetic engineering, but historically biotechnology was used in the selection of crops in order to enhance yield or characteristics and in controlled breeding experiments to cultivate certain qualities. This unit will investigate the uses of biotechnology in the past and present, and how it may benefit humans in the future.

Biotechnology is now influencing almost every aspect of our lives, providing solutions and breaking new ground. It is at the cutting edge of science and the biotechnology industry now has an annual turnover of tens of billions of pounds. With global demands for fuel and food ever increasing, and fossil fuels and usable land fast running out, scientists are focusing more on using biotechnology to come up with the solutions. Conversion of waste biomass into renewable biofuels, medicines produced by controlled cell systems, and possible cures for debilitating diseases like multiple sclerosis are just some of the incredible uses of biotechnology.

In this unit, learners will research the areas mentioned above and their underlying principles. Learners will research the manipulation of DNA and the host organisms that are used. By the end of the unit, learners should be able to describe the uses of biotechnology and how biotechnology is used in a laboratory environment. Learners should be able to discuss how biotechnology could help humans generally.

Learning aims

In this unit you will:

A Explore how the biotechnology industry has developed

B Explore how biotechnology is used in our everyday lives.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Explore how the biotechnology industry has developed	**A1** Historical biotechnology to make products **A2** Contemporary biotechnology to make products	Learners could produce a booklet or series of posters that explains and evaluates historical and contemporary uses of biotechnology.
B Explore how biotechnology is used in our everyday lives	**B1** Products from biotechnology **B2** Techniques in biotechnology **B3** Gene manipulation	Learners could produce an illustrated magazine article that explores how selected biotechnological techniques are used today.

Content

Learning aim A: Explore how the biotechnology industry has developed

A1 Historical biotechnology to make products

- Defining the term 'biotechnology':
  - use of living organisms, e.g. plants, animals, microorganisms to develop or make products.
- Principles and explanations of historical biotechnology processes:
  - breeding of plants and animals; cloning plants, e.g. cuttings, dividing
  - gathering/processing herbs for medicine
  - making foods, e.g. bread, cheese, yoghurt, wine
  - waste disposal, composting, biofuels
  - making vaccines.

A2 Contemporary biotechnology to make products

- Principles and applications of contemporary biotechnology processes:
  - artificial selection;
  - use of molecular markers and screening for desired or undesirable genes, e.g. mildew-resistant millet
  - genetic manipulation.

Learning aim B: Explore how biotechnology is used in our everyday lives

B1 Products from biotechnology

- The characteristics of products of biotechnology:
  - biodegradable plastics
  - biofuels
  - genetically modified crops
  - detergents
  - drugs
  - medical treatments
  - human enzymes
  - functional proteins
  - tissue culture, e.g. stem cell technology and fertility treatments.
- The uses of biotechnology in manufacturing:
  - drug production
  - large-scale laboratory production of materials
  - production of fuels and detergents.
- Principles and explanations of issues surrounding the use of biotechnology:
  - ethical considerations
  - drawbacks of using biotechnology
  - risks associated with new technologies
  - clinical efficacy and longevity of treatments
  - lack of long-term scientific trials for side effects.

B2 Techniques in biotechnology

- Production techniques:
  - cloning
  - tissue culture
  - fermentation
  - aseptic techniques in laboratory and manufacturing.
- Analytical techniques:
  - polymerised chain reaction (PCR)
  - genetic fingerprinting
  - identification of individual or organism.

B3 Gene manipulation

- Microorganisms used in manipulation of genes:
  - yeast
  - bacteria
  - plasmids
  - viruses.
- Processes of gene manipulation:
  - DNA isolation
  - restriction
  - ligation
  - transformation of host cells by plasmid or vector
  - selection and culture of the modified cells.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Explore how the biotechnology industry has developed		
A.P1 Describe processes used in the past to change biological characteristics in plant and animal systems. **A.P2** Describe contemporary uses of biotechnology to change biological characteristics in plants and animals.	**A.M1** Explain the differences in how genes have been selected in the past and present in plant and animal systems.	**A.D1** Evaluate the use of biotechnology procedures in plant and animal systems over time.
Learning aim B: Explore how biotechnology is used in our everyday lives		
B.P3 Describe areas where biotechnology is used to improve manufacturing and medicine. **B.P4** Describe a variety of techniques used within biotechnology. **B.P5** Describe the processes used for gene manipulation and summarise their advantages and disadvantages.	**B.M2** Explain how different products produced through biotechnology improve human health and make manufacturing more productive. **B.M3** Explain how different techniques allow biotechnology to make improvements to society. **B.M4** Describe how a biotechnology procedure is used on an industrial scale.	**B.D2** Evaluate the use of biotechnological techniques and procedures, giving consideration to ethical, environmental and social issues.

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is also further information on our website.

There is a maximum number of two summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.P2, A.M1, A.D1)

Learning aim: B (B.P3, B.P4, B.P5, B.M2, B.M3, B.M4, B.D2)

Further information for teachers and assessors

Resource requirements

There are no special resources needed for this unit, although there would be benefit in being able to use techniques such as DNA electrophoresis, genetic modification (e.g. pGLO), cloning (plant cuttings) if possible.

Essential information for assessment decisions

Learning aim A

For Distinction standard, learners need to show understanding of a range of biotechnology procedures used over time, in order to be able to evaluate them. At this level, learners must provide a coherent and logical argument with both advantages and disadvantages given. Examples must be used to illustrate their arguments. Learners do not have to give a final opinion about whether or not they support biotechnology.

For Merit standard, learners must explain that modern-day selection is based on an understanding of genes and how they work, and on modern technologies. Past efforts at selective breeding were based on the outward observation of desired characteristics, as there was no knowledge of the laws of inheritance and the work of Mendel.

For Pass standard, learners must describe the processes that have led to the plants and animals we see in agriculture today, particularly artificial selection. Historical details are not required. Learners must describe the processes and not just state the outcome. For example, they should not just say 'sheep were bred to be bigger or with more wool'. They should point out that farmers understood they could select sheep having the characteristics that they wanted and interbreed them.

Learners must describe the use of modern biotechnology to produce plants and animals having desired characteristics (e.g. golden rice, prevention of bovine leukocyte adhesion deficiency (BLAD)). Learners should give examples from both artificial selection and genetic manipulation, of which the best known will be genetically modified (GM) crops.

Learning aim B

For Distinction standard, learners need to evaluate the biological techniques studied in this unit. They must use examples to consider the benefits and disadvantages of the techniques, including relevant potential ethical, social and environmental issues, and arrive at a rational judgement that is clearly derived from the various dimensions considered. They should not judge individuals or groups.

For Merit standard, learners must use at least two products to show how biotechnology has been used to improve manufacturing processes and human health. Examples could include the use of DNA technology and cell culture to produce insulin. The benefits of this should be described.

Learners must explain how two different biotechnology techniques have led to improvements in society. For example, DNA fingerprinting is used in forensic science to identify victims and suspects in crime cases. DNA technology has been used to produce vaccines (e.g. hepatitis B).

Learners must describe one biotechnology procedure related to industrial-scale production. One example, such as drug production, brewing, detergents or fuels, could be chosen but the learner must consider the particular issues of industrial-scale production.

For Pass standard, learners are required to describe two areas in manufacturing processes that involve biotechnology and that have led to the improvement of those processes. The main areas will probably be in fuel and detergent production and medicines. Learners could also mention brewing or other food production processes. The details of the manufacturing processes are not required, as it should be a description of how biotechnology has been used to improve the processes.

Learners must describe three techniques used in biotechnology. These should not be confined to manufacturing and could include cloning, genetic manipulation, and genetic fingerprinting. Learners should describe the techniques and identify their uses.

Learners must make sure two processes for gene manipulation have been described and a summary given of advantages and disadvantages. The summary might be given as a table, but however it is presented it should refer to both processes listed.

Links to other units and other curriculum subjects

This unit links to:

- Unit 1: Principles of Science
- Unit 4: Biology and our Environment
- Unit 7: Health Applications of Life Science.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers, particularly if they were able to bring equipment and other examples of modern biotechnology
- visits to appropriate organisations.

Opportunities to develop transferable skills

In completing this unit, learners will have the opportunity to develop communication skills and to consider ethical issues in a rational and objective way.

Unit 23: Further Chemistry

Level: **2**
Unit type: **Internal**
Guided learning hours: **30**

Unit in brief

This unit enables learners to further build on key chemistry concepts learned in *Unit 1: Applications of Science* and *Unit 2: Chemistry and Our Earth* and extend their understanding of the principles behind industrial applications of chemistry learned in *Unit 5: Applications of Physical Science*.

Unit introduction

It is essential for chemists to understand the methods used to manufacture chemical products in the most efficient and effective way. This can be by using the process of electrolysis, equilibrium reactions, or organic chemistry reactions to manufacture products, such as solvents, textiles and flavourings.

Learners will learn the process of electrolysis and that it has many uses in the chemical industry. For example, to produce products such as sodium and chlorine, and to purify metals such as copper. Learners will also develop their understanding of reversible reactions and equilibrium reactions between gases. They will study the mole concept, molar volumes and also the factors that affect equilibrium systems. For example, those that affect the Haber process to produce ammonia efficiently to manufacture products, such as fertilisers. They will extend their knowledge of organic chemistry by studying the features and properties of alcohols, and learning how they are used to manufacture many important products such as cosmetics and polyester fibres. The aim of this unit is to develop learners' knowledge and understanding of electrolysis, equilibrium and alcohols and to build on the chemistry concepts they have learned in *Unit 1: Applications of Science*, *Unit 2: Chemistry and Our Earth* and *Unit 5: Applications of Physical Science.*

Learning aims

In this unit you will:

A Investigate electrolytic processes

B Explore equilibrium reactions between gases

C Explore the chemistry of alcohols.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Investigate electrolytic processes	**A1** Electrolysis process **A2** Applications of electrolysis	A report containing diagrams illustrating the process of electrolysis, equations indicating oxidation and reduction, and a written account of industrial applications.
B Explore equilibrium reactions between gases	**B1** Using quantities **B2** Dynamic equilibrium **B3** Industrial applications of equilibrium	A report to include diagrams illustrating the concept of dynamic equilibrium, chemical equations, calculations of molar volume and written descriptions with reference to industrial applications.
C Explore the chemistry of alcohols	**C1** Production of ethanol **C2** Homologous series of organic compounds **C3** Substances produced from ethanol	A report to include diagrams (e.g. molecular structures), equations for reactions involving the production of ethanol and descriptions, and the reactions involving alcohols and written descriptions.

Content

Learning aim A: Investigate electrolytic processes

A1 Electrolysis process

- Electrolytes as ionic substances that conduct electricity:
  - when molten
  - when in solution in water
  - and decomposed by the passage of the current.
- Electrolysis as the passing of an electric current through a liquid or solution containing ions:
  - molten liquid – decomposition of the substance
  - aqueous solutions – can give products from ions in water, rather than from ions of the dissolved solid.
- The movement of ions during electrolysis:
  - positively charged cations migrate to the negatively charged cathode
  - negatively charged anions migrate to the positively charged anode.
- Electrolysis involves oxidation and reduction:
  - oxidation can involve the loss of electrons and reduction can involve the gain of electrons
  - reduction occurs at the cathode and oxidation occurs at the anode in electrolysis reactions.
- Half-equations for reactions occurring at the anode and cathode in electrolysis reactions in this unit.

A2 Applications of electrolysis

- The formation of the products in the electrolysis, using inert electrodes, of the following electrolytes:
  - copper chloride solution
  - copper sulfate solution
  - molten lead bromide
  - sodium chloride solution
  - sodium sulfate solution.
- The purification of copper:
  - by electrolysis, using a pure copper cathode and an impure copper anode
  - additional production of small amounts of valuable metals from the anode sludge
  - change of mass at the electrodes during the electrolysis of copper sulfate solution, using copper electrodes.
- Electroplating can be used to:
  - improve the appearance
  - give resistance to corrosion of metal objects, e.g. gold, silver and chromium.
- Conditions that need to be used during electroplating in order to get an even coverage of the plating metal.

Learning aim B: Explore equilibrium reactions between gases

B1 Using quantities

- The amount of a substance can be measured in:
  - grams
  - number of particles
  - number of moles of particles.
- Conversion of masses of substances into moles of particles of the substance and vice versa using number of moles (n) = mass of substance (m/relative molecular mass (Mr).
- Molar volume of gases – one mole of any gas occupies 24 dm^3 at room temperature and atmospheric pressure.
- Explosives work by producing a rapid expansion as a small volume of solid releases gases, which take up a much larger volume (as an example of the application of molar volume).
- Balanced equations and calculations:
  - using balanced equations in calculations involving the masses of solids and volumes of gases
  - using Avogadro's law to calculate volumes of gases involved in gaseous reactions, given the relevant equations.

B2 Dynamic equilibrium

- The concept of reversible reactions and dynamic equilibrium.
- The position of a dynamic equilibrium is affected by changes in:
  - temperature
  - pressure.
- The consequential effects of factors on the rate of attainment of equilibrium from temperature and pressure changes and the need to use a catalyst.

B3 Industrial applications of equilibrium

- The Haber process:
  - uses a reversible reaction between nitrogen (extracted from the air) and hydrogen (obtained from natural gas and steam) to form ammonia
  - uses specific temperatures, pressures and catalysts to produce an acceptable yield in an acceptable time.
- Ammonia is oxidised to form nitric acid and the reaction between ammonia and nitric acid is used to make the fertiliser ammonium nitrate.

Learning aim C: Explore the chemistry of alcohols

C1 Production of ethanol

- Production of ethanol during the fermentation of carbohydrates:
  - the fermentation mixture is kept warm under anaerobic conditions
  - yeast gives an enzyme to catalyse this reaction
  - concentrated solutions of ethanol can be produced by fractional distillation of the fermentation mixture.
- Ethanol can also be manufactured by reacting ethene (from cracking of crude oil fractions) with steam.
- The factors that are relevant to the choice of method used in the manufacture of ethanol:
  - the relative availability of sugar cane, sugar beet and crude oil
  - the quality of the final product and whether it needs further processing.

C2 Homologous series of organic compounds

- Homologous series are series of compounds that:
  - have the same general formula
  - show a gradual variation in physical properties as exemplified by their boiling points
  - have similar chemical properties.
- The names, formulae and structures of members of the following homologous series (no treatment of isomers is required in any of these series):
  - alkanes, up to four carbon atoms per molecule
  - alkenes, up to three carbon atoms per molecule
  - alcohols, up to three carbon atoms per molecule
  - carboxylic acids, up to three carbon atoms per molecule.

C3 Substances produced from ethanol

- Ethanol can be oxidised to form ethanoic acid and this reaction occurs in open bottles of wine and in the production of ethanoic acid in vinegar.
- The reaction of ethanol with ethanoic acid to produce an ester, ethyl ethanoate and water:
  - writing an equation for this reaction using molecular and structural formulae
  - uses of esters as flavourings and perfumes, as they are pleasant smelling
  - uses of polyesters as fibres to make fabric and as plastics for making bottles.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Investigate electrolytic processes		**A.D1** Construct half-equations to represent the electrode reactions taking place during electrolysis. **A.D2** Account quantitatively for the changes occurring at the electrodes during the electrolytic purification of copper.
A.P1 Predict the products that form when solutions of electrolytes and molten electrolytes are electrolysed. **A.P2** Describe the process of electroplating.	**A.M1** Explain the redox processes that occur when ions migrate to electrodes during electrolysis. **A.M2** Explain how copper is purified using an electrolytic process.	
Learning aim B: Explore equilibrium reactions between gases		**B.D3** Explain how conditions are adjusted in industry in order to achieve the maximum yield in the fastest time from equilibrium reactions. **B.D4** Carry out molar volume calculations.
B.P3 Describe the principles of dynamic equilibrium. **B.P4** Describe what is meant by the term 'molar volume'.	**B.M3** Explain the changes that happen in equilibrium systems when the temperature and pressure of the system are changed. **B.M4** Apply Avogadro's law to calculate volumes of gases involved in gas phase reactions.	
Learning aim C: Explore the chemistry of alcohols		**C.D5** Evaluate the factors influencing the choice of method used to make ethanol. **C.D6** Construct equations for esterification reactions.
C.P5 Describe the two different methods used to produce ethanol. **C.P6** Describe the features and reactions of the homologous series of alcohols.	**C.M5** Compare the different reaction conditions used to produce ethanol. **C.M6** Describe the applications of esterification reactions.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is also further information on our website.

There is a maximum number of three summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.P2, A.M1, A.M2, A.D1, A.D2)

Learning aim: B (B.P3, B.P4, B.M3, B.M4, B.D3, B.D4)

Learning aim: C (C.P5, C.P6, C.M5, C.M6, C.D5, C.D6)

Further information for teachers and assessors

Resource requirements

There are no special resources needed for this unit.

Essential information for assessment decisions

Learning aim A

For Distinction standard, learners need to construct half-equations from two different electrolytic processes where the cations and anions are different. Learners need to use the quantity of electrons required at each electrode to discharge an amount of pure copper during the electrolytic purification process.

For Merit standard, learners need to explain the electrolytic process and, when ions migrate to the electrodes, the oxidation and reduction processes that occur for those used at Pass standard. Learners could use a diagram to explain the purification of copper.

For Pass standard, learners could be given two molten electrolytes and two aqueous solutions of electrolytes. Learners need to describe the nature of the electrolytes and predict the products formed. This could be done in the form of a table or diagrams. Learners need to describe the process of electroplating, which could be done by annotating a diagram.

Learning aim B

For Distinction standard, the equilibrium processes looked at for Merit standard can be used to explain how the conditions can be adjusted to achieve the maximum yield in the fastest time.

Learners need to carry out three different molar volume calculations successfully.

For Merit standard, learners can use a dynamic equilibrium process such as the Haber process to explain what happens when the temperature and pressure are changed. Learners need to use two examples of gas phase reactions to calculate volumes of gases using Avogadro's law.

For Pass standard, learners need to describe the principles of a dynamic equilibrium. This can be done using equations or diagrams to support the description. Learners can use a diagram and an equation to help them describe what is meant by a molar volume.

Learning aim C

For Distinction standard, learners need to evaluate the factors influencing the choice of manufacture, such as availability of raw materials, etc. This could be achieved in the form of diagrams or using a table or a poster with diagrams and conditions. Learners need to construct at least two balanced equations for esterification reactions.

For Merit standard, learners need to compare the reaction conditions of the methods of producing ethanol at Pass standard. Learners need to describe at least two applications of esterification reactions. This could be done through investigation or by the use of case studies.

For Pass standard, learners need to describe two different methods of producing ethanol. Learners need to describe three features of the homologous series of alcohols. Features may include similar chemical properties and the gradation in physical properties. Learners should also describe at least two reactions of different alcohols. This could be done by the use of equations and a brief outline.

Links to other units and other curriculum subjects

This unit links to:

- Unit 1: Principles of Science
- Unit 2: Chemistry and Our Earth
- Unit 5: Applications of Chemical Substances
- Unit 8: Scientific Skills
- Unit 19: Chemical Analysis and Detection.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers and interview opportunities
- work experience
- visits to appropriate business organisations.

Opportunities to develop transferable skills

In completing this unit, learners will have the opportunity to further develop knowledge and understanding of the applications of chemistry principles.

Unit 24: Further Physics

Level: **2**
Unit type: **Internal**
Guided learning hours: **30**

Unit in brief

This unit looks at the further physics topics covering important concepts that underpin applications of physics in medicine such as in medical diagnosis of disease, such as the use of X-rays, computerised axial tomography (CAT) scans, positron emission tomography (PET) scans and radioactive isotopes as tracers.

Unit introduction

In this unit, learners will investigate and explore the theory that underpins several major areas of the application of physics. From this work learners will look at the applications of these areas of physics in our world.

The investigation of X-rays is the first topic in this unit, and it is one with which learners might be familiar. The hazardous nature of X-rays prevents the usual hands-on experiments, but their properties can be demonstrated by using simulations from downloaded resources.

The topic of particle motion starts with circular motion and the use of cyclotrons (particle accelerators) to produce radioactive isotopes. The topic then moves on to kinetic energy and the conservation of momentum when particles collide. This provides an opportunity for some practical work to investigate collisions using trolleys to represent colliding particles.

Ionising radiation forms the third topic. Practical work is often difficult here, but there are online resources that can be used to facilitate learning. After looking at atomic sub structures and nuclear changes learners will look at the use of radioactive isotopes in medicine.

The final topic is the kinetic theory of gases. Learners will find some areas of this quite challenging, but practical work can be done to facilitate learning. The equations associated with the gas laws are related to practical work and a practical application involving bottled gases.

The teacher should encourage learners to see how parts of these topics are related to their applications in industry and medicine.

This unit is intended to build on the knowledge gained in *Unit 1: Principles of Science, Unit 3: Energy and Our Universe* and *Unit 6: Applications of Physical Science*. It is acknowledged that practical work may be minimal for some topics, but the section on kinetic theory and gases lends itself to some practical work.

Learning aims

In this unit you will:

A Investigate X-rays

B Investigate the motion of particles

C Investigate radioactivity

D Investigate kinetic theory and gases.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Investigate X-rays	**A1** Ionisation and production of X-rays **A2** X-rays and their use in medicine **A3** Controlling particles and particle equations	A series of small reports that could include diagrams, descriptions and use of given equations. This will focus on the ionising nature, use of X-rays in medicine and particle equations. The material presented will be the result of research, observation and carrying out practical work.
B Investigate the motion of particles	**B1** Particle acceleration **B2** Particle collision	Scenario sets the learner as a technical researcher for a local newspaper. A nearby hospital has a cyclotron for investigating collisions between particles. Description of the science involved with accelerating particles and colliding them at high speed with elastic and inelastic collisions.
C Investigate radioactivity	**C1** Radioactive decay and the stability curve **C2** Quarks, beta-, beta+ and $E = mc^2$ **C3** Radioactivity and medicine	General description of radioactive particles and what determines their stability. This work will include quarks as essential components of subatomic particles and positron-electron annihilation to produce gamma rays. This will include clear links to the medical industry.
D Investigate kinetic theory and gases	**D1** Kinetic theory and an 'ideal gas' **D2** Volume, temperature and pressure of gases	Informative report based on the kinetic theory of gases and changes of pressure with temperature. This leads to an explanation of theoretical absolute temperature.

Content

Learning aim A: Investigate X-rays

A1 Ionisation and production of X-rays

- The ionisation by X-rays is related to their frequency and energy ($E = hf$ is not required).
- The production of X-rays in an evacuated tube:
  - thermionic emission of electrons from a heated filament
  - a potential difference applied between the cathode (filament) and the anode (metal target) causes the electrons to accelerate, forming a beam of charged particles
  - a beam of charged particles is equivalent to an electric current
  - the collision of electrons with the metal target produces X-rays
  - why the vacuum is necessary.

A2 X-rays and their use in medicine

- Uses of X-rays in computerised axial tomography (CAT) scans and fluoroscopes.
- The risks and advantages of using X-rays for treatment and diagnosis.
- The intensity of a beam of X-rays is inversely proportional to the square of the distance travelled in air and this is used to minimise risks to operators of X-ray machines in hospitals.
- The need to control the X-ray beam for diagnostic and therapeutic purposes by adjusting:
  - the accelerating potential difference
  - the current flowing in the evacuated tube.

A3 Controlling particles and particle equations

- Use the equation:

  $I = Nq$

  current (ampere, A) = number of particles per second (1/s) × charge on each particle (coulomb, C).
- Use the equation:

  $KE = ½mv^2 = eV$

  kinetic energy (joule, J) = charge on the electron (coulomb, C) × accelerating potential difference (volt, V).

Learning aim B: Investigate the motion of particles

B1 Particle acceleration

- For motion in a circle there must be a resultant force, known as a centripetal force, that acts towards the centre of the circle.
- Particle accelerators called cyclotrons cause charged particles to move in a circular or spiral path, due to a magnetic field.
- Certain stable elements can be bombarded with proton radiation to change them into radioactive isotopes.
- The use of particle accelerators (cyclotrons) to produce radioactive isotopes for medical purposes.

B2 Particle collision

- For inelastic collisions, momentum is conserved but kinetic energy is not conserved.
- For elastic collisions, both momentum and kinetic energy are conserved.
- Carry out calculations using momentum conservation for a two-body collision (in one dimension only).
- Carry out calculations using conservation of kinetic energy for a two-body elastic collision (in one dimension only).

Learning aim C: Investigate radioactivity

C1 Radioactive decay and the stability curve

- Balance nuclear equations.
- The effects on the atomic (proton) number (Z) and mass (nucleon) number (A) of radioactive decays (alpha (α), beta (β) and gamma (γ) decay).
- The features of the *N–Z* curve for stable isotopes:
  - the position relative to the stability curve of radioactive isotopes
  - nuclei with high values of *Z* (above 82) usually undergo alpha decay
  - an isotope above the stability curve has too many neutrons to be stable and will undergo $\beta-$ decay
  - an isotope below the stability curve has too many protons to be stable and will undergo $\beta+$ decay.

C2 Quarks, beta–, beta+ and E = mc²

- Quarks:
  - protons and neutrons each contain three particles called quarks
  - the arrangement of up and down quarks in protons and neutrons
  - the charges and masses of up and down quarks related to the charge and mass of neutrons
  - the charges and masses of up and down quarks related to the charge and mass of protons
  - $\beta-$ decay as a process that involves a down quark changing into an up quark (a neutron becomes a proton and an electron)
  - $\beta+$ decay as a process that involves an up quark changing into a down quark (a proton becomes a neutron and a positron).
- For positron-electron annihilation:
  - production of gamma rays
  - conservation of momentum and charge
  - conservation of mass energy using the equation $E = mc^2$.

C3 Radioactivity and medicine

- In diagnosis of medical conditions, e.g. positron emission tomography (PET) scanners and tracers.
- In the treatment of tumours (applied internally and externally).
- Precautions taken to reduce the hazards of medical isotopes for medical personnel and patients, including limiting the dose.

Learning aim D: Investigate kinetic theory and gases

D1 Kinetic theory and an 'ideal gas'

- Kinetic theory model to describe movement of particles in gases.
- Relationship between the macroscopic and microscopic properties of an ideal gas:
  - the pressure of a gas is caused by its particles striking the wall of its container
  - increasing/decreasing the temperature of a gas increases/decreases the speed of its particles
  - the average kinetic energy of the particles in a gas is directly proportional to the Kelvin temperature of the gas
  - at absolute zero, −273°C, the particles of an ideal gas are at rest.

D2 Volume, temperature and pressure of gases

- The relationship between the Kelvin and Celsius scales.
- Use the equation: $V_1 = V_2T_1/T_2$ to calculate volume for gases of fixed mass at constant pressure (rearranging not required).
- Use the equation: $P_1V_1 = P_2V_2$ to calculate volume or pressure for gases of fixed mass at constant temperature.
- Use the equation: $P_1V_1/T_1 = P_2V_2/T_2$ for fixed masses of gas where: initial pressure (pascal, Pa) × initial volume (metre^3, m^3) / initial temperature (kelvin, K) = final pressure (pascal, Pa) × final volume (metre^3, m^3) / final temperature (kelvin, K).
- The application of gas laws to bottled gases.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Investigate X-rays		
A.P1 Describe the ionising nature of X-rays and how these are produced in an X-ray tube. **A.P2** Describe the relationship between the variables used to find the current for a beam of charged particles, using words and symbols. **A.P3** Describe the relationship between the variables used to find the kinetic energy for a beam of charged particles, using words and symbols. **A.P4** Describe the uses and advantages of X-rays for treatment and diagnosis in medicine. **A.P5** Describe how to minimise the risks of using X-rays in medicine.	**A.M1** Calculate current and kinetic energy for a beam of charged particles, using appropriate equations. **A.M2** Assess the benefits and risks of X-rays in medicine.	**A.D1** Explain why the current and accelerating potential difference of a beam of particles used to produce X-rays for diagnostic and therapeutic purposes needs to be carefully controlled.
Learning aim B: Investigate the motion of particles		
B.P6 Describe how cyclotrons can be used to produce fast-moving charged particles.	**B.M3** Explain how proton radiation from a cyclotron may be used to change stable elements into radioactive isotopes for medical purposes.	**B.D2** Calculate momentum and kinetic energy for two-body elastic and inelastic collisions in one dimension only, using appropriate equations.

Pass	Merit	Distinction
Learning aim C: Investigate radioactivity		
C.P7 Relate the different types of radioactive decay to the position of isotopes on the *N*–*Z* graph and proton and nucleon numbers. **C.P8** Identify the uses of radioactive isotopes in medicine and describe the precautions taken to reduce the hazards of medical isotopes for hospital staff and patients.	**C.M4** Balance equations for radioactive decay and describe the relationship between quarks and beta decay. **C.M5** Explain the advantages of using radioactive sources in the diagnosis and treatment of medical conditions despite the hazards involved.	**C.D3** Explain how momentum, charge and mass-energy are conserved in positron-electron annihilation.
Learning aim D: Investigate kinetic theory and gases		
D.P9 Relate qualitatively the macroscopic properties of ideal gases to their microscopic properties.	**D.M6** Calculate the temperature, pressure and volume of fixed masses of gases, converting between Celsius and Kelvin scales, using appropriate equations.	**D.D4** Explain the application of gas laws to bottled gases.

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is also further information on our website.

There is a maximum number of four summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.P2, A.P3, A.P4, A.P5, A.M1, A.M2, A.D1)

Learning aim: B (B.P6, B.M3, B.D2)

Learning aim: C (C.P7, C.P8, C.M4, C.M5, C.D3)

Learning aim: D (D.P9, D.M6, D.D4)

Further information for teachers and assessors

Resource requirements

There are no special resources needed for this unit.

Essential information for assessment decisions

Learning aim A

For Distinction standard, learners should know that the X-ray beam consists of a range of different frequencies and therefore a range of different energies. Learners must use this to show an understanding of the fact that increasing the accelerating potential difference increases the maximum frequency and hence energy of the X-rays produced (mathematical relationship not required). They also need to show an understanding of the fact that increasing the current flowing through the evacuated tube produces more X-rays with the same range of energies (for a set voltage). They must then explain the importance of controlling these two quantities for diagnostic and therapeutic purposes. Details of the different types of scattering (e.g. photoelectric scattering, Compton scattering) are not expected.

For Merit standard, for A.M2 learners may well cover this criterion when they complete A.P2 and A.P3. Learners will be expected to substitute correctly into the equation, most probably with figures given to them by the teacher or extracted from simulations. Learners must assess the benefits and risks of X-rays in medicine.

For Pass standard, learners are expected to describe the ionising nature of X-rays. This should include a description of how the atom becomes ionised by a beam of X-rays. They should also show knowledge of the fact that the energy of X-rays increases as their frequency increases and therefore high- frequency X-rays will be more ionising in nature than low-frequency X-rays. The use of the equation $E = hf$ is not required. Learners are also expected to describe how X-rays are produced. This should include a description of the purpose of each part of an X-ray tube and its contribution to the production of an X-ray beam. For A.P2 and A.P3, the relationship must be described using words and symbols. Appropriate units should be included. A detailed description of the uses and advantages of X-rays in medicine must also be given, but details about the working of the machines are not required other than where it adds to the description of how the X-rays are used. At least one therapeutic and one diagnostic application must be included. A detailed description of how the risks of using X-rays in medicine are minimised must be given but again details about the working of the machines are not required other than where it adds to the description of the risks of X-rays. This must include how the inverse square law relates to reducing risk.

Learning aim B

For Distinction standard, learners must carry out calculations that involve both elastic and inelastic collisions. Collisions must involve two bodies in one dimension only. They must state if the outcome of the calculations shows conservation of kinetic energy and momentum or otherwise. Data from practical activities into collisions could be used to part evidence this criteria on.

For Merit standard, the Pass assessment criteria can be extended by considering how proton beams may be used to change stable elements into radioactive isotopes for medical purposes, for example to produce cobalt-60 from a stable isotope of cobalt.

For Pass standard, learners must describe how cyclotrons accelerate particles in a circular or spiral path to produce fast-moving charged particles.

Learning aim C

For Distinction standard, learners must use the equation $E = mc^2$ when discussing mass–energy conservation. The equation can be given to learners with an explanation of the meaning of the symbols. Learners could use figures from their own work or those given to them by the teacher to show they can use this equation. The equation is to be used to explain conservation of mass–energy, not just the use of the equation. Learners must also explain how momentum and charge are conserved in positron-electron annihilation.

For Merit standard, the nuclear equations can be given to learners, but they must balance two or more equations. Learners must describe how changes in the states of quarks result in different types of beta decay and how the change in state affects the mass and charge of the nucleon produced. Descriptions only are required when describing quarks. However, more able learners may use equations. Learners must explain the advantages of using radioactive sources in medicine and comment on the hazards involved. Sources for both diagnosis and treatment of medical conditions must be included.

For Pass standard, learners must describe how the proton and neutron number affects the stability of radioactive isotopes and how beta decay relates to the position of isotopes on the N–Z curve. An example should be given for proton and neutron number alterations, such as uranium to thorium. Learners must identify a minimum of three uses of radioactive isotopes in medicine, covering both diagnostic and therapeutic applications. Details of the machines used, side effects, etc. are not required. Learners must also describe precautions that are taken to reduce the hazards caused by medical isotopes. At least two precautions for hospital staff and two precautions for patients must be given.

Learning aim D

For Distinction standard, one or more gas laws must be applied quantitatively to bottled gases. For example, transporting bottled gases can be done in bulk if the gas is subjected to pressure. Learners could calculate the pressure that a gas needs to be compressed to in order to place it in a container of a fixed volume. A suitable context could be a scuba diving cylinder.

For Merit standard, learners must be given the formulae listed in the content and be able to apply them as required. The figures used in the equation could come from their own work, demonstrations or simulations. The work could be related to experiments seen or carried out. Some calculations must involve converting between the Celsius and Kelvin scales of temperature.

For Pass standard, learners must explain how gas pressure arises from the movement of gas particles, describe how changing the temperature of a gas affects the speed of its particles, and describe the relationship between Kelvin temperature and the kinetic energy of the gas particles. They must also explain that as the temperature of an ideal gas decreases, the speed of its particles will decrease until they become stationary at absolute zero. A quantitative explanation is not required for this criterion.

Links to other units and other curriculum subjects

This unit links to:

- Unit 1: Principles of Science
- Unit 3: Energy and Our Universe.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers from the radiology department of a general hospital
- work experience in the medical physics section of a local hospital
- visits to X-ray department of a local hospital
- a visit to industrial manufacturer for bottled gas supplies.

Opportunities to develop transferable skills

In completing this unit, learners will have the opportunity to develop research and planning skills related to gas modelling and behaviour, and to solve complex maths problems related to particle physics and gas pressure laws.

4 Planning your programme

How do I choose the right BTEC International Level 2 qualification for my learners?

BTEC International Level 2 qualifications come in a range of sizes, each with a specific purpose. You will need to recruit learners very carefully to ensure that they start on the right size of qualification to fit into their study programme and that they take the right pathways or optional units to allow them to progress to the next stage.

Some learners may want to take a number of complementary qualifications or keep their progression options open. These learners may be suited to taking a BTEC International Level 2 Award or Certificate. Learners who then decide to continue with a fuller vocational programme can transfer to a BTEC International Level 2 Extended Certificate or Diploma.

Some learners are sure of the sector in which they wish to work and are aiming for progression into that sector via higher education. These learners should be directed to the two-year BTEC International Level 2 Diploma as the most suitable qualification.

Is there a learner entry requirement?

As a centre, it is your responsibility to ensure that the learners you recruit have a reasonable expectation of success on the programme. There are no formal entry requirements but we expect learners to have sufficient learning to study at this level.

If learners are studying in English we recommend that they have attained at least Level B2 in the Common European Framework of Reference for Languages or Pearson Global Scale of English 51. Please see resources available from Pearson at www.pearson.com/english.

What is involved in becoming an approved centre?

All centres must be approved before they can offer these qualifications – so that they are ready to assess learners and so that we can provide the support that is needed. Further information is given in *Section 8 Quality assurance*.

What level of sector knowledge is needed to teach these qualifications?

We do not set any requirements for teachers but recommend that centres assess the overall skills and knowledge of the teaching team to ensure that they are relevant and up to date. This will give learners a rich programme to prepare them for employment in the sector.

What resources are required to deliver these qualifications?

As part of your centre approval, you will need to show that the necessary material resources and work spaces are available to deliver BTEC International Level 2 qualifications. For some units, specific resources are required.

Which modes of delivery can be used for these qualifications?

You are free to deliver BTEC International Level 2 qualifications using any form of delivery that meets the needs of your learners. We recommend making use of a wide variety of modes, including direct instruction in classrooms or work environments, investigative and practical work, group and peer work, private study and e-learning.

How can Pearson Progress help with planning for these qualifications?

Pearson Progress is a digital support system that supports the delivery, assessment and quality assurance of BTECs in centres. It supports teachers with activities such as course creation, creating and verifying assignments and creating assessment plans and recording assessment decisions.

For further information, see *Section 10 Resources and support*.

What are the recommendations for employer involvement?

BTEC International Level 2 qualifications are vocational qualifications and, as an approved centre, you are encouraged to work with employers on the design, delivery and assessment to ensure that they are engaging and relevant, and equip learners for progression. There are suggestions in many of the units about how employers could become involved in delivery and/or assessment but these are not intended to be exhaustive and there will be other possibilities at local level.

What support is available?

We provide a wealth of support materials, including curriculum plans, delivery guides, sample Pearson Set Assignments, Authorised Assignment Briefs and examples of marked learner work.

You will be allocated a standards verifier early on in the planning stage to support you with planning your assessments. There will be extensive training programmes as well as support from our Subject Advisor team.

For further details see *Section 10 Resources and support*.

5 Assessment structure

Introduction

BTEC International Level 2 qualifications are assessed using a combination of *internal assessments*, which are set and marked by teachers, and *Pearson Set Assignments*, which are set by Pearson and marked by teachers.

- Mandatory units have a combination of internal and Pearson Set Assignments.
- All optional units are internally assessed.

In developing an overall plan for delivery and assessment for the programme, you will need to consider the order in which you deliver units, whether delivery is over short or long periods and when assessment can take place. You must plan the assignments so that learners can demonstrate learning from across their programme.

In administering an internal assignment or a Pearson Set Assignment, the centre needs to be aware of the specific procedures and policies that apply, for example for registration, entries and results. An overview, with signposting to relevant documents, is given in *Section 7 Administrative arrangements*.

Internal assessment

Our approach to internal assessment for these qualifications will be broadly familiar to experienced centres. It offers flexibility in how and when you assess learners, provided that you meet assessment and quality assurance requirements. You will need to take account of the requirements of the unit format, which we explain in *Section 3 Units*, and the requirements for delivering assessment given in *Section 6 Internal assessment*.

Pearson Set Assignment units

A summary of the set assignments for this qualification is given in *Section 2 Structure*. You should check this information carefully, together with the details of the unit being assessed, so that you can timetable learning and assessment periods appropriately.

Learners must take the authorised Pearson Set Assignment for the set assignment unit. Teachers are not permitted to create their own assessments for set assignment units. Some assignments may need to be taken in controlled conditions. These are described in each unit.

Please see *Section 6 Internal assessment* for resubmission and retaking regulations.

6 Internal assessment

This section gives an overview of the key features of internal assessment and how you, as an approved centre, can offer it effectively. The full requirements and operational information are given in the *BTEC International Quality Assurance Handbook*. All members of the assessment team need to refer to this document.

For BTEC International Level 2 qualifications, it is important that you can meet the expectations of stakeholders and the needs of learners by providing a programme that is practical and applied. Centres can tailor programmes to meet local needs and use links with local employers and the wider vocational sector.

When internal assessment is operated effectively, it is challenging, engaging, practical and up to date. It must also be fair to all learners and meet international standards.

All units in these qualifications are internally assessed but Pearson sets the assignments for some of the units.

Principles of internal assessment (applies to all units)

Assessment through assignments

For all units, the format of assessment is an assignment taken after the content of the unit, or part of the unit if several assignments are used, has been delivered. An assignment may take a variety of forms, including practical and written types. An assignment is a distinct activity, completed independently by learners, that is separate from teaching, practice, exploration and other activities that learners complete with direction from teachers.

An assignment is issued to learners as an assignment brief with a defined start date, a completion date and clear requirements for the evidence that they need to provide. There may be specific observed practical components during the assignment period. Assignments can be divided into tasks and may require several forms of evidence. A valid assignment will enable a clear and formal assessment outcome, based on the assessment criteria. For most units, teachers will set the assignments. For Pearson Set Assignment units, Pearson will set the assignment.

Assessment decisions through applying unit-based criteria

Assessment decisions for BTEC International Level 2 qualifications are based on the specific criteria given in each unit and set at each grade level. To ensure that standards are consistent in the qualification and across the suite as a whole, the criteria for each unit have been defined according to a framework. The way in which individual units are written provides a balance of assessment of understanding, practical skills and vocational attributes appropriate to the purpose of qualifications.

The assessment criteria for a unit are hierarchical and holistic. For example, if a Merit criterion requires the learner to show 'analysis' and the related Pass criterion requires the learner to 'explain', then to satisfy the Merit criterion, a learner will need to cover both 'explain' and 'analyse'. The unit assessment grid shows the relationships between the criteria so that assessors can apply all the criteria to the learner's evidence at the same time. In *Appendix 2: Glossary of terms used*, we have set out a definition of terms that assessors need to understand.

Assessors must show how they have reached their decisions using the criteria in the assessment records. When a learner has completed all the assessment for a unit, then the assessment team will give a grade for the unit. This is given according to the highest level for which the learner is judged to have met all the criteria. Therefore:

- to achieve a Distinction, a learner must have satisfied all the Distinction criteria (and therefore the Pass and Merit criteria); these define outstanding performance across the unit as a whole
- to achieve a Merit, a learner must have satisfied all the Merit criteria (and therefore the Pass criteria) through high performance in each learning aim
- to achieve a Pass, a learner must have satisfied all the Pass criteria for the learning aims, showing coverage of the unit content and therefore attainment at Level 2 of the qualification.

The award of a Pass is a defined level of performance and cannot be given solely on the basis of a learner completing assignments. Learners who do not satisfy the Pass criteria should be reported as Unclassified.

The assessment team

It is important that there is an effective team for internal assessment. There are three key roles involved in implementing assessment processes in your centre, each with different interrelated responsibilities; the roles are listed below. There is detailed information in the *BTEC International Quality Assurance Handbook*.

- The Lead Internal Verifier (the Lead IV) has overall responsibility for the programme, its assessment and internal verification, record keeping and liaison with the standards verifier, ensuring our requirements are met. The Lead IV acts as an assessor, standardises and supports the rest of the assessment team, making sure that they have the information they need about our assessment requirements and organises training, making use of our standardisation, guidance and support materials.
- Internal verifiers (IVs) oversee all assessment activities in consultation with the Lead IV. They check that assignments and assessment decisions are valid and that they meet our requirements. IVs will be standardised by working with the Lead IV. Normally, IVs are also assessors but they do not verify their own assessments.
- Assessors set or use assignments to assess learners. Before making any assessment decisions, assessors participate in standardisation activities led by the Lead IV. They work with the Lead IV and IVs to ensure that the assessment is planned and carried out in line with our requirements.

Effective organisation

Internal assessment needs to be well organised so that the progress of learners can be tracked and so that we can monitor that assessment is being carried out. We support you through, for example, providing training materials and sample documentation.

Our online Pearson Progress service can help support you in planning and record keeping. Further information on using Pearson Progress can be found in *Section 10 Resources and support*, and on our website.

It is particularly important that you manage the overall assignment programme and deadlines to make sure that learners are able to complete assignments on time.

Learner preparation

To ensure that you provide effective assessment for your learners, you need to make sure that they understand their responsibilities for assessment and the centre's arrangements.

From induction onwards, you will want to ensure that learners are motivated to work consistently and independently to achieve the requirements of the qualifications. Learners need to understand how assignments are used, the importance of meeting assignment deadlines and that all the work submitted for assessment must be their own.

You will need to give learners a guide that explains how assignments are used for assessment, how assignments relate to the teaching programme and how learners should use and reference source materials, including what would constitute plagiarism. The guide should also set out your approach to operating assessment, such as how learners must submit work and request extensions.

Making valid assessment decisions

Authenticity of learner work

Once an assessment has begun, learners must not be given feedback on progress towards fulfilling the targeted criteria.

An assessor must assess only learner work that is authentic, i.e. learners' own independent work. Learners must authenticate the evidence that they provide for assessment through signing a declaration stating that it is their own work.

Assessors must ensure that evidence is authentic to a learner through setting valid assignments and supervising them during the assessment period. Assessors must take care not to provide direct input, instructions or specific feedback that may compromise authenticity.

Assessors must complete a declaration that:

- to the best of their knowledge the evidence submitted for this assignment is the learner's own
- the learner has clearly referenced any sources used in the work
- they understand that false declaration is a form of malpractice.

Centres can use Pearson templates or their own templates to document authentication.

During assessment, an assessor may suspect that some or all of the evidence from a learner is not authentic. The assessor must then take appropriate action using the centre's policies for malpractice. Further information is given in *Section 7 Administrative arrangements*.

Making assessment decisions using criteria

Assessors make judgements using the criteria. The evidence from a learner can be judged using all the relevant criteria at the same time. The assessor needs to make a judgement against each criterion that evidence is present and sufficiently comprehensive. For example, the inclusion of a concluding section may be insufficient to satisfy a criterion requiring 'evaluation'.

Assessors should use the following information and support in reaching assessment decisions:

- the *Essential information for assessment decisions* section in each unit, which gives examples and definitions related to terms used in the criteria
- the explanation of key terms in *Appendix 2: Glossary of terms used*
- your Lead IV and assessment team's collective experience.

Pass and Merit criteria relate to individual learning aims. The Distinction criteria as a whole relate to outstanding evidence across the unit. Therefore, criteria may relate to more than one learning aim (for example A.D1) or to several learning aims (for example DE.D3). Distinction criteria make sure that learners have shown that they can perform consistently at an outstanding level across the unit and/or that they are able to draw learning together across learning aims.

Issuing assessment decisions and feedback

Once the assessment team has completed the assessment process for an assignment, the outcome is a formal assessment decision. This is recorded formally and reported to learners.

The information given to the learner:

- must show the formal decision and how it has been reached, indicating how or where criteria have been met
- may show why attainment against criteria has not been demonstrated
- must not provide feedback on how to improve evidence
- must be validated by an IV before it is given to the learner.

Planning and record keeping

For internal processes to be effective, an assessment team needs to be well organised and keep effective records. The centre will work closely with us so that we can ensure that standards are being satisfied and achieved. This process gives stakeholders confidence in the assessment approach.

The programme must have an assessment plan validated by the Lead IV.
When producing a plan, the assessment team needs to consider:

- the time required for training and standardisation of the assessment team
- the time available to undertake teaching and carry out assessment, taking account of when learners may complete assessments and when quality assurance will take place
- the completion dates for different assignments and the name of each Assessor
- who is acting as the internal verifier for each assignment and the date by which the assignment needs to be internally verified

- setting an approach to sampling assessor decisions through internal verification that covers all assignments, assessors and a range of assessment decisions
- how to manage the assessment and verification of learners' work so that they can be given formal decisions promptly
- how resubmission opportunities can be scheduled.

The Lead IV will also maintain records of assessment undertaken. The key records are:

- internal verification of assignment briefs
- learner authentication declarations
- assessor decisions on assignments, with feedback given to learners
- internal verification of assessment decisions
- assessment tracking for the unit.

There are examples of records and further information in the *BTEC International Quality Assurance Handbook*.

Setting effective assignments (applies to all units without Pearson Set Assignments)

Setting the number and structure of assignments

This section does not apply to set assignment units. In setting your assignments, you need to work with the structure of assignments shown in the *Essential information for assignments* section of a unit. This shows the structure of the learning aims and criteria that you must follow and the recommended number of assignments that you should use. For these units we provide sample Authorised Assignment Briefs and we give you suggestions on how to create suitable assignments. You can find these materials on our website. In designing your own assignment briefs, you should bear in mind the following points:

- The number of assignments for a unit must not exceed the number shown in the *Essential information for assignments*. However, you may choose to combine assignments, for example to create a single assignment for the whole unit.
- You may also choose to combine all or parts of different units into single assignments, provided that all units and all their associated learning aims are fully addressed in the programme overall. If you choose to take this approach, you need to make sure that learners are fully prepared so that they can provide all the required evidence for assessment and that you are able to track achievement in the records.
- A learning aim must always be assessed as a whole and must not be split into two or more assignments.
- The assignment must be targeted to the learning aims but the learning aims and their associated criteria are not tasks in themselves. Criteria are expressed in terms of the outcome shown in the evidence.
- For units containing synoptic assessment, the planned assignments must allow learners to select and apply their learning, using appropriate self-management of tasks.
- You do not have to follow the order of the learning aims of a unit in setting assignments but later learning aims often require learners to apply the content of earlier learning aims and they may require learners to draw their learning together.

- Assignments must be structured to allow learners to demonstrate the full range of achievement at all grade levels. Learners need to be treated fairly by being given the opportunity to achieve a higher grade if they have the ability.
- As assignments provide a final assessment, they will draw on the specified range of teaching content for the learning aims. The specified content is compulsory. The evidence for assessment need not cover every aspect of the teaching content as learners will normally be given particular examples, case studies or contexts in their assignments. For example, if a learner is carrying out one practical performance, or an investigation of one organisation, then they will address all the relevant range of content that applies in that instance.

Providing an assignment brief

A good assignment brief is one that, through providing challenging and realistic tasks, motivates learners to provide appropriate evidence of what they have learned.

An assignment brief should have:

- a vocational scenario – this could be a simple situation or a full, detailed set of vocational requirements that motivates the learner to apply their learning through the assignment
- clear instructions to the learner about what they are required to do, normally set out through a series of tasks
- an audience or purpose for which the evidence is being provided
- an explanation of how the assignment relates to the unit(s) being assessed.

Forms of evidence

BTECs have always allowed for a variety of forms of evidence to be used – provided that they are suited to the type of learning aim being assessed. For many units, the practical demonstration of skills is necessary and, for others, learners will need to carry out their own research and analysis. The units give you information on what would be suitable forms of evidence to give learners the opportunity to apply a range of employability or transferable skills. Centres may choose to use different suitable forms of evidence to those proposed. Overall, learners should be assessed using varied forms of evidence.

Full definitions of types of assessment are given in *Appendix 2: Glossary of terms used*. These are some of the main types of assessment:

- written reports
- projects
- time-constrained practical assessments with observation records and supporting evidence
- recordings of performance
- sketchbooks, working logbooks, reflective journals
- presentations with assessor questioning.

The form(s) of evidence selected must:

- allow the learner to provide all the evidence required for the learning aim(s) and the associated assessment criteria at all grade levels
- allow the learner to produce evidence that is their own independent work
- allow a verifier to independently reassess the learner to check the assessor's decisions.

For example, when you are using performance evidence, you need to think about how supporting evidence can be captured through recordings, photographs or task sheets.

Centres need to take particular care that learners are enabled to produce independent work. For example, if learners are asked to use real examples, then best practice would be to encourage them to use their own or to give the group a number of examples that can be used in varied combinations.

Late completion, resubmission and retakes (applies to all units including Pearson Set Assignment units)

Dealing with late completion of assignments for internally-assessed units

Learners must have a clear understanding of the centre policy on completing assignments by the deadlines that you give them. Learners may be given authorised extensions for legitimate reasons, such as illness at the time of submission, in line with your centre policies.

For assessment to be fair, it is important that learners are all assessed in the same way and that some learners are not advantaged by having additional time or the opportunity to learn from others. Therefore, learners who do not complete assignments by your planned deadline or by the authorised extension deadline may not have the opportunity to subsequently resubmit.

If you accept a late completion by a learner, then the assignment should be assessed normally when it is submitted, using the relevant assessment criteria.

Resubmission of improved evidence for internally-assessed units

An assignment provides the final assessment for the relevant learning aims and is normally a final assessment decision, except where the Lead IV approves one opportunity to resubmit improved evidence based on the completed assignment brief.

The Lead IV has the responsibility to make sure that resubmission is operated fairly. This means:

- checking that a learner can be reasonably expected to perform better through a second submission, for example that the learner has not performed as expected
- making sure that giving a further opportunity can be done in such a way that it does not give an unfair advantage over other learners, for example through the opportunity to take account of feedback given to other learners
- checking that the assessor considers that the learner will be able to provide improved evidence without further guidance and that the original evidence submitted has been authenticated by both the learner and assessor and remains valid.

Once an assessment decision has been given to the learner, the resubmission opportunity must have a deadline within 15 working days after the timely issue of assessment feedback to learners, which is within term time in the same academic year.

A resubmission opportunity must not be provided where learners:

- have not completed the assignment by the deadline without the centre's agreement
- have submitted work that is not authentic.

We recognise that there are circumstances where the resubmission period may fall outside of the 15-day limit owing to a lack of resources being available, for example where learners may need to access a performance space or have access to specialist equipment. Where it is practical to do so, for example, evaluations, presentations, extended writing, resubmission must remain within the normal 15-day period.

Retake of internal assessment

A learner who has not achieved the level of performance required to pass the relevant learning aims after resubmission of an assignment may be offered a single retake opportunity using a new assignment. The retake may be achieved at a Pass only.

The Lead Internal Verifier must authorise a retake of an assignment only in exceptional circumstances where they believe it is necessary, appropriate and fair to do so. The retake is not timebound and the assignment can be attempted by the learner on a date agreed between the Lead IV and assessor within the same academic year.

For further information on offering a retake opportunity, you should refer to the *BTEC Centre Guide to Internal Assessment*. Information on writing assignments for retakes is given on our website (www.btec.co.uk/keydocuments).

7 Administrative arrangements

Introduction

This section focuses on the administrative requirements for delivering a BTEC qualification. It is of particular value to Quality Nominees, Lead IVs, Programme Leaders and Examinations Officers.

Learner registration and entry

Shortly after learners start the programme of learning, you need to make sure that they are registered for the qualification and that appropriate arrangements are made for internal assessment. You need to refer to the *International Information Manual* for information on making registrations for the qualification.

Learners can be formally assessed only for a qualification on which they are registered. If learners' intended qualifications change, for example, if a learner decides to choose a different pathway specialism, then the centre must transfer the learner appropriately.

Access to assessment

Assessments need to be administered carefully to ensure that all learners are treated fairly, and that results and certification are issued on time to allow learners to progress to their chosen progression opportunities.

Our equality policy requires that all learners should have equal opportunity to access our qualifications and assessments, and that our qualifications are awarded in a way that is fair to every learner. We are committed to making sure that:

- learners with a protected characteristic are not, when they are undertaking one of our qualifications, disadvantaged in comparison to learners who do not share that characteristic
- all learners achieve the recognition they deserve for undertaking a qualification and that this achievement can be compared fairly to the achievement of their peers.

Further information on access arrangements can be found in the Joint Council for Qualifications (JCQ) document *Access Arrangements, Reasonable Adjustments and Special Consideration for General and Vocational Qualifications*.

Administrative arrangements for assessment

Records

You are required to retain records of assessment for each learner. Records should include assessments taken, decisions reached and any adjustments or appeals. Further information can be found in the *International Information Manual*. We may ask to audit your records, so they must be retained as specified.

Reasonable adjustments to assessment

To ensure that learners have fair access to demonstrate the requirements of the assessments, a reasonable adjustment is one that is made before a learner takes an assessment. You are able to make adjustments to internal assessments to take account of the needs of individual learners. In most cases, this can be achieved through a defined time extension or by adjusting the format of evidence. We can advise you if you are uncertain as to whether an adjustment is fair and reasonable. You need to plan for time to make adjustments if necessary.

Further details on how to make adjustments for learners with protected characteristics are given on our website, in the document *Guidance for reasonable adjustments and special consideration in vocational internally assessed units*.

Special consideration

Special consideration is given after an assessment has taken place for learners who have been affected by adverse circumstances, such as illness. You must operate special consideration in line with our policy (see above). You can give special consideration related to the period of time given for evidence to be provided or for the format of the assessment if it is equally valid. You may not substitute alternative forms of evidence to that required in a unit or omit the application of any assessment criteria to judge attainment. Pearson can consider applications for special consideration if they are in line with the policy.

Appeals against assessment

Your centre must have a policy for dealing with appeals from learners. These appeals may relate to assessment decisions being incorrect or assessment not being conducted fairly. The first step in such a policy could be a consideration of the evidence by a Lead IV or other member of the programme team. The assessment plan should allow time for potential appeals after assessment decisions have been given to learners. If there is an appeal by a learner, you must document the appeal and its resolution. Learners have a final right of appeal to Pearson but only if the procedures that you have put in place have not been followed. Further details are given in the document *Enquiries and appeals about Pearson vocational qualifications and end point assessment policy*.

Conducting set assignments

Centres must make arrangements for the secure delivery of Pearson Set Assignments.

At least one Pearson Set Assignment will be available each year for each unit with an additional one provided for resits. Centres must not select an assignment that learners have attempted already.

Each set assignment unit will contain instructions on how to conduct the assessment of that unit.

Some set assignments will need to be taken with limited controls. Limited controls are described in each unit and may include the following conditions:

- Time: each assignment has a recommended time period. This is for advice only and can be adjusted depending on the needs of learners.
- Supervision: you should be confident of the authenticity of learner work. This may mean that learners be supervised.
- Resources: all learners should have access to the same types of resource to complete the assignment.
- Research: learners should be given the opportunity to carry out research outside of the learning context if required for the assignment.

Schools and colleges must be able to confirm that learner evidence is authentic.

Dealing with malpractice in assessment

Malpractice means acts that undermine the integrity and validity of assessment, the certification of qualifications, and/or that may damage the authority of those responsible for delivering the assessment and certification.

Pearson does not tolerate actions (or attempted actions) of malpractice by learners, centre staff or centres in connection with Pearson qualifications. Pearson may impose penalties and/or sanctions on learners, centre staff or centres where incidents (or attempted incidents) of malpractice have been proven.

Malpractice may arise or be suspected in relation to any unit or type of assessment within the qualification. For further details regarding malpractice and advice on preventing malpractice by learners, please see Pearson's *Centre guidance: Dealing with malpractice and maladministration in vocational qualifications*, available on our website.

Centres are required to take steps to prevent malpractice and to investigate instances of suspected malpractice. Learners must be given information that explains what malpractice is for internal assessment and how suspected incidents will be dealt with by the centre. The *Centre Guidance: Dealing with malpractice and maladministration in vocational qualifications* document gives comprehensive information on the actions we expect you to take.

Pearson may conduct investigations if we believe that a centre is failing to conduct internal assessment according to our policies. The above document gives further information and examples, and details the penalties and sanctions that may be imposed.

In the interests of learners and centre staff, centres need to respond effectively and openly to all requests relating to an investigation into an incident of suspected malpractice.

Learner malpractice

Learner malpractice refers to any act by a learner that compromises or which seeks to compromise the process of assessment or which undermines the integrity of the qualifications or the validity of results/certificates.

Learner malpractice in examinations **must** be reported to Pearson using a *JCQ Form M1* (available at www.jcq.org.uk/exams-office/malpractice). The form should be emailed to candidatemalpractice@pearson.com. Please provide as much information and supporting documentation as possible. Note that the final decision regarding appropriate sanctions lies with Pearson.

Failure to report malpractice constitutes staff or centre malpractice.

Staff/centre malpractice

Staff and centre malpractice includes both deliberate malpractice and maladministration of our qualifications. As with learner malpractice, staff and centre malpractice is any act that compromises or which seeks to compromise the process of assessment, or which undermines the integrity of the qualifications or the validity of results/certificates.

All cases of suspected staff malpractice and maladministration **must** be reported immediately, before any investigation is undertaken by the centre, to Pearson on a *JCQ Form M2* (available at www.jcq.org.uk/exams-office/malpractice).

The form, supporting documentation and as much information as possible should be emailed to pqsmalpractice@pearson.com. Note that the final decision regarding appropriate sanctions lies with Pearson.

Failure to report malpractice itself constitutes malpractice.

More-detailed guidance on malpractice can be found in the latest version of the document *JCQ Suspected Malpractice Policies and Procedures*, available at www.jcq.org.uk/exams-office/malpractice.

Sanctions and appeals

Where malpractice is proven, we may impose sanctions or penalties.

Where learner malpractice is evidenced, penalties may be imposed such as:

- disqualification from the qualification
- being barred from registration for Pearson qualifications for a period of time.

If we are concerned about your centre's quality procedures, we may impose sanctions such as:

- working with you to create an improvement action plan
- requiring staff members to receive further training
- placing temporary blocks on your certificates
- placing temporary blocks on registration of learners
- debarring staff members or the centre from delivering Pearson qualifications
- suspending or withdrawing centre approval status.

The centre will be notified if any of these apply.

Pearson has established procedures for centres that are considering appeals against penalties and sanctions arising from malpractice. Appeals against a decision made by Pearson will normally be accepted only from Heads of Centres (on behalf of learners and/or members of staff) and from individual members (in respect of a decision taken against them personally). Further information on appeals can be found in our document *Enquiries and appeals about Pearson vocational qualifications and end point assessment policy*, which is on our website. In the initial stage of any aspect of malpractice, please notify the Investigations Team by email via pqsmalpractice@pearson.com, who will inform you of the next steps.

Certification and results

Once a learner has completed all the required components for a qualification, the centre can claim certification for the learner, provided that quality assurance has been successfully completed. For the relevant procedures, please refer to our *International Information Manual*. You can use the information provided on qualification grading to check overall qualification grades.

Changes to qualification requests

Where a learner who has taken a qualification wants to resit a unit to improve their qualification grade, you firstly need to decline their overall qualification grade. You may decline the grade before the certificate is issued.

Additional documents to support centre administration

As an approved centre, you must ensure that all staff delivering, assessing and administering the qualifications have access to the following documentation. These documents are reviewed annually and are reissued if updates are required.

- *BTEC International Quality Assurance Handbook*: this sets out how we will carry out quality assurance of standards and how you need to work with us to achieve successful outcomes.
- *International Information Manual*: this gives procedures for registering learners for qualifications, transferring registrations and claiming certificates.
- *Regulatory policies*: our regulatory policies are integral to our approach and explain how we meet internal and regulatory requirements. We review the regulated policies annually to ensure that they remain fit for purpose. Policies related to this qualification include:
  - adjustments for candidates with disabilities and learning difficulties, access arrangements and reasonable adjustments for general and vocational qualifications
  - age of learners
  - centre guidance for dealing with malpractice
  - recognition of prior learning and process.

This list is not exhaustive and a full list of our regulatory policies can be found on our website.

8 Quality assurance

Centre and qualification approval

As part of the approval process, your centre must make sure that the resource requirements listed below are in place before offering the qualification.

- Centres must have appropriate physical resources (for example equipment, IT, learning materials, teaching rooms) to support the delivery and assessment of the qualification.
- Staff involved in the assessment process must have relevant expertise and/or occupational experience.
- There must be systems in place to ensure continuing professional development for staff delivering the qualification.
- Centres must have in place appropriate health and safety policies relating to the use of equipment by learners.
- Centres must deliver the qualification in accordance with current equality and diversity legislation and/or regulations.
- Centres should refer to the *Further information for teachers and assessors* section in individual units to check for any specific resources required.

Continuing quality assurance and standards verification

On an annual basis, we produce the *BTEC International Quality Assurance Handbook*. It contains detailed guidance on the quality processes required to underpin robust assessment and internal verification.

The key principles of quality assurance are that:

- a centre delivering BTEC programmes must be an approved centre, and must have approval for the programmes or groups of programmes that it is delivering
- the centre agrees, as part of gaining approval, to abide by specific terms and conditions around the effective delivery and quality assurance of assessment; the centre must abide by these conditions throughout the period of delivery
- Pearson makes available to approved centres resources and processes that exemplify assessment and appropriate standards. Approved centres must use these to ensure that all staff delivering BTEC qualifications keep up to date with the guidance on assessment
- an approved centre must follow agreed protocols for standardisation of assessors and verifiers, for the planning, monitoring and recording of assessment processes, and for dealing with special circumstances, appeals and malpractice.

The approach of quality-assured assessment is through a partnership between an approved centre and Pearson. We will make sure that each centre follows best practice and employs appropriate technology to support quality-assurance processes, where practicable. We work to support centres and seek to make sure that our quality-assurance processes do not place undue bureaucratic processes on centres. We monitor and support centres in the effective operation of assessment and quality assurance.

The methods we use to do this for BTEC Level 2 qualifications include:

- making sure that all centres complete appropriate declarations at the time of approval
- undertaking approval visits to centres
- making sure that centres have effective teams of assessors and verifiers who are trained to undertake assessment
- assessment sampling and verification, through requested samples of assessments, completed assessed learner work and associated documentation
- an overarching review and assessment of a centre's strategy for delivering and quality assuring its BTEC programmes, for example making sure that synoptic units are placed appropriately in the order of delivery of the programme.

Centres that do not fully address and maintain rigorous approaches to delivering, assessing and quality assurance cannot seek certification for individual programmes or for all BTEC Level 2 programmes. An approved centre must make certification claims only when authorised by us and strictly in accordance with requirements for reporting.

Centres that do not comply with remedial action plans may have their approval to deliver qualifications removed.

9 Understanding the qualification grade

Awarding and reporting for the qualification

This section explains the rules that we apply in awarding a qualification and in providing an overall qualification grade for each learner. It shows how all the qualifications in this sector are graded.

Eligibility for an award

In order to be awarded a qualification, a learner must complete all units, and achieve a Pass or above in all mandatory units unless otherwise specified. Refer to the structure in *Section 2 Structure*.

To achieve any qualification grade, learners must:

- complete and have an outcome (D, M, P or U) for all units within a valid combination
- achieve the **required units at Pass or above** shown in *Section 2*, abiding by the minimum requirements in the compensation table below
- achieve the **minimum number of points** at a grade threshold.

It is the responsibility of a centre to ensure that a correct unit combination is adhered to. Learners who do not achieve the required minimum grade (P) in units shown in the structure will not achieve a qualification.

Learners who do not achieve sufficient points for a qualification or who do not achieve all the required units may be eligible to achieve a smaller qualification in the same suite, provided they have completed and achieved the correct combination of units and met the appropriate qualification grade points threshold.

Calculation of the qualification grade

These qualifications are Level 2 qualifications and the certification may show a grade ranging from Level 2 Pass to Level 2 Distinction*. Please refer to the *Calculation of qualification grade* table for the full list of grades. Each individual unit will be awarded a grade of Level 2 Pass, Merit, Distinction. Learners whose level of achievement is below a Level 2 Pass will receive an Unclassified (U) for that unit. Distinction* is not available at unit level. Award of Distinction* (D*) D* is an aggregated grade for the qualification, based on the learner's overall performance. In order to achieve this grade, learners will have to demonstrate a strong performance across the qualification as a whole.

To achieve a Level 2 qualification, learners must:

- complete and report an outcome for all units within the permitted combination (NB Unclassified is a permitted unit outcome), and
- achieve the minimum number of points at a grade threshold – see the *Calculation of qualification grade* table with the following allowable tolerances.

Qualification	Units required at Pass or above	Unit equivalence
Award (120 GLH)	All units must be achieved at Pass or above	0 units
Certificate (240 GLH)	All units must be achieved at Pass or above	0 units
Extended Certificate (360 GLH)	Mandatory units must be achieved at Pass or above, 60 GLH only at U grade permitted from optional units	e.g. 2 ´ 30 GLH unit
Diploma (480 GLH)	Mandatory units must be achieved at Pass or above, 120 GLH only at U grade permitted from optional units	e.g. 4 ´ 30 GLH units

Points available for unit size and grades

The table below shows the **number of points scored per 10 Guided Learning Hours** at each grade.

Points per grade per 10 Guided Learning Hours			
Unclassified	**Level 2 Pass (P)**	**Level 2 Merit (M)**	**Level 2 Distinction (D)**
0	4	6	8

We will automatically calculate the qualification grade for your learners when your learner unit grades are submitted. Learners will be awarded qualification grades for achieving the sufficient number of points within the ranges shown in the *Calculation of qualification grade* table.

Example

A learner achieves a Level 2 Pass grade for a unit. The unit size is 30 Guided Learning Hours (GLH). Therefore, they gain 12 points for that unit, i.e. 4 points for each 10 GLH, so 12 points for 30 GLH.

Calculation of qualification grade

Award		Certificate		Extended Certificate		Diploma	
120 GLH		240 GLH		360 GLH		480 GLH	
Grade	Points threshold	Grade	Points threshold	Grade	Points threshold	Grade	Points threshold
U	0	U	0	U	0	U	0
Level 2 Pass	48	Level 2 PP	96	Level 2 PP	144	Level 2 PP	192
		Level 2 MP	114	Level 2 MP	174	Level 2 MP	234
Level 2 Merit	66	Level 2 MM	132	Level 2 MM	204	Level 2 MM	276
		Level 2 DM	150	Level 2 DM	234	Level 2 DM	318
Level 2 Distinction	84	Level 2 DD	168	Level 2 DD	264	Level 2 DD	360
		Level 2 D*D	174	Level 2 D*D	270	Level 2 D*D	366
Level 2 Distinction*	90	Level 2 D*D*	180	Level 2 D*D*	276	Level 2 D*D*	372

This table shows the minimum thresholds for calculating grades. The table will be kept under review over the lifetime of the qualification. The most up-to-date table will be issued on our website.

Pearson will monitor the qualification standard and reserves the right to make appropriate adjustments.

The tables below give examples of how the overall grade is determined.

Examples used are for illustrative purposes only. Other unit combinations are possible, see *Section 2 Structure*.

Example 1

Achievement of an Award with a Level 2 Merit grade

	GLH	Weighting (GLH/10)	Grade	Grade points	Points per unit (weighting × grade points)
Unit 1	30	3	Level 2 Merit	6	18
Unit 2	30	3	Level 2 Pass	4	12
Unit 3	30	3	Level 2 Merit	6	18
Unit 4	30	3	Level 2 Merit	6	18
Qualification grade totals	**240**	**24**	**Level 2 MM**		**66**

The learner has sufficient points for a Level 2 Merit grade.

Example 2

Achievement of a Certificate with a Level 2 D*D grade

	GLH	Weighting (GLH/10)	Grade	Grade points	Points per unit (weighting × grade points)
Unit 1	30	3	Level 2 Merit	6	18
Unit 2	30	3	Level 2 Distinction	8	24
Unit 3	30	3	Level 2 Merit	6	18
Unit 4	30	3	Level 2 Distinction	8	24
Unit 5	30	3	Level 2 Merit	6	18
Unit 6	30	3	Level 2 Distinction	8	24
Unit 7	30	3	Level 2 Distinction	8	24
Unit 8	30	3	Level 2 Distinction	8	24
Qualification grade totals	**240**	**24**	**Level 2 D*D**		**174**

The learner has sufficient points for a Level 2 D*D grade.

Example 3

Achievement of an Extended Certificate with a Level 2 PP grade

	GLH	Weighting (GLH/10)	Grade	Grade points	Points per unit (weighting × grade points)
Unit 1	30	3	Level 2 Merit	6	18
Unit 2	30	3	Level 2 Merit	6	18
Unit 3	30	3	Level 2 Pass	4	12
Unit 4	30	3	Level 2 Pass	4	12
Unit 5	30	3	Level 2 Merit	6	18
Unit 6	30	3	Level 2 Pass	4	12
Unit 7	30	3	Level 2 Pass	4	12
Unit 8	30	3	Level 2 Merit	6	18
Unit 9	30	3	Level 2 Pass	4	12
Unit 15	30	3	Level 2 Pass	4	12
Unit 16	30	3	Level 2 Pass	4	12
Unit 17	30	3	Level 2 Pass	4	12
Qualification grade totals	**360**	**36**	**Level 2 PP**		**168**

The learner has sufficient points for a Level 2 PP grade.

Example 4

Achievement of a Diploma with a Level 2 MP grade

	GLH	Weighting (GLH/10)	Grade	Grade points	Points per unit (weighting × grade points)
Unit 1	30	3	Level 2 Merit	6	18
Unit 2	30	3	Level 2 Pass	4	12
Unit 3	30	3	Level 2 Merit	6	18
Unit 4	30	3	Level 2 Merit	6	18
Unit 5	30	3	Level 2 Merit	6	18
Unit 6	30	3	Level 2 Pass	4	12
Unit 7	30	3	Level 2 Distinction	8	24
Unit 8	30	3	Level 2 Distinction	8	24
Unit 9	30	3	Level 2 Merit	6	18
Unit 10	30	3	Level 2 Pass	4	12
Unit 11	30	3	Level 2 Pass	4	12
Unit 12	30	3	Level 2 Distinction	8	24
Unit 13	30	3	Level 2 Distinction	8	24
Unit 14	30	3	Level 2 Merit	6	18
Unit 15	30	3	Unclassified	0	0
Unit 16	30	3	Level 2 Pass	4	12
Qualification grade totals	**480**	**48**	**Level 2 MP**		**264**

The learner has sufficient points for a Level 2 MP grade.
The learner is within the 120 GLH threshold limit for Unclassified grades from the optional units.

Example 5

Achievement of a Diploma with an Unclassified grade

	GLH	Weighting (GLH/10)	Grade	Grade points	Points per unit (weighting × grade points)
Unit 1	30	3	Level 2 Distinction	8	24
Unit 2	30	3	Level 2 Distinction	8	24
Unit 3	30	3	Level 2 Merit	6	18
Unit 4	30	3	Level 2 Distinction	8	24
Unit 5	30	3	Level 2 Merit	6	18
Unit 6	30	3	Level 2 Distinction	8	24
Unit 7	30	3	Level 2 Distinction	8	24
Unit 8	30	3	Level 2 Distinction	8	24
Unit 9	30	3	Level 2 Distinction	8	24
Unit 10	30	3	Unclassified	0	0
Unit 11	30	3	Unclassified	0	0
Unit 12	30	3	Level 2 Merit	6	18
Unit 13	30	3	Level 2 Merit	6	18
Unit 14	30	3	Level 2 Distinction	8	24
Unit 15	30	3	Level 2 Distinction	8	24
Unit 16	30	3	Level 2 Distinction	8	24
Qualification grade totals	**480**	**48**	**Unclassified**		**312**

The learner has sufficient points for a Level 2 MM grade but has not met the minimum requirement for a P or higher in Unit 11.

10 Resources and support

Our aim is to give you a wealth of resources and support to enable you to deliver BTEC International Level 2 qualifications with confidence. You will find a list of resources to support teaching and learning, and professional development on our website.

Support for setting up your course and preparing to teach

Specification

The specification (for teaching from September 2020) gives you details of the administration of the qualifications and information on the units for the qualifications.

Pearson Progress

Pearson Progress is a digital support system that helps you to manage the assessment and quality assurance of the Pearson BTEC International Level 2 Applied Science qualifications. It supports delivery, assessment and quality assurance of BTECs in centres and supports teachers and students as follows:

- course creation
- creating and verifying assignments
- creating assessment plans and recording assessment decisions
- upload of assignment evidence
- tracking progress of every learner

The system is accessible for teachers and learners so that both teachers and learners can track their progress.

Support for teaching and learning

Pearson Learning Services provides a range of engaging resources to support BTEC International Level 2 qualifications, these may include:

- delivery guides, which give you important advice on how to choose the right course for your learners and how to ensure you are fully prepared to deliver the course. They explain the key features of the BTEC International Level 2 Applied Science qualifications, for example employer involvement and employability skills. They also cover guidance on assessment and quality assurance.
- sample schemes of work are provided for each mandatory unit as well as a selection of optional units. These are available in Word™ format for ease of customisation
- slide presentations for use in your teaching to outline the key concepts of a unit
- delivery plans that help you structure delivery of a qualification

We also provide paid for resources and courseware which may include:

- teacher resource packs developed by Pearson including materials and activities to fully support your teaching of units
- student books, designed to support the teaching and learning journey. These include case studies, discussion prompts, key content and supporting images to help learners develop their understanding. Items from the student books will link with other resources, which will support teaching and learning.

Support for assessment

Sample assessment materials for internally-assessed units

For internal units assessed with a Pearson Set Assignment we will provide a sample assignment as an example of the form of assessment for the unit. For the remaining internally set units, we allow you to set your own assignments, according to your learners' preferences and to link with your local employment profile.

We provide a service in the form of Authorised Assignment Briefs and sample Pearson Set Assignments, which are approved by Pearson Standards Verifiers. They are available via our website.

Pearson English

Pearson provides a full range of support for English learning including diagnostics, qualifications and learning resources. Please see www.pearson.com/english

Training and support from Pearson

People to talk to

There are many people available to support you and give you advice and guidance on delivering your BTEC International Level 2 qualifications. They include the following:

- Subject Advisors – available for all sectors. They understand all Pearson qualifications in their sector and can answer sector-specific queries on planning, teaching, learning and assessment.
- Standards verifiers – they can support you with preparing your assignments, ensuring that your assessment plan is set up correctly, and support you in preparing learner work and providing quality assurance through sampling.
- Regional teams – they are regionally based and have a full overview of the BTEC qualifications and of the support and resources that Pearson provides. Regions often run network events.
- Customer Services – the 'Support for You' section of our website gives the different ways in which you can contact us for general queries. For specific queries, our service operators can direct you to the relevant person or department.

Training and professional development

Pearson provides a range of training and professional development events to support the introduction, delivery, assessment and administration of BTEC International Level 2 qualifications. These sector-specific events, developed and delivered by specialists, are available both face to face and online.

'Getting Ready to Teach'

These events are designed to get teachers ready for delivery of the BTEC International Level 2 qualifications. They include an overview of qualification structures, planning and preparation for internal assessment, and quality assurance.

Teaching and learning

Beyond the 'Getting Ready to Teach' professional development events, there are opportunities for teachers to attend sector- and role-specific events. These events are designed to connect practice to theory; they provide teacher support and networking opportunities with delivery, learning and assessment methodology.

Details of our training and professional development programme can be found on our website.

Appendix 1: Transferable employability skills

The need for transferable skills

In recent years, higher-education institutions and employers have consistently flagged the need for learners to develop a range of transferable skills to enable them to respond with confidence to the demands of undergraduate study and the world of work.

The Organisation for Economic Co-operation and Development (OECD) defines skills, or competencies, as 'the bundle of knowledge, attributes and capacities that can be learned and that enable individuals to successfully and consistently perform an activity or task and can be built upon and extended through learning.' [1]

To support the design of our qualifications, the Pearson Research Team selected and evaluated seven global 21st-century skills frameworks. Following on from this process, we identified the National Research Council's (NRC) framework [2] as the most evidence-based and robust skills framework, and have used this as a basis for our adapted skills framework.

The framework includes cognitive, intrapersonal skills and interpersonal skills.

The NRC framework is included alongside literacy and numeracy skills.

The skills have been interpreted for this specification to ensure that they are appropriate for the subject. All of the skills listed are evident or accessible in the teaching, learning and/or assessment of the qualifications. Some skills are directly assessed. Pearson materials will support you in identifying these skills and in developing these skills in learners.

The table overleaf sets out the framework and gives an indication of the skills that can be found in Applied Science, it indicates the interpretation of the skills in this area. A full interpretation of each skill, with mapping to show opportunities for learner development, is given on the subject pages of our website: http://qualifications.pearson.com.

[1] OECD – *Better Skills, Better Jobs, Better Lives* (OECD Publishing, 2012)

[2] Koenig, J. A. (2011) *Assessing 21st Century Skills: Summary of a Workshop* (National Academies Press, 2011)

Cognitive skills	Cognitive processes and strategies	Critical thinking Problem solving Analysis Reasoning/argumentation Interpretation Decision making Adaptive learning Executive function
	Creativity	Creativity Innovation
Intrapersonal skills	Intellectual openness	Adaptability Personal and social responsibility Continuous learning Intellectual interest and curiosity
	Work ethic/ conscientiousness	Initiative Self-direction Responsibility Perseverance Productivity Self-regulation (metacognition, forethought, reflection) Ethics Integrity
	Positive core self-evaluation	Self-monitoring/ self-evaluation/ self-reinforcement
Interpersonal skills	Teamwork and collaboration	Communication Collaboration Teamwork Cooperation Interpersonal skills Empathy/perspective taking Negotiation
	Leadership	Responsibility Assertive communication Self-presentation

Evaluates data and experimental methods, drawing conclusions, which are consistent with evidence from secondary sources and experimental activities. Suggests possible improvements and further investigations.

Planning and carrying out science-based problem solving under own direction.

Sharing own resources and own learning techniques with other students.

Appendix 2: Glossary of terms used

This is a summary of the key terms used to define the requirements in the units.

Term	Definition
Analyse/Study	Learners present the outcome of methodical and detailed examination, either: · breaking down a theme, topic or situation in order to interpret and study the interrelationships between the parts and/or · information or data to interpret and study key trends and interrelationships. Analysis can be through performance, practice, written or, less commonly, verbal presentation.
Assemble/Build/Construct/Devise/ Design/Plan	Related to use and demonstration of practical equipment/techniques/ procedures.
Carry out/Conduct/Use	This is used to show depth of knowledge through selection and isolation of characteristics.
Classify	Learners arrange scientific information in categories according to shared qualities or characteristics.
Demonstrate	Learners give a practical exhibition and explanation of how a scientific skill is performed.
Develop	Learners create and build in familiar scientific contexts.
Evaluate	Learners' work draws on varied information, themes or concepts to consider aspects such as: · strengths or weaknesses · advantages or disadvantages · alternative actions · relevance or significance. Learners' inquiries should lead to a supported judgement showing relationship to its context. This will often be in a conclusion.
Explore	Skills and/or knowledge involving practical testing or trialling.

Term	Definition
Identify	Usually requires some key information to be selected from a given stimulus/resource.
Investigate	Knowledge based on personal research and development.
Know/Understand	For defined knowledge in familiar contexts.
Measure	To determine the dimensions or angle from a diagram using an instrument such as a ruler or protractor.
Process	Learners perform a series of actions.
Account/Outline	Learners give a summary of different points in relation to an area of content.
Assess	Learners present a careful consideration of varied factors or events that apply to a specific situation or to identify those which are the most important or relevant and arrive at a conclusion.
Balance	Learners use this in the context of chemical equations.
Calculate	Learners manipulate quantitative data to help analyse and compare findings.
Collate	Learners gather data/scientific information.
Compare/Relate	Learners identify the main factors relating to two or more items/situations or aspects of a subject that is extended to explain the similarities, differences, advantages and disadvantages.
Deduce	Draw/reach conclusion(s) from the information provided.
Describe	Learners' work gives a clear, objective account in their own words showing recall and, in some cases, application of the relevant features and information about a subject.
Determine	Use of this verb normally requires breadth of content coverage.
Discuss	Learners consider different aspects of: · a theme or topic · how they interrelate and · the extent to which they are important. A conclusion is not required.
Draw	Produce a diagram either using a ruler or freehand.

Term	Definition
Explain	Learners' work shows clear details and gives reasons and/or evidence to support an opinion, view or argument. It could show how conclusions are drawn (arrived at). Learners are able to show that they comprehend the origins, functions and objectives of a subject and its suitability for purpose.
Justify	Learners give reasons or evidence to: · support an opinion · prove something right or reasonable.
Interpret	Learners scrutinise scientific data/information to come to a conclusion.
Predict (make predictions)	Learners can synthesise predictions using applications of relevant knowledge and understanding in a given context.
Prepare	Used with a standard to demonstrate competence in preparation of testing materials, for example organic and inorganic substances/solutions.
Present	When learners show their scientific information/observation(s) in an appropriate way.
Produce	When learners are required to create/make/establish.
Record	When learners evidence their scientific observations/raw data.
State	Requires recall of one or more pieces of information.
Write	When the questions ask for an equation.

This is a key summary of the types of evidence used for BTEC International Level 2 qualifications.

Type of evidence	Definition and purpose
Case study	A specific example to which all learners must select and apply knowledge. Used to show application to a realistic context where direct experience cannot be gained.
Portfolio of evidence	A written and/or audio/visual record of competence against assessment criteria
Individual project	A self-directed, large-scale activity requiring planning, research, exploration, outcome and review. Used to show self-management, project management and/or deep learning, including synopticity.
Development log	A record kept by the learner to show the process of development. Used to show method, self-management and skill development.

For information about Pearson Qualifications, including Pearson Edexcel and BTEC qualifications visit qualifications.pearson.com

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