Pearson
BTEC

Extended Certificate

Specification

BTEC FIRST APPLIED SCIENCE

From September 2018

BTEC Level 1/Level 2 First Extended Certificate in Applied Science

Issue 6

Pearson
BTEC Level 1 / Level 2
First Extended Certificate
in Applied Science

Specification

First teaching September 2012

Issue 6

Pearson Education Limited is one of the UK's largest awarding organisations, offering academic and vocational qualifications and testing to schools, colleges, employers and other places of learning, both in the UK and internationally. Qualifications offered include GCSE, AS and A Level, NVQ and our BTEC suite of vocational qualifications, ranging from Entry Level to BTEC Higher National Diplomas. Pearson Education Limited administers BTEC qualifications.

Through initiatives such as onscreen marking and administration, Pearson is leading the way in using technology to modernise educational assessment, and to support teachers and learners.

This specification is Issue 6. 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. We do 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.)

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Summary of Pearson BTEC Level 1/Level 2 First Extended Certificate in Applied Science specification Issue 6 changes

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<tr><th>Summary of an additional change made between previous issues and this current issue</th><th>Page/section number</th></tr>
<tr><td>The wording in Section 8 Internal assessment subsection Dealing with malpractice has been updated to clarify suspension of certification in certain circumstances.</td><td>Page 29</td></tr>
<tr><td>Section 10 Awarding and reporting the qualifications
The wording under Calculation of qualification change has been updated.</td><td>Page 33</td></tr>
<tr><td>Unit 2: Chemistry and Our Earth
Learning aim A: Investigate chemical reactivity and bonding
Topic A.2 Bonding and structure
● ‘properties of simple covalent, giant covalent and ionic materials’ updated to ‘properties of simple molecular, giant covalent and ionic substances’
Learning aim C: Investigate the factors involved in the rate of chemical reactions
Topic C.1 Equations
● ‘simple balanced equations’ updated to ‘simple balanced chemical equations’
Assessment guidance
Learning aim A
● ‘solubility in water’ updated to ‘solubility with water’
● ‘viscosity’ removed
● ‘giant molecular’ updated to ‘giant covalent’ for 2A.D2
Learning aim C
● ‘learners must describe these factors’ updated to ‘learners must describe the effect on the rate of these factors’
● ‘particle size’ updated to ‘surface area’ for 2C.P6
Suggested assignment outlines
Assessment evidence
● ‘binding and structures’ updated to ‘bonding and structures’</td><td>Pages 52, 53, 56, 57 and 59</td></tr>
<tr><td>Unit 3: Energy and Our Universe
● ‘space tourism and the future of space flight’ added as C.2 c.
Assessment guidance
Learning aim C
● ‘stars and solar systems’ updated to ‘and other star systems’ for 2C.P8.</td><td>Page 64

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Summary of an additional change made between previous issues and this current issue (continued)	**Page / section number**
Unit 5: Applications of Chemical Substances *Learning aim A: Investigate and understand enthalpy changes associated with chemical reactions* Topic A.1 Exothermic and endothermic reactions ● Specific heat capacity units updated to $J°C^{-1}$ g^{-1} and temperature change units updated to °C	Page 84
Unit 6: Applications of Physical Science *Learning aim A: Investigate motion* ● Units added to kinetic energy and gravitational potential energy equations. *Suggested assignment outlines* Scenario ● 'current flowing through each light' updated to 'current in each light'.	Page 96, 107
Unit 8: Scientific Skills ● Reference to 'Key Stage 4 Science Programme of Study' removed from Unit introduction and unit content.	Pages 117 and 118
Unit 12: The Living Body *Assessment guidance* Learning aim A 1A.1 has been reworded to include 'mechanical digestion'.	Page 154
Unit 15: Investigating a Crime Scene *Unit aims and unit content* ● 'facial recognition from CCTV and mobile phones' added to A.8 b.	Page 179
Unit 17: Understanding Human Behaviour The *Assessment guidance* for 1C.7 has been changed to 'learners should give examples of behaviours that can be attributed to the Social Learning Theory, e.g. smoking. More than one example must be given.'	Page 205
Unit 20: Exploring Our Universe *Unit aims and unit content* ● 'exoplanets' added as A.1 c. ● 'and probes to the sun' added to B.3 b.	Page 235
Unit 24: Further Physics *Unit introduction* CAT and PET scans have non abbreviated words followed by abbreviation in brackets.	Pages 270, 271, 272

Summary of a Pearson BTEC Level 1/Level 2 First Extended Certificate in Applied Science specification Issue 5 change

Summary of changes made between Issue 4 and Issue 5	Page number
The assessment availability has been changed in *Section 9* to February	Page 31
The wording under *Section 10 Awarding and reporting for the qualifications* subsection *Calculation of the qualification grade* has been updated to clarify current practice in ensuring maintenance and consistency of qualification standards.	Pages 35-36

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

Welcome to your BTEC First 2012 specification

For more than 25 years, BTECs have earned their reputation as well-established, enduringly effective qualifications. They have a proven track record in improving motivation and achievement among young learners. Additionally, BTECs provide progression routes to the next stage of education or into employment.

BTECs are evolving

Informed by recent policy developments, including the *Review of Vocational Education – The Wolf Report* (March 2011), we have designed this new suite of BTEC Firsts to:

- ensure high quality and rigorous standards
- conform to quality criteria for non-GCSE qualifications
- be fit for purpose for learners, pre- or post-16, in schools and in colleges.

We conducted in-depth, independent consultations with schools, colleges, higher education, employers, the Association of Colleges and other professional organisations. This new suite builds on the qualities – such as a clear vocational context for learning and teacher-led assessment based on centre-devised assignments – that you told us make BTECs so effective and engaging.

This new suite introduces features to meet the needs of educators, employers and the external environment. They are fully aligned with requirements for progression – to further study at level 3, into an apprenticeship or into the workplace. We believe these features will make BTEC even stronger and more highly valued.

What are the key principles of the new suite of BTEC Firsts?

To support young people to succeed and progress in their education, we have drawn on our consultations with you and embedded four key design principles into the new BTEC Firsts.

1 Standards: a common core and external assessment

Each new Level 2 BTEC First qualification has an essential core of knowledge and applied skills. We have introduced external assessment appropriate to the sector. This provides independent evidence of learning and progression alongside the predominantly portfolio-based assessment.

2 Quality: a robust quality-assurance model

Building on strong foundations, we have further developed our quality-assurance model to ensure robust support for learners, centres and assessors.

We will make sure that:

- every BTEC learner's work is independently scrutinised through the external assessment process
- every BTEC assessor will take part in a sampling and quality review during the teaching cycle
- we visit each BTEC centre every year to review and support your quality processes.

We believe this combination of rigour, dialogue and support will underpin the validity of the teacher-led assessment and the learner-centric approach that lie at the heart of BTEC learning.

3 Breadth and progression: a range of options building on the mandatory units; contextualised English and mathematics

The **mandatory units**, developed in consultation with employers and educators, gives learners the opportunity to gain a broad understanding and knowledge of a vocational sector that are essential to the curriculum area or vocational industry.

The **optional specialist units** provide a closer focus on a vocational area, supporting progression into a more specialised level 3 vocational or academic course or into an apprenticeship.

Opportunities to develop skills in English and mathematics are indicated in the units where appropriate. These give learners the opportunity to practise these essential skills in naturally occurring and meaningful contexts, where appropriate to the industry.

The skills have been mapped against GCSE (including functional elements) English and mathematics subject content areas.

4 Recognising achievement: opportunity to achieve at level 1

The new BTEC Firsts are level 2 qualifications with Pass, Merit, Distinction and Distinction* grades.

However, we recognise that some learners may fail to achieve a Pass at Level 2, so we have included the opportunity for learners to gain a level 1 qualification.

Improved specification and support

In our consultation, we also asked about what kind of guidance you, as teachers and tutors, need. As a result, we have streamlined the specification itself to make the units easier to navigate, and provided enhanced support in the accompanying Delivery Guide.

Thank you

Finally, we would like to extend our thanks to everyone who provided support and feedback during the development of the new BTEC Firsts, particularly all of you who gave up many evenings of your own time to share your advice and experiences to shape these new qualifications. We hope you enjoy teaching the course.

Contents

Purpose of this specification

The purpose of this specification, as defined by Ofqual, is to set out:

- the qualification's objectives
- any other qualification that a learner must have completed before taking the qualification
- any prior knowledge, skills or understanding that the learner is required to have before taking the qualification
- units that a learner must have completed before the qualification will be awarded, and any optional routes
- any other requirements that a learner must have satisfied before the learner will be assessed, or before the qualification will be awarded
- the knowledge, skills and understanding that will be assessed as part of the qualification (giving a clear indication of their coverage and depth)
- the method of any assessment and any associated requirements relating to it
- the criteria against which learners' level of attainment will be measured (such as assessment criteria)
- any specimen materials (supplied separately)
- any specified levels of attainment.

Qualification title and Qualification Number

Qualification title	**Pearson BTEC Level 1 / Level 2 First Extended Certificate in Applied Science**
Qualification Number (QN)	**600/6318/X**

This qualification is on the Regulated Qualifications Framework (RQF).

Your centre should use the Qualification Number (QN) when seeking funding for your learners.

The qualification title, units and QN will appear on each learner's final certificate. You should tell your learners this when your centre recruits them and registers them with us. Further information about certification is in the *Information Manual* on our website, qualifications.pearson.com

1 What are BTEC Firsts?

BTEC First qualifications were originally designed for use in colleges, schools and the workplace as an introductory level 2 course for learners wanting to study in the context of a vocational sector. This is still relevant today. The knowledge, understanding and skills learnt in studying a BTEC First will aid progression to further study and prepare learners to enter the workplace in due course. In the science sector, typical employment opportunities may include working as a technician or a laboratory assistant.

These qualifications are intended primarily for learners in the 14–19 age group, but may also be used by other learners who wish to gain an introductory understanding of a vocational area. When taken as part of a balanced curriculum, there is a clear progression route to a level 3 course or to an apprenticeship.

BTECs are vocationally related qualifications, where learners develop knowledge and understanding by applying their learning and skills in a work-related context. Additionally, they are popular and effective because they engage learners to take responsibility for their own learning and to develop skills that are essential for the modern-day workplace. These skills include: teamworking; working from a prescribed brief; working to deadlines; presenting information effectively; and accurately completing administrative tasks and processes. BTEC Firsts motivate learners, and open doors to progression into further study and responsibility within the workplace.

The BTEC First suite continues to reflect this ethos and builds on the recommendations outlined in the *Review of Vocational Education – The Wolf Report* (March 2011). That report confirmed the importance of a broad and balanced curriculum for learners.

The BTEC First suite of qualifications

The following qualifications are part of the BTEC First suite for first teaching from Autumn 2012:

Qualification	Award	Certificate	Extended Certificate
Application of Science	✓	✕	✕
Applied Science	✕	✕	✓
Art and Design	✓	✓	✓
Business	✓	✓	✓
Engineering	✓	✓	✓
Health and Social Care	✓	✓	✓
Information and Creative Technology	✓	✓	✓
Performing Arts	✓	✓	✓
Principles of Applied Science	✓	✕	✕
Sport	✓	✓	✓

Visit www.btec.co.uk for information about these qualifications and also for information about additional qualifications in larger sizes (Diploma), and in different vocational sectors.

Objectives of the BTEC First suite

The BTEC First suite will:

- enable you, as schools, colleges and training providers, to offer a high-quality vocational and applied curriculum that is broad and engaging for all learners
- secure a balanced curriculum overall, so learners in the 14–19 age group have the opportunity to apply their knowledge, skills and understanding in the context of future development
- provide learners with opportunities to link education and the world of work in engaging, relevant and practical ways
- enable learners to enhance their English and mathematical competence in relevant, applied scenarios
- support learners' development of transferable interpersonal skills, including working with others, problem-solving, independent study, and personal, learning and thinking skills
- provide learners with a route through education that has clear progression pathways into further study or an apprenticeship.

Breadth and progression

This qualification has a core of underpinning knowledge, skills and understanding, and a range of options to reflect the breadth of pathways within a sector. This gives learners the opportunity to:

- gain a broad understanding and knowledge of a vocational sector
- investigate areas of specific interest
- develop essential skills and attributes prized by employers, further education colleges and higher education institutions.

This suite of qualifications provides opportunities for learners to progress to either academic or more specialised vocational pathways.

Progression from Level 1

This qualification has been designed to provide a progression route from the following qualifications:

- Pearson BTEC Level 1 Certificate in Applied Science
- Pearson BTEC Level 1 Diploma in Applied Science

This qualification is also designed to provide a progression route from the following qualifications:

- Pearson BTEC Level 1 Certificate in Vocational Studies
- Pearson BTEC Level 1 Diploma in Vocational Studies

See website for details: qualifications.pearson.com

2 Key features of the Pearson BTEC First Extended Certificate

The Pearson BTEC Level 1/Level 2 First Extended Certificate:

- is a level 2 qualification; the grades range from Level 2 PP to Level 2 D*D*. Learners who do not achieve at Level 2 may be awarded a Level 1 grade. Learners whose level of achievement is below a Level 1 will receive an Unclassified (U) result
- is for learners aged 14 years and over
- has mandatory and optional specialist units
- will be available on the Regulated Qualifications Framework (RQF)
- presents knowledge in a work-related context
- gives learners the opportunity to develop and apply skills in English and mathematics in naturally occurring, work-related contexts
- provides opportunities for synoptic assessment. Learners will apply the skills and knowledge gained from the mandatory units when studying the optional specialist units. See *Annexe D* for more detailed information.
- is a 360-guided-learning-hour qualification (equivalent in teaching time to three GCSEs)
- has $16^2/_3$ per cent of the qualification that is externally assessed. Pearson sets and marks these assessments.

Learners can register for this BTEC Level 1/Level 2 First Extended Certificate in Applied Science qualification from August 2012. The first certification opportunity for this qualification will be 2014.

Types of units within this qualification

The Pearson BTEC Level 1/Level 2 First Extended Certificate in Applied Science has mandatory and optional specialist units. See *Section 4* for more detailed information.

Mandatory units

- This qualification has mandatory units totalling 240 guided learning hours.
- Mandatory units are designed to cover the body of content that employers and educators within the sector consider essential for 14–19 year old learners.
- The units assess knowledge, skills and understanding that are essential to the curriculum area or vocational sector.
- The eight mandatory units in this qualification are each 30 GLH, two units are externally assessed and six units are internally assessed.

Optional specialist units

The remainder of the qualification in the sector will be formed from optional specialist units.

- Optional specialist units are sector specific, focus on a particular area within the vocational sector and provide an opportunity to demonstrate knowledge, skills and understanding.
- Optional specialist units will normally be 30 GLH, but may be smaller or larger.

Total qualification time (TQT)

For all regulated qualifications, Pearson specifies a total number of hours that it is expected learners will be required to undertake in order to complete and show achievement for the qualification: this is the Total Qualification Time (TQT). The TQT value indicates the size of a qualification.

Within this, Pearson will also identify the number of Guided Learning Hours (GLH) that we expect a centre delivering the qualification will need to provide. Guided learning means activities that directly or immediately involve tutors and assessors in teaching, supervising, and invigilating learners, such as lessons, tutorials, online instruction and supervised study.

In addition to guided learning, other required learning directed by tutors or assessors will include private study, preparation for assessment and undertaking assessment when not under supervision, such as preparatory reading, revision and independent research.

Qualifications can also have a credit value, which is equal to one tenth of TQT, rounded to the nearest whole number.

Qualification sizes for BTEC Firsts in the Applied Science sector

This suite of BTEC Firsts for the Applied Science sector is available in the following sizes:

	GLH	**TQT**
First award	120	160
First extended certificate	360	480
First diploma	480	640

Pearson BTEC Level 1 / Level 2 First Extended Certificate in Applied Science

3 Pearson BTEC Level 1 / Level 2 First Extended Certificate in Applied Science

The rationale for all qualifications in the BTEC First suite is to:

- inspire and enthuse learners to consider a career in the science sector
- give learners the opportunity to gain a broad understanding and knowledge of, and skills in, the science sector e.g. practical & investigative skills and knowledge of areas of biology, chemistry and physics
- support progression to a more specialised level 3 vocational or academic Science course or an apprenticeship
- give learners the potential opportunity, in due course, to enter employment within a wide range of junior job roles across the science sector, such as laboratory technician.

Within the suite, the **Pearson BTEC Level 1 / Level 2 First Extended Certificate** qualification has been developed to meet the needs of learners with a range of educational requirements. These include learners who:

- wish to add breadth to their knowledge and understanding of the sector as part of their career progression and development plans
- have had some achievement in their Key Stage 4 programme and wish to top-up their level 2 achievement to progress to employment or other qualifications
- are working towards achieving Level 2 English or Mathematics qualifications in a post-16 setting and wish to complement their study programme with a qualification that supports preparation for work or progression.

Rationale for the Pearson BTEC Level 1 / Level 2 First Extended Certificate in Applied Science

Applied Science adopts a different structure from other qualifications in the suite, to reflect the unique nature of science learning. To ensure sufficient breadth and depth, the Pearson BTEC Level 1/Level 2 First Extended Certificate in Applied Science has eight mandatory units and a choice of 16 further optional specialist units.

The Pearson BTEC Level 1/Level 2 First Extended Certificate in Applied Science has been designed to deliver the Key Stage 4 Programme of Study for science by covering the key scientific principles vital for both scientists and citizens of the future and lead to further progression or employment. The qualification is appropriate for learners of all abilities who will benefit from a practical and applied approach to learning in a vocational context. It has been developed to:

- exemplify scientific principles in vocational contexts, leading to an understanding of how those principles are applied in practice, and can facilitate a move either on to further periods of study or into employment
- give learners the opportunity to gain a broad understanding and knowledge of science principles and practice
- give learners the opportunity to develop a range of related skills and techniques that are essential for successful performance in working life
- give opportunities for learners to achieve a nationally recognised level 1 or level 2 science qualification
-

- support progression into a more specialised level 3 vocational or academic course or into an apprenticeship
- give full-time learners the opportunity to enter potential employment within a wide range of science sectors such as process, industrial, medical, or forensic.

Vocational learning in science is critical in order to enable and support technical roles in the STEM sector. The qualification is appropriate for learners of all abilities who benefit from a practical and applied approach to learning in a vocational context. From the knowledge and skills developed in this qualification, you may expect to seek employment at a junior level in companies that manufacture pharmaceuticals, computer-chip technology materials and food products, in companies that investigate the causes of disease and help to combat pollution, or in energy companies and those that manufacture products reliant upon energy.

The Pearson BTEC Level 1/Level 2 First Extended Certificate in Applied Science has been designed primarily for young people aged 14–19 who may wish to explore a vocational route throughout Key Stage 4. It provides an engaging, robust, broad-based introduction to applied science principles. The underpinning knowledge, understanding and practical skills that make up this qualification reflect the needs of employers and higher and further education professionals. It presents knowledge, skills and understanding in a meaningful work-related context, allowing learners to understand theory and application.

The Pearson BTEC Level 1/Level 2 First Extended Certificate in Applied Science comprises eight mandatory units that underpin the knowledge and skills that are key to progression within science-based industries. These mandatory units cover the range of essential scientific principles together with underlying introductions to essential knowledge and applications in biology, chemistry and physics. English and mathematics have been contextualised within the assessment aims. This allows learners to practise these essential skills in naturally occurring and meaningful contexts, where appropriate.

This qualification includes two externally assessed units that deal with science principles and scientific skills. The approach for the internally assessed units provides opportunities to explore beyond these principles into vocationally linked activities and enables learners to receive feedback on their progress throughout the course as they provide evidence towards meeting the unit assessment criteria.

Locally available vocational examples and the opportunity to localise assignments to fit learner experience allow a more realistic and motivating basis for learning and can start to ensure learning serves the needs of local areas.

Employers value employees who are able to communicate effectively both verbally and using electronic communication methods. The qualification provides opportunities for learners to develop their communication skills as they progress through the course. This can be achieved through presentations and in discussions where they have the opportunity to express their opinions.

Learners should be encouraged to take responsibility for their own learning and achievement, taking account of the industry standards for behaviour and performance.

Assessment approach

The Pearson BTEC Level 1/Level 2 First Extended Certificate in Applied Science includes two externally assessed units to introduce externality into vocational programmes of study. This will assist learners as they progress either into higher levels of vocational learning or to related academic qualifications, such as GCSEs and GCEs.

The assessment approach for the internally assessed units in the qualification structure enables learners to receive feedback on their progress throughout the course as they provide evidence towards meeting the unit assessment criteria.

Delivery strategies should reflect the nature of work within the science sector by encouraging learners to research and carry out assessment in vocational scenarios. It will be beneficial to learners to use local examples, wherever possible, and for your centre to engage with local employers for support and input. This allows a more realistic and motivating basis for learning and can start to ensure learning serves the needs of local areas.

Learners should be encouraged to take responsibility for their own learning and achievement, taking account of the industry standards for behaviour and performance.

Progression opportunities

This qualification builds on a foundation of the Key Stage 3 Science Programme of Study. Learners could progress from this qualification to related vocational qualifications, such as BTEC Nationals, specifically the Pearson BTEC Level 3 in Applied Science, including the Forensic Science and Medical Science endorsed pathways.

Learners can also progress to a range of level 2 vocational qualifications, such as BTEC Firsts, specifically the Pearson BTEC Level 2 qualifications in related areas such as Beauty Therapy Science, Health and Social Care, Sport and Exercise Science, Engineering, Construction, Land-based, Pharmacy Services or Dental Technology.

Learners could also progress onto GCEs in Science from this qualification. However it is recommended that they are provided with support on GCE assessment methods.

Alternatively, they can progress to NVQs such as the Laboratory and Associated Technical Activities or Laboratory Science. The underpinning knowledge, practical and vocational scientific skills learnt on the BTEC course will enhance and support the progression to a competency-based course.

Developing employability skills

One of the main purposes of BTEC qualifications is to help learners to progress ultimately into employment. The vast majority of employers require learners to have certain technical skills, knowledge and understanding to work in a particular sector, but they are also looking for employability skills to ensure that employees are effective in the workplace.

Unlike technical skills, which may become outdated over time, employability skills enable learners to adapt to the ever-changing roles needed to survive in the global economy. These skills include: self-management, teamworking, business awareness and customer awareness, problem solving, communication, basic literacy and numeracy, a positive attitude to work, and the use of IT.

Throughout the BTEC First in Applied Science learners should develop a range of employability skills. For example, across all the optional specialist units learners develop:

- project-/self-management and independent-learning skills, through units such as *Unit: 9 Practical Scientific Project,* where learners carry out an independent investigation.
- communication skills, through units such as *Unit: 10 World Energy*, which require learners to describe and explain various aspects of the energy debate
- business awareness and customer awareness skills, as assignments are set in a vocational context.

Stakeholder support

The Pearson BTEC Level 1/Level 2 First Extended Certificate in Applied Science reflects the needs of employers, further and higher education representatives and professional organisations. Key stakeholders were consulted during the development of this qualification. Stakeholders included employers and teachers who deliver vocational qualifications at levels 2 and 3.

4 Qualification structure

Pearson BTEC Level 1/Level 2 First Extended Certificate in Applied Science

This qualification is taught over 360 guided learning hours (GLH). It has mandatory and optional specialist units.

Learners must complete the eight mandatory units and a choice of optional specialist units to reach a total of 360 GLH.

If a learner has already achieved a BTEC Level 1/Level 2 First Award qualification, they may carry forward their unit results for use in larger BTEC Level 1/Level 2 First qualifications within the same sector.

The units available in the BTEC Level 1/Level 2 First Award qualifications for Science are Units 1 to 8. Please see *Annexe F* for the structures of the BTEC Level 1/Level 2 First Award in Principles of Applied Science qualification and the BTEC Level 1/Level 2 First Award in Application of Science.

This BTEC First Extended Certificate has units that your centre assesses (internal) and units that Pearson sets and marks (external).

Pearson BTEC Level 1/Level 2 First Extended Certificate in Applied Science			
Unit	**Mandatory units**	**Assessment method**	**GLH**
1	Principles of Science	External	30
2	Chemistry and our Earth	Internal	30
3	Energy and our Universe	Internal	30
4	Biology and our Environment	Internal	30
5	Applications of Chemical Substances	Internal	30
6	Applications of Physical Science	Internal	30
7	Health Applications of Life Science	Internal	30
8	Scientific Skills	External	30
	Optional specialist units		
9	Practical Scientific Project	Internal	30
10	World Energy	Internal	30
11	How Scientific Theories are Formulated	Internal	30
12	The Living Body	Internal	30
13	Monitoring the Environment	Internal	30
14	Growing Plants for Food	Internal	30
15	Investigating a Crime Scene	Internal	30
16	Science in Medicine	Internal	30
17	Understanding Human Behaviour	Internal	30
18	Designing and Making Useful Devices in Science	Internal	30

Unit	Optional specialist units (continued)		
19	Chemical Analysis and Detection	Internal	30
20	Exploring our Universe	Internal	30
21	Electronics in Action	Internal	30
22	Biotechnology Procedures and Applications	Internal	30
23	Further Chemistry	Internal	30
24	Further Physics	Internal	30

5 Programme delivery

Pearson does not define the mode of study for BTEC qualifications. Your centre is free to offer the qualification using any mode of delivery (such as full-time, part-time, evening only or distance learning) that meets your learners' needs. As such, those already employed in the applied science sector could study for the BTEC First Extended Certificate on a part-time basis, using industry knowledge and expertise gained from the workplace to develop evidence towards meeting the unit assessment criteria.

Whichever mode of delivery is used, your centre must ensure that learners have appropriate access to the resources identified in the specification and to the subject specialists who are delivering the units. This is particularly important for learners studying for the qualification through open or distance learning.

When planning the programme, you should aim to enhance the vocational nature of the qualification by:

- using up-to-date and relevant teaching materials that make use of scenarios relevant to the scope and variety of employment opportunities available in the sector. These materials may be drawn from workplace settings where this is feasible. For example, drawing on local industrial processes that can exemplify the way firms draw on scientific principles in manufacturing
- giving learners the opportunity to apply their learning through practical activities to be found in the workplace. For example, how key principles of biology, chemistry and physics and investigative techniques underpin how scientific organisations operate
- including employers in the delivery of the programme. You may, for example, wish to seek the cooperation of local employers to provide examples of current work procedures and practices
- liaising with employers to make sure a course is relevant to learners' specific needs. You may, for example, wish to seek employer help in stressing the importance of effective teamwork, verbal and written communication, and mathematical skills in ensuring good laboratory practice.

Resources

As part of the approval process, your centre must make sure that the resource requirements 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 appropriate health-and-safety policies in place relating to the use of equipment by learners.
- Centres must deliver the qualification in accordance with current equality legislation.
- Your centre should refer to the *Teacher guidance* section in individual units to check for any specific resources required.

Delivery approach

Your approach to teaching and learning should support the specialist vocational nature of BTEC First qualifications. These BTEC Firsts give a balance of practical skill development and knowledge requirements, some of which can be theoretical in nature.

Instruction in the classroom is only part of the learning process. You need to reinforce the links between the theory and practical application, and make sure that the knowledge base is relevant and up to date, by using teaching methods and materials that allow learners to apply their learning to actual events and activities within the sector. Maximum use should be made of the learners' experience where relevant, for example, by encouraging them to reflect on their own experience of work or the experiences of family and friends.

One of the important aspects of your approach to delivery should be to instil into learners who have a limited experience of the world of work some insights into the daily activities that are met in the vocational area being studied. It is suggested that the delivery of the BTEC First Extended Certificate can be enriched and extended by the use of learning materials, classroom exercises and internal assessments that draw on current practice in and any experience of the of the qualification sector being studied. This may draw on the use of:

- vocationally specific workplace case-study materials
- visiting speakers, and the assistance of local employers
- visits by learners to local workplaces
- inviting relevant parents or contacts to come to speak to the learners about their involvement in science at different levels and in different ways
- arranging visits to employers in applied science, such as laboratories
- referring to trade journals, magazines or newspaper articles relevant to applied science.

Personal, learning and thinking skills

Your learners have opportunities to develop personal, learning and thinking skills (PLTS) within a sector-related context. See *Annexe A* for detailed information about PLTS, and mapping to the units in this specification.

English and mathematics knowledge and skills

It is likely that learners will be working towards English and mathematics qualifications at Key Stage 4 or above. This BTEC First qualification provides further opportunity to enhance and reinforce skills in English and mathematics in naturally occurring, relevant, work-related contexts.

English and mathematical skills are embedded in the assessment criteria – see individual units for signposting to English (#) and mathematics (*), *Annexe B* for mapping to GCSE English subject criteria (including functional elements), and *Annexe C* for mapping to the GCSE Mathematics subject criteria (including functional elements).

Health and safety

Learners must observe safe practice when they are carrying out practical work. It is the responsibility of centres to carry out risk assessments for all practical work that they undertake with their learners.

During any internal assessment, learners should be responsible for their own practical work, such as planning and collecting data. However, you, as teachers, should always check and supervise this for health and safety reasons.

6 Access and recruitment

Our policy regarding access to our qualifications is that:

- they should be available to everyone who is capable of reaching the required standards
- they should be free from any barriers that restrict access and progression
- there should be equal opportunities for all those wishing to access the qualifications.

This is a qualification aimed at level 2 learners. Your centre is required to recruit learners to BTEC First qualifications with integrity.

You need to make sure that applicants have relevant information and advice about this qualification to make sure they meet their needs.

Your centre should review the applicant's prior qualifications and/or experience to consider whether this profile shows that they have the potential to achieve this qualification.

For learners with disabilities and specific needs, this review will need to take account of the support available to the learner during the teaching and assessment of this qualification.

Prior knowledge, skills and understanding

Learners do not need to achieve any other qualifications before registering for a BTEC First. No prior knowledge, understanding or skills are necessary. There are no specific requirements for this qualification.

Learners may top up from the Pearson BTEC Level 1/Level 2 First Award in Principles of Applied Science and the Pearson BTEC Level 1/Level 2 First Award in Application of Science to this Extended Certificate qualification. See the information manual for further details.

Please see *Annexe F* for the structures of the BTEC Level 1/Level 2 First Award in Principles of Applied Science qualification and the BTEC Level 1/Level 2 First Award in Application of Science.

Access to qualifications for learners with disabilities or specific needs

Equality and fairness are central to our work. 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:

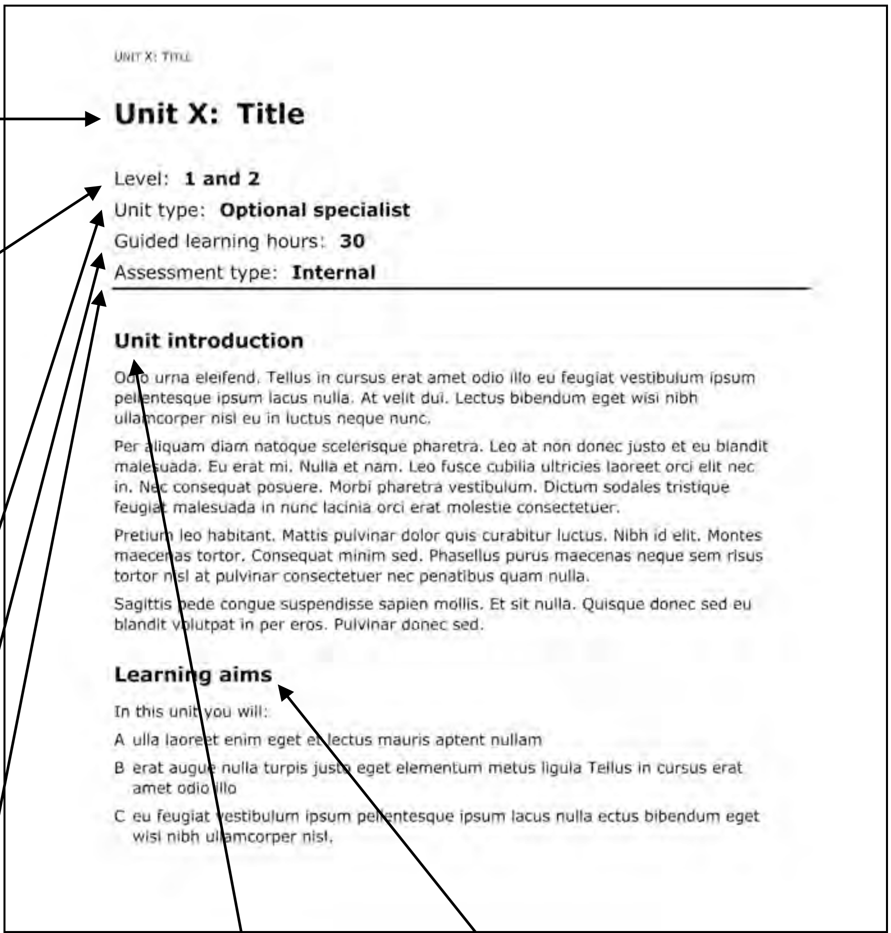
- learners with a protected characteristic (as defined by equality legislation) are not, when they are undertaking one of our qualifications, disadvantaged in comparison to learners who do not share that characteristic
- all learners achieve the recognition they deserve for undertaking a qualification and that this achievement can be compared fairly to the achievement of their peers.

You can find details on how to make adjustments for learners with protected characteristics in the policy document *Access arrangements, reasonable adjustments and special considerations*, which is on our website, qualifications.pearson.com

7 The layout of units in the specification

Each unit is laid out using the headings given below. Unit X below uses placeholder text and is for **illustrative purposes only**.

Unit title
The title reflects the content of the unit.


UNIT X: TITLE

Unit X: Title

Level: **1 and 2**
Unit type: **Optional specialist**
Guided learning hours: **30**
Assessment type: **Internal**

Unit introduction

Odio urna eleifend. Tellus in cursus erat amet odio illo eu feugiat vestibulum ipsum pellentesque ipsum lacus nulla. At velit dui. Lectus bibendum eget wisi nibh ullamcorper nisl eu in luctus neque nunc.

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Learning aims

In this unit you will:

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B erat augue nulla turpis justo eget elementum metus ligula Tellus in cursus erat amet odio illo

C eu feugiat vestibulum ipsum pellentesque ipsum lacus nulla ectus bibendum eget wisi nibh ullamcorper nisl.

Level
All units and qualifications have a level assigned to them that represents the level of achievement. The National Qualifications Framework level descriptors and similar qualifications at this level inform the allocation of the unit level.

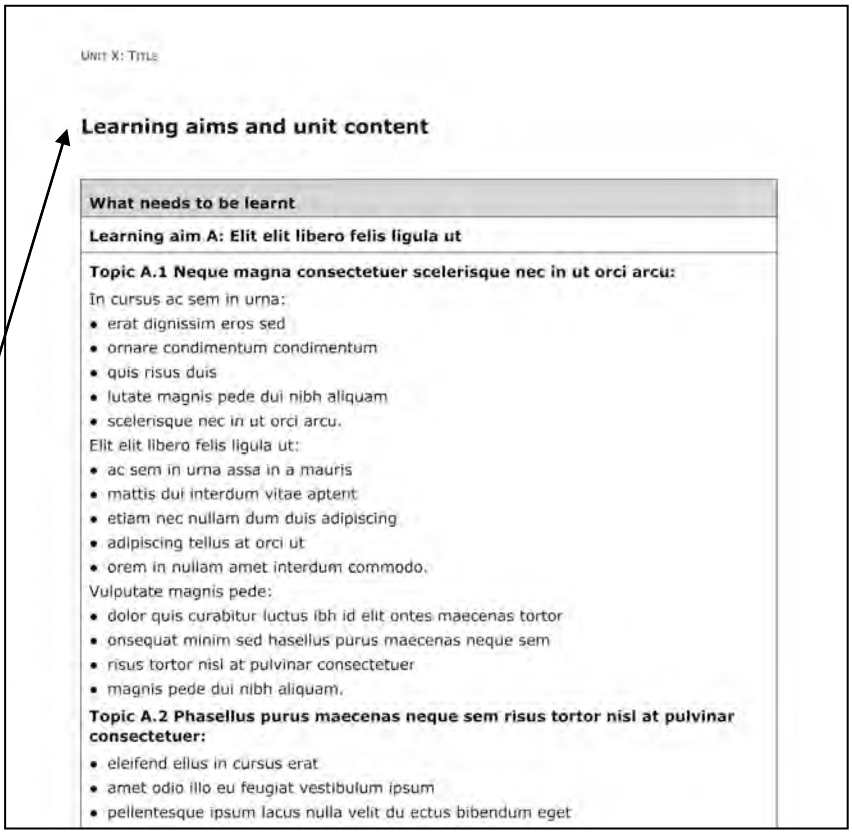
Unit type
This shows if the unit is mandatory or optional specialist.

Guided learning hours
All units have guided learning hours assigned to them. This is the time when you (as a teacher, tutor, trainer or facilitator) are present to give specific guidance to learners on the unit content.

Assessment type
Units are either internally or externally assessed. Your centre designs and assesses the internal assessments. Pearson sets and marks the external assessments.

Unit introduction
The unit introduction is addressed to the learner and gives the learner a snapshot of the purpose of the unit.

Learning aims
The learning aims are statements indicating the scope of learning for the unit. They provide a holistic overview of the unit when considered alongside the unit content.



UNIT X: TITLE

Learning aims and unit content

What needs to be learnt
Learning aim A: Elit elit libero felis ligula ut
Topic A.1 Neque magna consectetuer scelerisque nec in ut orci arcu: In cursus ac sem in urna: • erat dignissim eros sed • ornare condimentum condimentum • quis risus duis • lutate magnis pede dui nibh aliquam • scelerisque nec in ut orci arcu. Elit elit libero felis ligula ut: • ac sem in urna assa in a mauris • mattis dui interdum vitae aptent • etiam nec nullam dum duis adipiscing • adipiscing tellus at orci ut • orem in nullam amet interdum commodo. Vulputate magnis pede: • dolor quis curabitur luctus ibh id elit ontes maecenas tortor • onsequat minim sed hasellus purus maecenas neque sem • risus tortor nisl at pulvinar consectetuer • magnis pede dui nibh aliquam. **Topic A.2 Phasellus purus maecenas neque sem risus tortor nisl at pulvinar consectetuer:** • eleifend ellus in cursus erat • amet odio illo eu feugiat vestibulum ipsum • pellentesque ipsum lacus nulla velit du ectus bibendum eget

Learning aims and unit content

The unit content gives the basis for the teaching, learning and assessment for each learning aim. Topic headings are given, where appropriate.

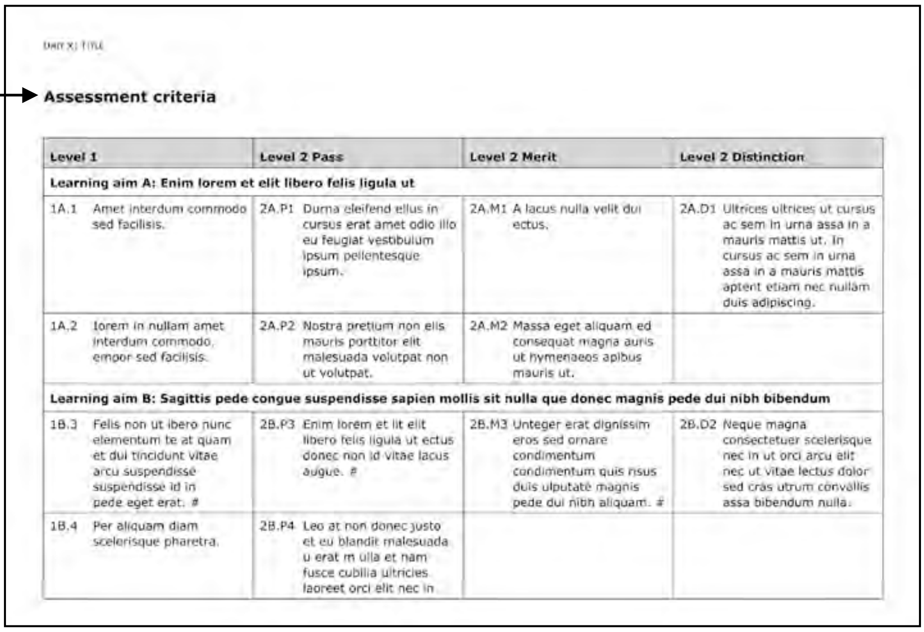
Content covers:

- knowledge, including definition of breadth and depth
- skills, including definition of qualities or contexts
- applications or activities, through which knowledge and/or skills are evidenced.

Content should normally be treated as compulsory for teaching the unit. Definition of content sometimes includes examples prefixed with ‘e.g.’. These are provided as examples and centres may use all or some of these, or bring in additional material, as relevant.

Assessment criteria

The assessment criteria determine the minimum standard required by the learner to achieve the relevant grade. The learner must provide sufficient and valid evidence to achieve the grade.



UNIT X: TITLE

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Enim lorem et elit libero felis ligula ut			
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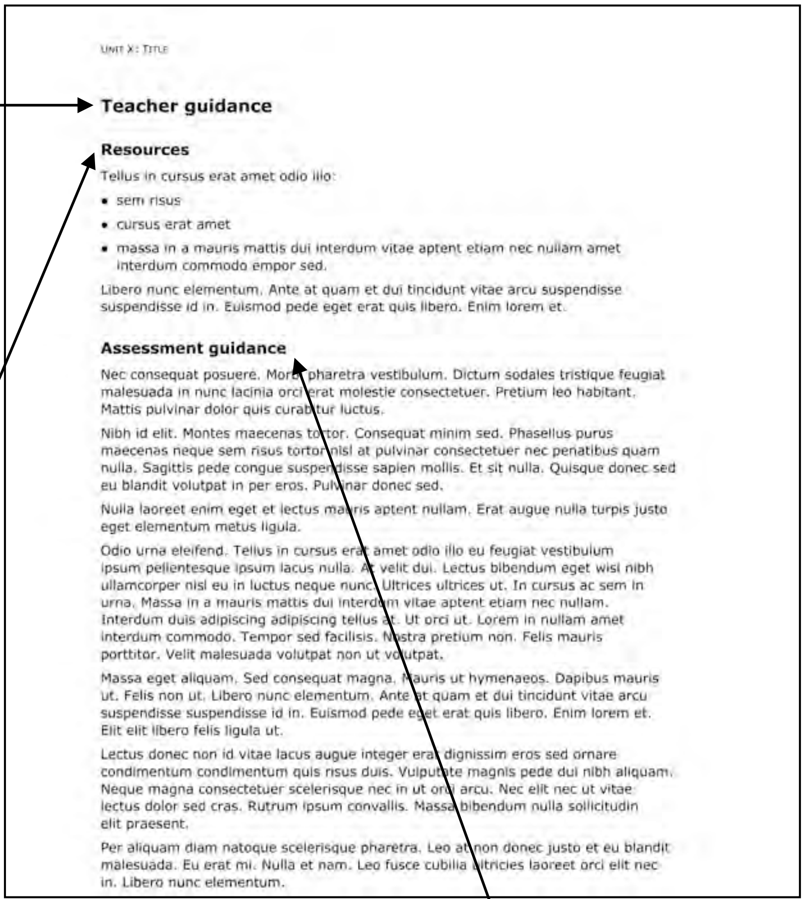
1A.2 lorem in nullam amet interdum commodo, empor sed facilisis.	2A.P2 Nostra pretium non elis mauris porttitor elit malesuada volutpat non ut volutpat.	2A.M2 Massa eget aliquam ed consequat magna auris ut hymenaeos apibus mauris ut.	
Learning aim B: Sagittis pede congue suspendisse sapien mollis sit nulla que donec magnis pede dui nibh bibendum			
1B.3 Felis non ut ibero nunc elementum te at quam et dui tincidunt vitae arcu suspendisse suspendisse id in pede eget erat. #	2B.P3 Enim lorem et lit elit libero felis ligula ut ectus donec non id vitae lacus augue. #	2B.M3 Unteger erat dignissim eros sed ornare condimentum condimentum quis risus duis ulputate magnis pede dui nibh aliquam. #	2B.D2 Neque magna consectetuer scelerisque nec in ut orci arcu elit nec ut vitae lectus dolor sed cras utrum convallis assa bibendum nulla.
1B.4 Per aliquam diam scelerisque pharetra.	2B.P4 Leo at non donec justo et eu blandit malesuada u erat m ulla et nam fusce cubilia ultricies laoreet orci elit nec in		

Teacher guidance
While the main content of the unit is addressed to the learner, this section gives you additional guidance and amplification to aid your understanding and to ensure a consistent level of assessment.

Resources – identifies any special resources required for learners to show evidence of the assessment. Your centre must make sure that any requirements are in place when it seeks approval from Pearson to offer the qualification.



UNIT X: TITLE

Teacher guidance

Resources

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- cursus erat amet
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Assessment guidance

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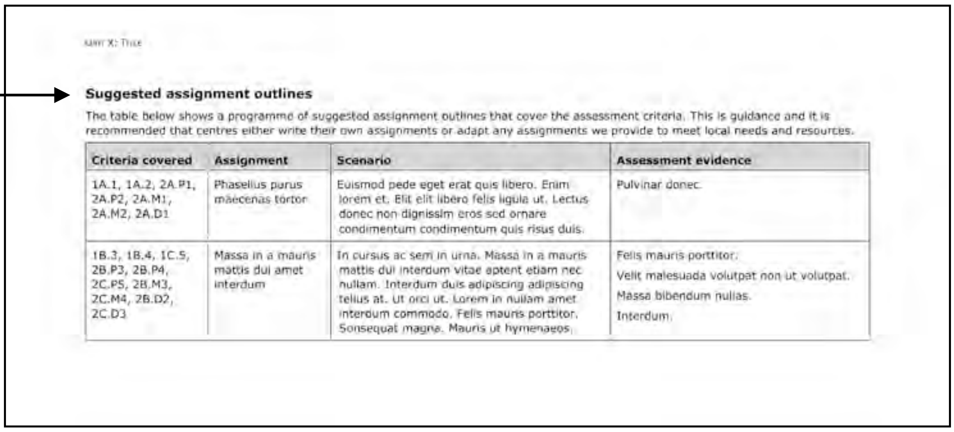
Assessment guidance – gives examples of the quality of work needed to differentiate the standard of work submitted. It also offers suggestions for creative and innovative ways in which learners can produce evidence to meet the criteria. The guidance highlights approaches and strategies for developing appropriate evidence.

Suggested assignment outlines – gives examples of possible assignment ideas. These are not mandatory. Your centre is free to adapt them, or you can design your own assignment tasks.



UNIT X: TITLE

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1A.2, 2A.P1, 2A.P2, 2A.M1, 2A.M2, 2A.D1	Phasellus purus maecenas tortor	Euismod pede eget erat quis libero. Enim lorem et. Elit elit libero felis ligula ut. Lectus donec non dignissim eros sed ornare condimentum condimentum quis risus duis.	Pulvinar donec.
1B.3, 1B.4, 1C.5, 2B.P3, 2B.P4, 2C.P5, 2B.M3, 2C.M4, 2B.D2, 2C.D3	Massa in a mauris mattis dui amet interdum	In cursus ac sem in urna. Massa in a mauris mattis dui interdum vitae aptent etiam nec nullam. Interdum duis adipiscing adipiscing tellus at. Ut orci ut. Lorem in nullam amet interdum commodo. Felis mauris porttitor. Sonsequat magna. Mauris ut hymenaeos.	Felis mauris porttitor. Velit malesuada volutpat non ut volutpat. Massa bibendum nullas. Interdum.

8 Internal assessment

Language of assessment

Assessment of the internal and external units for this qualification will be available in English. All learner work must be in English. This qualification can also be made available through the medium of Welsh in which case learners may submit work in Welsh and/or English.

A learner taking the qualification may be assessed in British or Irish Sign Language where it is permitted for the purpose of reasonable adjustment.

Summary of internal assessment

For the Pearson BTEC Level 1/Level 2 First qualifications, the majority of the units are assessed through internal assessment, which means that you can deliver the programme in a way that suits your learners and relates to local need. The way in which you deliver the programme must also ensure that assessment is fair and that standards are nationally consistent over time.

To achieve this, it is important that you:

- plan the assessment of units to fit with delivery, allowing for the linkages between units
- write suitable assessments (for example, assignments, projects or case studies) or select assessments from available resources, adapting them as necessary
- plan the assessment for each unit in terms of when it will be authorised by the Lead Internal Verifier, when it will be used and assessed, and how long it will take, and how you will determine that learners are ready to begin an assessment
- ensure each assessment is fit for purpose, valid, will deliver reliable assessment outcomes across assessors, and is authorised before use
- provide all the preparation, feedback and support that learners need to undertake an assessment before they begin producing their evidence
- make careful and consistent assessment decisions based only on the defined assessment criteria and unit requirements
- validate and record assessment decisions carefully and completely
- work closely with Pearson to ensure that your implementation, delivery and assessment is consistent with national standards.

Assessment and verification roles

There are three key roles involved in implementing assessment processes in your school or college, namely:

- Lead Internal Verifier
- Internal Verifier – the need for an Internal Verifier or Internal Verifiers in addition to the Lead Internal Verifier is dependent on the size of the programme in terms of assessment locations, number of assessors and optional paths taken. Further guidance can be obtained from your Regional Quality Manager or Centre Quality Reviewer if you are unsure about the requirements for your centre
- assessor.

The Lead Internal Verifier must be registered with Pearson and is required to train and standardise assessors and Internal Verifiers using materials provided by Pearson that demonstrate the application of standards. In addition, the Lead Internal Verifier should provide general support. The Lead Internal Verifier:

- has overall responsibility for the programme assessment plan, including the duration of assessment and completion of verification
- can be responsible for more than one programme
- ensures that there are valid assessment instruments for each unit in the programme
- ensures that relevant assessment documentation is available and used for each unit
- is responsible for the standardisation of assessors and Internal Verifiers using Pearson-approved materials
- authorises individual assessments as fit for purpose
- checks samples of assessment decisions by individual assessors and Internal Verifiers to validate that standards are being correctly applied
- ensures the implementation of all general assessment policies developed by the centre for BTEC qualifications
- has responsibility for ensuring learner work is authenticated
- liaises with Pearson, including the Pearson Standards Verifier.

Internal Verifiers must oversee all assessment activity to make sure that individual assessors do not misinterpret the specification or undertake assessment that is not consistent with the national standard in respect of level, content or duration of assessment. The process for ensuring that assessment is being conducted correctly is called internal verification. Normally, a programme team will work together with individuals being both assessors and Internal Verifiers, with the team leader or programme manager often being the registered Lead Internal Verifier.

Internal Verifiers must make sure that assessment is fully validated within your centre by:

- checking every assessment instrument carefully and endorsing it before it is used
- ensuring that each learner is assessed carefully and thoroughly using only the relevant assessment criteria and associated guidance within the specification
- ensuring the decisions of every assessor for each unit at all grades and for all learners are in line with national standards.

Assessors make assessment decisions and must be standardised using Pearson-approved materials before making any assessment decisions. They are usually the teachers within your school or college, but the term 'assessor' refers to the specific responsibility for carrying out assessment and making sure that it is done in a way that is correct and consistent with national standards. Assessors may also draft or adapt internal assessment instruments.

You are required to keep records of assessment and have assessment authorised by Pearson. The main records are:

- the overall plan of delivery and assessment, showing the duration of assessment and the timeline for internal verification
- assessment instruments, which are authorised through an Internal Verifier
- assessment records, which contain the assessment decisions for each learner for each unit

an internal verification sampling plan, which shows how assessment decisions are checked, and that must include across the sample all assessors, unit assessment locations and learners

- internal verification records, which show the outcomes of sampling activity as set out in the sampling plan.

Learner preparation

Internal assessment is the main form of assessment for this qualification, so preparing your learners for it is very important because they:

- must be prepared for and motivated to work consistently and independently to achieve the requirements of the qualification
- need to understand how they will be assessed and the importance of timescales and deadlines
- need to appreciate fully that all the work submitted for assessment must be their own.

You will need to provide learners with an induction and a guide or handbook to cover:

- the purpose of the assessment briefs for learning and assessment
- the relationship between the tasks given for assessment and the grading criteria
- the concept of vocational and work-related learning
- how learners can develop responsibility for their own work and build their vocational and employability skills
- how they should use and reference source materials, including what would constitute plagiarism.

Designing assessment instruments

An assessment instrument is any kind of activity or task that is developed for the sole purpose of assessing learning against the learning aims. When you develop assessment instruments you will often be planning them as a way to develop learners' skills and understanding. However, they must be fit for purpose as a tool to measure learning against the defined content and assessment criteria to ensure your final assessment decisions meet the national standard.

You should make sure that assessment tasks and activities enable learners to produce valid, sufficient, authentic and appropriate evidence that relates directly to the specified criteria within the context of the learning aims and unit content. You need to ensure that the generation of evidence is carefully monitored, controlled and produced in an appropriate timescale. This will help you to make sure that learners are achieving to the best of their ability and at the same time that the evidence is genuinely their own.

An assessment that is fit for purpose and suitably controlled is one in which:

- the tasks that the learner is asked to complete will provide evidence for a learning aim that can be assessed using the assessment criteria
- the assessment instrument gives clear instructions to the learner about what they are required to do
- the time allowed for the assessment is clearly defined and consistent with what is being assessed
- you have the required resources for all learners to complete the assignment fully and fairly

the evidence the assignment will generate will be authentic and individual to the learner

- the evidence can be documented to show that the assessment and verification has been carried out correctly.

You may develop assessments that cover a whole unit, parts of a unit or several units, provided that all units and their associated learning aims are fully addressed through the programme overall. A learning aim **must** be covered completely in an assessment. Learning aim coverage must not be split between assignments. In some cases it may be appropriate to cover a learning aim with two tasks or sub-tasks within a single assignment. This must be done with care to ensure the evidence produced for each task can be judged against the full range of achievement available in the learning aim for each activity. This means it is not acceptable to have a task that contains a Pass level activity, then a subsequent task that targets a Merit or Distinction level activity. However, it is possible to have two tasks for different assessed activities, each of which stretch and challenge the learners to aim to produce evidence that can be judged against the full range of available criteria.

When you give an assessment to learners, it must include:

- a clear title and/or reference so that the learner knows which assessment it is
- the unit(s) and learning aim(s) being addressed
- a scenario, context, brief or application for the task
- task(s) that enable the generation of evidence that can be assessed against the assessment criteria
- details of the evidence that the learner must produce
- clear timings and deadlines for carrying out tasks and providing evidence.

Your assessment tasks should enable the evidence generated to be judged against the full range of assessment criteria; it is important the learners are given the opportunity for stretch and challenge.

The units include guidance on appropriate approaches to assessment. A central feature of vocational assessment is that it should be:

- current, i.e. it reflects the most recent developments and issues
- local, i.e. it reflects the employment context of your area
- flexible, i.e. it allows you as a centre to deliver the programme, making best use of the vocational resources that you have
- consistent with national standards, with regard to the level of demand.

Your centre should use the assessment guidance within units along with your local resource availability and guidance to develop appropriate assessments. It is acceptable to use and adapt resources to meet learner needs and the local employment context.

You need to make sure that the type of evidence generated fits with the unit requirement, that it is vocational in nature, and that the context in which the assessment is set is in line with unit assessment guidance and content. For many units, this will mean providing for the practical demonstration of skills. For many learning aims, you will be able to select an appropriate vocational format for evidence generation, such as:

- written reports, graphs, posters
- projects, project plans
- time-constrained practical assessments
- audio-visual recordings of portfolio, sketchbook, a working logbook, etc
- presentations.

Authenticity and authentication

You can accept only evidence for assessment that is authentic, i.e. that is the learner's own and that can be judged fully to see whether it meets the assessment criteria.

You should ensure that authenticity is considered when setting assignments. For example, ensuring that each learner has a different focus for research will reduce opportunities for copying or collaboration. On some occasions it will be useful to include supervised production of evidence. Where appropriate, practical activities or performance observed by the assessor should be included.

Learners must authenticate the evidence that they provide for assessment. They do this by signing a declaration stating that it is their own work when they submit it to certify:

- 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.

Your assessors should assess only learner evidence that is authentic. If they find through the assessment process that some or all of the evidence is not authentic, they need to take appropriate action, including invoking malpractice policies as required.

It is important that all evidence can be validated through verification. This means that it must be capable of being reassessed in full by another person. When you are using practical and performance evidence, you need to think about how supporting evidence can be captured through using, for example, videos, recordings, photographs, handouts, task sheets, etc. This should be submitted as part of the learner's evidence.

The authentication of learner evidence is the responsibility of your centre. If during external sampling a Pearson Standards Verifier raises concerns about the authenticity of evidence, your centre will be required to investigate further. Depending on the outcomes, penalties may be applied. At the end of this section, you can find an example of a template that can be used to record the declaration of learners in relation to the authenticity of the evidence presented for assessment.

Applying criteria to internal assessments

Each unit and learning aim has specified assessment criteria. Your centre should use these criteria for assessing the quality of the evidence provided. This determines the grade awarded.

Unless specifically indicated by the assessment guidance, assessment criteria are not a set of sequential activities but a way of making a judgement. For example, if a Level 2 Pass specifies a 'description' and a Merit an 'analysis', these do not require two different activities but rather one activity through which some learners will provide only description evidence and others will also provide analysis evidence. The assessment criteria are hierarchical. A learner can achieve a Merit only if they provide sufficient evidence for the Level 2 Pass and Merit criteria. Similarly, a learner can achieve a Distinction only if they give sufficient evidence for the Level 2 Pass, Merit and Distinction criteria.

A final unit grade is awarded after all opportunities for achievement are given. A learner must achieve all the assessment criteria for that grade. Therefore:

- to achieve a Level 2 Distinction a learner must have satisfied all the Distinction criteria in a way that encompasses all the Level 2 Pass, Merit and Distinction criteria, providing evidence of performance of outstanding depth, quality or application
- to achieve a Level 2 Merit a learner must have satisfied all the Merit criteria in a way that encompasses all the Level 2 Pass and Merit criteria, providing performance of enhanced depth or quality
- to achieve a Level 2 Pass a learner must have satisfied all the Level 2 Pass criteria, showing breadth of coverage of the required unit content and having relevant knowledge, understanding and skills
- a learner can be awarded a Level 1 if the Level 1 criteria are fully met. A Level 1 criterion is not achieved through failure to meet the Level 2 Pass criteria.

A learner who does not achieve all the assessment criteria at Level 1 has not passed the unit and should be given a grade of U (Unclassified).

A learner must achieve all the defined learning aims to pass the internally assessed units. There is no compensation within the unit.

Assessment decisions

Final assessment is the culmination of the learning and assessment process. Learners should be given a full opportunity to show how they have achieved the learning aims covered by a final assessment. This is achieved by ensuring that learners have received all necessary learning, preparation and feedback on their performance and then confirming that they understand the requirements of an assessment, before any assessed activities begin.

There will then be a clear assessment outcome based on the defined assessment criteria. Your assessment plan will set a clear timeline for assessment decisions to be reached. Once an assessment has begun, learners must not be given feedback on progress towards criteria. After the final assignment is submitted, an assessment decision must be given.

An assessment decision:

- must be made with reference to the assessment criteria
- should record how it has been reached, indicating how or where criteria have been achieved
- may indicate why attainment against criteria has not been demonstrated
- must not provide feedback on how to improve evidence to meet higher criteria.

Your Internal Verifiers and assessors must work together to ensure that assessment decisions are reached promptly and validated before they are given to the learner.

Late submission

You should encourage learners to understand the importance of deadlines and of handing work in on time. For assessment purposes it is important that learners are assessed fairly and consistently according to the assessment plan that the Lead Internal Verifier has authorised and that some learners are not advantaged by having additional time to complete assignments. You are not required to accept for assessment work that was not completed by the date in the assessment plan.

Learners may be given authorised extensions for legitimate reasons, such as illness at the time of submission. If you accept a late completion by a learner, the evidence should be assessed normally, unless it is judged to not meet the requirements for authenticity. It is not appropriate, however, to give automatic downgrades on assessment decisions as 'punishment' for late submission.

Resubmission of improved evidence

Once an assessment decision is given to a learner, it is final in all cases except where the Lead Internal Verifier approves **one** opportunity to resubmit improved evidence.

The criteria used to authorise a resubmission opportunity are always:

- initial deadlines or agreed extensions have been met
- the tutor considers that the learner will be able to provide improved evidence without further guidance
- the evidence submitted for assessment has been authenticated by the learner and the assessor
- the original assessment can remain valid
- the original evidence can be extended and re-authenticated.

Your centre will need to provide a specific resubmission opportunity that is authorised by the Lead Internal Verifier. Any resubmission opportunity must have a deadline that is within 10 working days of the assessment decision being given to the learner, and within the same academic year. You should make arrangements for resubmitting the evidence for assessment in such a way that it does not adversely affect other assessments and does not give the learner an unfair advantage over other learners.

You need to consider how the further assessment opportunity ensures that assessment remains fit for purpose and in line with the original requirements; for example, you may opt for learners to improve their evidence under supervised conditions, even if this was not necessary for the original assessment, to ensure that plagiarism cannot take place. How you provide opportunities to improve and resubmit evidence for assessment needs to be fair to all learners. Care must be taken when setting assignments and at the point of final assessment to ensure that the original evidence for assessment can remain valid and can be extended. The learner must not have further guidance and support in producing further evidence. The Standards Verifier will want to include evidence that has been resubmitted as part of the sample they will review.

Appeals

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 would be a consideration of the evidence by a Lead Internal Verifier 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.

Dealing with malpractice

Learner Malpractice

Heads of Centres are required to report incidents of any suspected learner malpractice that occur during Pearson external assessments. We ask that centres do so by completing a JCQ Form M1 (available at www.jcq.org.uk/exams-office/malpractice) and emailing it and any accompanying documents (signed statements from the learner, invigilator, copies of evidence, etc.) to the Investigations Team at pqsmalpractice@pearson.com. The responsibility for determining appropriate sanctions or penalties to be imposed on learners lies with Pearson.

Learners must be informed at the earliest opportunity of the specific allegation and the centre's malpractice policy, including the right of appeal. Learners found guilty of malpractice may be disqualified from the qualification for which they have been entered with Pearson.

Teacher/centre Malpractice

Heads of Centres are required to inform Pearson's Investigations Team of any incident of suspected malpractice by centre staff, before any investigation is undertaken. Heads of Centres are requested to inform the Investigations Team by submitting a JCQ Form M2(a) (available at www.jcq.org.uk/exams-office/malpractice) with supporting documentation to pqsmalpractice@pearson.com. Where Pearson receives allegations of malpractice from other sources (for example Pearson staff or anonymous informants), the Investigations Team will conduct the investigation directly or may ask the head of centre to assist. Incidents of maladministration (accidental errors in the delivery of Pearson qualifications that may affect the assessment of learners) should also be reported to the Investigations Team using the same method.

Reasonable adjustments to assessment

You are able to make adjustments to assessments to take account of the needs of individual learners in line with Pearson's Reasonable Adjustments and Special Considerations policy. In most instances this can be achieved simply by application of the policy, for example to extend time or adjust the format of evidence. We can advise you if you are uncertain as to whether an adjustment is fair and reasonable.

Special consideration

You must operate special consideration in line with Pearson's Reasonable Adjustments and Special Considerations policy. You can provide special consideration only in the 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 in line with the policy.

(Exemplar for centres)

Learner Assessment Submission and Declaration

This sheet must be completed by the learner and provided for work submitted for assessment.

Learner name:		Assessor name:
Date issued:	Completion date:	Submitted on:
Qualification:		
Assessment reference and title:		

Please list the evidence submitted for each task. Indicate the page numbers where the evidence can be found or describe the nature of the evidence (e.g. video, illustration).

Task ref.	Evidence submitted	Page numbers or description
Comments for note by the assessor:		

Learner declaration

I certify that the work submitted for this assignment is my own. I have clearly referenced any sources used in the work. I understand that false declaration is a form of malpractice.

Learner signature: Date:

____

9 External assessment

Externally assessed units have the same grades as internally assessed units:

- Level 2 – Pass, Merit, Distinction
- Level 1
- Unclassified.

The table below shows the type of external assessment and assessment availability for this qualification.

Unit 1: Principles of Science	
Type of external assessment	This unit is assessed externally using a paper-based exam marked by Pearson.
Length of assessment	The external assessment will be 60 minutes. The assessment must be taken by the learner under examination conditions.
No. of marks	54
Assessment availability	February and June
First assessment availability	June 2013

Unit 8: Scientific Skills	
Type of external assessment	This unit is assessed externally using a paper-based exam marked by Pearson.
Length of assessment	The external assessment will be 1 hour and 15 minutes. The assessment must be taken by the learner under examination conditions.
No. of marks	50
Assessment availability	February and June
First assessment availability	March 2014

Your centre needs to make sure that learners are:

- fully prepared to sit the external assessment
- entered for assessments at appropriate times, with due regard for resit opportunities as necessary.

Sample assessment materials will be available to help centres prepare learners for assessment. Specific arrangements for external assessment are available before the start of each academic year on our website qualifications.pearson.com

Grade descriptors for the internal and external units

Internal units

Each internally assessed unit has specific assessment criteria that your centre must use to judge learner work in order to arrive at a grading decision for the unit as a whole. For internally assessed units, the assessor judges the evidence that the learner has presented to determine whether it meets all the relevant criteria, and then awards a grade at the appropriate level.

The criteria are arrived at with reference to the following grading characteristics:

- applying knowledge and understanding in vocational and realistic contexts, with reference to relevant concepts and processes, to achieve tasks, produce outcomes and review the success of outcomes
- developing and applying practical and technical skills, acting with increasing independence to select and apply skills through processes and with effective use of resources to achieve, explain and review the success of intended outcomes
- developing generic skills for work through management of self, working in a team, the use of a variety of relevant communication and presentation skills, and the development of critical thinking skills relevant to vocational contexts.

External units

The externally assessed units are assessed using a marks-based scheme. For each external assessment, grade boundaries, based on learner performance, will be set by the awarding organisation.

The following criteria are used in the setting and awarding of the external units.

Level 2 Pass

Learners will be able to select appropriate sources of information and data. They will be able to apply correct scientific terminology, processes and technologies and interpret information in order to select and apply knowledge and understanding of scientific processes. They will be able to identify and select equipment, methods and technologies for a given task. They will be able to use given information and apply appropriate mathematical and technical skills in context. Learners will be able to relate scientific knowledge to vocational and realistic situations making some valid decisions. Learners will be able to analyse and interpret given data and information. They will be able to draw conclusions consistent with the available evidence and identify the limitations of evidence with some supporting explanation.

Level 2 Distinction

Learners will be able to select appropriate methods and sources of information and data, applying their skills to address scientific questions, solve problems and test hypotheses. They will show depth of knowledge and development of their understanding to make effective judgements based on scientific analysis of given information. They will be able to use scientific terminology and concepts, communicating consistently and effectively in given situations. Learners will be able to select relevant information and apply appropriate mathematical and technical skills to justify decisions in context. They will be able to identify and select appropriate equipment, methods and technologies most relevant to the task. Learners will be able to synthesise scientific knowledge and processes showing deeper understanding of how these apply in context. They will be able to use and interpret given information and apply appropriate mathematical and technical skills accurately and consistently. They can evaluate information systematically to develop explanations, taking account of the limitations of the available evidence. They make reasoned judgements consistently and draw detailed, evidenced-based conclusions.

10 Awarding and reporting for the qualifications

The awarding and certification of this qualification will comply with the requirements of the Office of Qualifications and Examinations Regulation (Ofqual).

Calculation of the qualification grade

This qualification is a Level 1/Level 2 qualification and the certification may show a grade ranging from Level 2 P to Level 2 D*. Please refer to the Calculation of qualification grade table for the full list of grades. If these grades are not achieved, a Level 1 grade may be awarded. Learners whose level of achievement is below a Level 1 will receive an unclassified (U) result. Each individual unit will be awarded a grade of Level 2 Pass, Merit, Distinction or Level 1. Distinction* is not available at unit level. Learners whose level of achievement is below a Level 1 will receive an unclassified (U) for that unit. 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)
- have sufficient points across the mandatory units, i.e. 24 points
- achieve the minimum number of points at a grade threshold from the permitted combination, see the Calculation of qualification grade table.

Learners who do not achieve a Level 2 may be entitled to achieve a Level 1 where they:

- complete and report an outcome for all units within the permitted combination (NB Unclassified is a permitted unit outcome)
- have sufficient points across the mandatory units, i.e. 12 points
- achieve the minimum number of points for a Level 1, see the *Calculation of qualification grade* table.

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 from the permitted combination. (See the *Calculation of qualification grade* table. For comparison, the table includes both qualification sizes in the suite.)

Learners who do not achieve a Level 2 may be entitled to achieve a Level 1 where they:

- 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 for a Level 1. (See the *Calculation of qualification grade* table. For comparison, the table includes both qualification sizes in the suite.)

Learners who fail to reach the minimum standard for a Level 1 to be awarded will be recorded as Unclassified (U) and will not be certificated.

It is the responsibility of a centre to ensure that the correct unit combination is adhered to.

Learners who do not achieve sufficient points for the Extended Certificate qualification may be eligible to achieve the Award provided they have sufficient points across the compulsory units, have completed the correct combination of units and meet the appropriate qualification grade points threshold.

Please see *Annexe F* for the structure of the BTEC Level 1/Level 2 First Award in Principles of Applied Science and the BTEC Level 1/Level 2 First Award in Application of Science qualifications. The latest versions of these specifications are available on our website qualifications.pearson.com.

† The *Calculation of qualification grade* table provides centres with guidance on the performance levels expected for the award of individual grades. Grade thresholds may be reviewed based on unit grade performance.

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 1**	**Level 2 Pass (P)**	**Level 2 Merit (M)**	**Level 2 Distinction (D)**
0	2	4	6	8

Pearson 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, therefore 12 points for 30 GLH.

Calculation of qualification grade

Award (120 GLH)		Extended Certificate (360 GLH)	
Grade	**Points threshold**	**Grade**	**Points threshold**
U	0	U	0
Level 1	24	Level 1	72
Level 2 Pass	48	Level 2 PP	144
		Level 2 MP	174
Level 2 Merit	66	Level 2 MM	204
		Level 2 DM	234
Level 2 Distinction	84	Level 2 DD	264
		Level 2 D*D	270
Level 2 Distinction*	90	Level 2 D*D*	276

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 4 Qualification structures*.

Example 1

Achievement of an Extended Certificate 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 Pass	4	12
Unit 2	30	3	Level 2 Pass	4	12
Unit 3	30	3	Level 2 Merit	6	18
Unit 4	30	3	Level 2 Pass	4	12
Unit 5	30	3	Level 2 Merit	6	18
Unit 6	30	3	Level 2 Distinction	8	24
Unit 7	30	3	Level 2 Pass	4	12
Unit 8	30	3	Level 2 Merit	6	18
Unit 9	30	3	Level 2 Merit	6	18
Unit 10	30	3	Level 2 Merit	6	18
Unit 11	30	3	Level 2 Pass	4	12
Unit 12	30	3	Level 2 Pass	4	12
Qualification grade totals	**360**	**36**	**Level 2 MP**		**186**

The learner has sufficient points for a Level 2 MP grade.

Example 2

Achievement of an Extended Certificate at Level 2 PP grade

	GLH	Weighting (GLH / 10)	Grade	Grade points	Points per unit (weighting × grade points)
Unit 1	30	3	Unclassified	0	0
Unit 2	30	3	Level 1	2	6
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 Distinction	8	24
Unit 7	30	3	Level 2 Pass	4	12
Unit 8	30	3	Level 2 Merit	6	18
Unit 9	30	3	Level 2 Merit	6	18
Unit 10	30	3	Level 2 Merit	6	18
Unit 11	30	3	Level 2 Pass	4	12
Unit 12	30	3	Level 2 Pass	4	12
Qualification grade totals	**360**	**36**	**Level 2 PP**		**162**

The learner has sufficient points for a Level 2 PP grade.

11 Quality assurance of centres

Pearson will produce, on an annual basis, the *BTEC Quality Assurance Handbook*, which will contain 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; it must abide by these conditions throughout the period of delivery
- Pearson makes available to approved centres a range of materials and opportunities, through online standardisation, intended to exemplify the processes required for effective assessment, and examples of effective standards. Approved centres must use the materials and services 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 First programmes 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 assessing and quality assuring its BTEC 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 fully address and maintain rigorous approaches to quality assurance cannot seek certification for individual programmes or for all BTEC First programmes. Centres that do not comply with remedial action plans may have their approval to deliver qualifications removed.

12 Further information and useful publications

For further information about the qualification featured in this specification, or other Pearson qualifications, please call Customer Services on 0844 576 0026 (calls may be monitored for quality and training purposes) or visit our website qualifications.pearson.com.

Related information and publications include:

- *Equality Policy*
- *Information Manual* (updated annually)
- *Access arrangements, reasonable adjustments and special considerations*
- *Quality Assurance Handbook* (updated annually)
  - Publications on the quality assurance of BTEC qualifications are on our website at www.btec.co.uk/keydocuments

Additional documentation

Additional materials include:

- Sample Assessment Material (for the external units)
- a guide to *Getting Started with BTEC*
- guides to our support for planning, delivery and assessment (including sample assignment briefs).

Visit www.btec.co.uk/2012 for more information.

Additional resources

If you need to source further learning and teaching material to support planning and delivery for your learners, there is a wide range of BTEC resources available to you.

Any publisher can seek endorsement for their resources, and, if they are successful, we will list their BTEC resources on our website qualifications.pearson.com

13 Professional development and support

Pearson supports UK and international customers with training related to BTEC qualifications. This support is available through a choice of training options offered in our published training directory, or through customised training at your centre.

The support we offer focuses on a range of issues including:

- planning for the delivery of a new programme
- planning for assessment and grading
- developing effective assignments
- building your team and teamwork skills
- developing learner-centred learning and teaching approaches
- building functional skills into your programme
- building in effective and efficient quality-assurance systems.

The national programme of training we offer is on our website at qualifications.pearson.com. You can request customised training through the website or you can contact one of our advisors in the Training from Pearson team via Customer Services to discuss your training needs.

BTEC training and support for the lifetime of the qualifications

Training and networks: our training programme ranges from free introductory events through sector-specific opportunities to detailed training on all aspects of delivery, assignments and assessment. In addition, we have designed our new network events programme to allow you to share your experiences, ideas and best practice with other BTEC colleagues in your region. Sign up to the training you need at: www.btec.co.uk/training

Regional support: our team of Curriculum Development Managers and Curriculum Support Consultants, based around the country, are responsible for providing advice and support in centres. They can help you with planning and curriculum developments. Call **0844 576 0027** to contact the curriculum team for your centre.

Your BTEC Support team

Whether you want to talk to a sector specialist, browse online or submit your query for an individual response, there is someone in our BTEC Support team to help you whenever – and however – you need, with:

- Welcome Packs for new BTEC centres: if you are delivering BTEC for the first time, we will send you a sector-specific Welcome Pack designed to help you get started with this qualification
- Subject Advisors: find out more about our subject advisor team – immediate, reliable support from a fellow subject expert – at: qualifications.pearson.com/subjectadvisors
- BTEC Hotline: call the BTEC Hotline on 0844 576 0026 with your query

Units

Unit 1: Principles of Science

Level: **1 and 2**

Unit type: **Mandatory**

Guided learning hours: **30**

Assessment type: **External**

Unit introduction

It is important that science technicians and scientists are able to use and apply 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 the function of plant organs, 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 the National 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. The assessment for this unit focuses on your understanding and application of these concepts, and so will not be vocational in context. A strong grasp of these concepts will enable you to use and apply this knowledge and understanding in vocational contexts when studying other units within this specification.

Learning aims

In this unit you will:

A explore cells, organs and genes

B explore the roles of the nervous and endocrine systems in homeostasis and communication

C explore atomic structure and the periodic table

D explore substances and chemical reactions

E explore the importance of energy stores, energy transfers and energy transformations

F explore the properties and applications of waves in the electromagnetic spectrum.

You will be asked to apply knowledge and understanding of these learning aims in familiar and unfamiliar contexts to solve mathematical and non-mathematical problems.

Learning aims and unit content

What needs to be learnt	
Learning aim A: Explore cells, organs and genes	
A.1	The basic structure, function and adaptations of the following eukaryotic cells: a. motor and sensory neurones b. red blood cell c. white blood cell d. egg cell e. sperm cell f. root hair cell g. xylem and phloem cells h. guard cell.
A.2	The function of the following components of eukaryotic cells: a. nucleus – contains genetic information that controls the activities of the cell b. cytoplasm – where most chemical reactions take place c. cell membrane – allows entry and exit of substances d. chloroplasts – the sites of photosynthesis e. cell wall – provides structural support f. vacuole – contains cell sap and provides extra support for the cell g. mitochondria – the sites of respiration.
A.3	Cells form tissues, tissues form organs and organs work together to form organ systems, as illustrated by the cardiovascular system (it is not necessary to learn the detail of each organ in this system).
A.4	The functions of the following plant organs: a. roots – take in water from the soil and provide anchorage b. xylem – carries water and mineral salts c. phloem – carries glucose d. leaf – where photosynthesis takes place.
A.5	Loss of water vapour from the leaves drives transpiration.
A.6	DNA is a double helix containing a sequence of complementary base pairs: a. adenine pairs with thymine b. guanine pairs with cytosine.
A.7	Chromosomes, in the nucleus, are made up of DNA, and sections of DNA represent genes which give instructions for individual characteristics.
A.8	Alleles are different forms of the same gene that give rise to heterozygous and homozygous genotypes.
A.9	Monohybrid inheritance using Punnett squares and genetic diagrams.
A.10	Pedigree analysis using homozygous and heterozygous individuals.
A.11	Determination of genotypes and phenotypes of offspring from genetic diagrams and pedigree analysis.

continued

What needs to be learnt	
A.12	The probability, percentage or ratio of offspring displaying particular inherited characteristics from genetic crosses.
A.13	Gene mutations occur when the base sequence on a DNA molecule is changed: a. genetic mutations can change the characteristics of organisms b. genetic mutations can be beneficial or harmful to organisms.
Learning aim B: Explore the roles of the nervous and endocrine systems in homeostasis and communication	
B.1	Homeostasis is the maintenance of a constant internal environment that is controlled by nervous and hormonal communication.
B.2	The structure of the nervous system is made up of the central nervous system (CNS) (brain and spinal cord) and the peripheral nervous system (PNS) (sensory and motor neurones). The PNS transmits electrical impulses to and from the CNS.
B.3	The difference between involuntary and voluntary responses.
B.4	The transmission of electrical impulses from receptor to effector and the role of chemical transmission across synapses.
B.5	The components of a simple reflex arc and its role in protecting the body from harm.
B.6	The endocrine system consists of glands that release hormones into the blood stream, which travel through the blood to target organs.
B.7	The differences in communication between the endocrine and nervous systems: a. speed of communication b. method of transport or transmission c. duration of response.
B.8	Blood glucose concentration is regulated by the endocrine system using insulin and glucagon (insulin lowers blood glucose concentrations and glucagon raises it).
B.9	The process for body temperature regulation by the nervous system using the following mechanisms: a. sweating b. shivering c. raising/lowering of body hair d. vasoconstriction and vasodilation.

What needs to be learnt	
Learning aim C: Explore atomic structure and the periodic table	
C.1	Elements as metals or non-metals according to their position in the periodic table.
C.2	The structure of the atom as a nucleus containing protons and neutrons, surrounded by electrons in shells (energy levels).
C.3	The nucleus of an atom is very small compared to the overall size of the atom.
C.4	Atoms of a given element have the same number of protons in the nucleus and this number is unique to that element.
C.5	The meaning of the terms ‘atomic number’, ‘mass number’ and ‘relative atomic mass’.
C.6	The relative charge and relative mass of a proton, a neutron and an electron.
C.7	Atoms contain equal numbers of protons and electrons.
C.8	Elements are arranged in the periodic table in order of increasing atomic number, in rows called periods. Elements with similar properties are placed in the same vertical column – these columns are called groups.
C.9	Definition of an isotope of an element, as having the same number of protons but a different number of neutrons.
C.10	The existence of isotopes means that some relative atomic masses are not whole numbers.
C.11	The relative atomic mass of an element from the relative masses and abundances of its isotopes.
C.12	Rules about the filling of electron shells (energy levels) to predict the electronic configuration of the first 20 elements in the periodic table as diagrams and in the form 2.8.1.
C.13	The connection between the number of outer electrons and the position of an element in the periodic table.

What needs to be learnt	
Learning aim D: Explore substances and chemical reactions	
D.1	Use the periodic table to recognise elements and formulae of simple compounds.
D.2	Definitions of elements, compounds, mixtures, molecules (molecular elements).
D.3	Word equations for reactions in this unit.
D.4	Simple balanced chemical equations for reactions in this unit.
D.5	Chemicals react to form products with different properties, including acids, alkalis and salts.
D.6	Definition of: a. acids b. bases c. alkalis as a subset of bases which are soluble in water.
D.7	Neutralisation reactions using hydrochloric acid, nitric acid and sulfuric acid, with a metal oxide (copper oxide or zinc oxide) and sodium hydroxide.
D.8	The reactions of hydrochloric acid and sulfuric acid with metals (not group 1 metals).
D.9	The reactions of hydrochloric acid, sulfuric acid and nitric acid with sodium carbonate, copper carbonate and calcium carbonate.
D.10	The chemical tests for hydrogen and carbon dioxide.
D.11	pH tests using universal indicator and litmus.
D.12	Hazard symbols for the chemicals used in this learning aim.
D.13	Applications of neutralisation reactions: a. indigestion remedies (safe dose, chemicals used) b. reducing acidity of soils c. reducing acidity of lakes, caused by acid rain.
D.14	Formulae of all reagents named in this learning aim.

What needs to be learnt
Learning aim E: Explore the importance of energy stores, energy transfers and energy transformations
E.1 Forms of energy and their uses: a. thermal b. electrical c. light d. sound e. mechanical (kinetic and potential) f. nuclear. E.2 Energy stores and their uses: a. chemical b. kinetic (in a moving object) c. gravitational potential (due to the position of an object in a gravitational field) d. elastic potential (in a stretched or compressed spring) e. thermal (in a warm object) f. nuclear. E.3 Energy transfers (from one place to another): a. mechanically (when a force moves through a distance) b. electrically (electrical devices) c. by conduction (temperature differences) d. by convection (currents in a fluid) e. by radiation (infrared and sound). E.4 Energy transfer measurement: a. joule (J) as the unit of energy b. principle of conservation of energy c. diagrams to represent energy transfers and energy dissipation d. watt (W) as the unit of power e. power calculations using: $\text{power (watts)} = \frac{\text{energy (joules)}}{\text{time (secs)}}$ f. cost of electricity per unit (kWhr). E.5 Efficiency of energy transfers and transformations: a. efficiency as the proportion of energy transferred to useful forms b. calculations involving efficiency using: $\text{efficiency} = \frac{\text{useful energy}}{\text{total energy supplied}} \text{ X } 100\%$ E.6 Sources and storage of energy: a. renewable (solar, wind, biofuels, hydroelectric, wave, tidal, geothermal) b. non-renewable (fossil fuels, nuclear) c. using energy stores effectively d. storage of energy using batteries and fuel cells.

What needs to be learnt
Learning aim F: Explore the properties and applications of waves in the electromagnetic spectrum
F.1 Wave characteristics: a. amplitude (m) b. frequency (Hz) c. wavelength (m) d. wave speed (m/s). F.2 Wave calculations: a. using wave speed (m/s) = wavelength (m) x frequency (Hz) b. using values expressed in standard form. F.3 The electromagnetic (e.m.) spectrum: a. radio waves, microwaves, infrared, visible (including the colours of the visible spectrum), ultraviolet, X-rays and gamma rays b. the e.m. spectrum is continuous from radio waves to gamma rays, grouped in order of wavelength or frequency c. each group has a range of wavelengths with different uses and dangers. F.4 Uses of electromagnetic radiation in transferring energy: a. radio waves (broadcasting and satellite transmissions) b. microwaves (cooking, satellite transmissions, communications and weather forecasting) c. infrared (cooking, thermal imaging, optical fibres, television remote controls and security systems) d. visible light (vision, photography and illumination) e. ultraviolet (fluorescent lamps, detecting forged bank notes and disinfecting water) f. X-rays (observing the internal structure of objects and medical X-rays) g. gamma rays (sterilising food and medical equipment, and the detection of cancer and its treatment). F.5 Harmful effects of excessive exposure to electromagnetic radiation: a. microwaves (internal heating of body cells) b. infrared (skin burns) c. ultraviolet (damage to surface cells and eyes, leading to skin cancer and eye conditions) d. X-rays and gamma rays (mutation or damage to cells in the body).

Teacher guidance

Resources

There are no special resources needed for this unit.

Assessment guidance

This unit is assessed externally using a paper-based exam marked by Pearson.

Examination format

The learner will complete a 60-minute examination with 54 marks. The paper will consist of three sections. Section A will be biology, Section B will be chemistry and Section C will be physics. Each section will be worth 18 marks.

The learner will need to demonstrate knowledge and understanding, and the application of this knowledge.

Unit 2: Chemistry and Our Earth

Level: **1 and 2**

Unit type: **Mandatory**

Guided learning hours: **30**

Assessment type: **Internal**

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.

You 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 you study the structure of elements, and how they bond together to form molecules, which are covalently or ionically bonded. You 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. You will study the factors that affect the rates of chemical reactions and the reaction conditions that optimise their effectiveness in industry.

You 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 you have learnt in Unit 1 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.

Learning aims and unit content

What needs to be learnt
Learning aim A: Investigate chemical reactivity and bonding
A.1 Chemical and physical properties of groups 1 and 7 of the periodic table: a. trends in physical properties of groups 1 and 7 (appearance, melting point, boiling point, electrical conductivity) b. reactivity with water for group 1 c. displacement reactions for group 7 d. trends in chemical properties in group 1 and group 7 – relationship with electronic configuration. A.2 Bonding and structure: a. formulae of molecules (in A.2b and A.2c) b. covalent bonding (hydrogen, chlorine, carbon dioxide, methane, water, oxygen) c. ionic bonding (sodium chloride, magnesium oxide, magnesium chloride) d. 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
B.1 Use of chemicals based on their physical properties: a. electrical conductivity b. thermal conductivity c. melting and boiling points d. solubility in different solvents e. viscosity. B.2 Use of chemicals based on their chemical properties: a. sodium azide in airbags b. argon in welding c. silicon in computer–chip technology d. carbon dioxide in fire extinguishers.

What needs to be learnt
Learning aim C: Investigate the factors involved in the rate of chemical reactions
C.1 Equations: a. word equations b. simple balanced chemical equations (including state symbols: (s), (l), (g), (aq)) c. recognise reactants and products in a reaction (displacement, combustion, neutralisation reactions) d. reversible and irreversible chemical change. C.2 Reaction rates: a. effect of catalysts (lowering the energy needed for a reaction to occur), surface area, concentration and temperature on rate of reaction b. use of reaction rate graphs c. collision theory. C.3 Industrial processes: a. the concept of yield (mass of product obtained) and that the actual yield is less than the theoretical yield b. altering rates of reaction c. atom economy.
Learning aim D: Understand the factors that are affecting the Earth and its environment
D.1 Natural activity factors (tectonic plates and volcanic eruptions) influencing: a. the Earth's crust b. the evolution of the atmosphere and oceans. D.2 Human activity factors: a. obtaining materials from the sea, land and air, e.g. coal, natural gas, oil, metal ores, salt, nitrogen, oxygen b. production of useful materials from their natural sources c. effects on the environment (local and global effects) d. effects of chemical processing (energy factors, health and safety, disposal). D.3 Sustainable development issues: a. human choices (recycling, use of fossil fuels versus nuclear fission fuels) b. human solutions (renewable energy, biofuels (ethanol), nuclear fusion).

Assessment criteria

<table>
<tr><th>Level 1</th><th>Level 2 Pass</th><th>Level 2 Merit</th><th>Level 2 Distinction</th></tr>
<tr><td colspan="4">Learning aim A: Investigate chemical reactivity and bonding</td></tr>
<tr><td>1A.1 Classify group 1 and 7 elements based on their physical properties.</td><td>2A.P1 Describe the physical and chemical properties of group 1 and 7 elements.</td><td>2A.M1 Describe trends in the physical and chemical properties of group 1 and 7 elements.</td><td>2A.D1 Explain the trends in chemical properties of group 1 and 7 elements in terms of electronic structure.</td></tr>
<tr><td>1A.2 Describe properties of ionic and covalent substances.</td><td>2A.P2 Compare properties of ionic and covalent substances.</td><td>2A.M2 Explain the properties of ionic and covalent substances.</td><td rowspan="2">2A.D2 Relate applications of compounds to their properties and to their bonding and structure.</td></tr>
<tr><td>1A.3 Classify substances as ionic or covalent.</td><td>2A.P3 Draw dot-and-cross diagrams of simple ionic and covalent substances.</td><td>2A.M3 Describe the formation of ionic and covalent substances.</td></tr>
<tr><td colspan="4">Learning aim B: Investigate how uses of chemical substances depend on their chemical and physical properties</td></tr>
<tr><td>1B.4 Describe physical properties of chemical substances.</td><td>2B.P4 Describe how chemical substances are used based on their physical properties.</td><td rowspan="2">2B.M4 Explain how physical and chemical properties of chemical substances make them suitable for their uses.</td><td rowspan="2">2B.D3 Assess the suitability of different types of substance for a specified use.</td></tr>
<tr><td>1B.5 Describe chemical properties of chemical substances.</td><td>2B.P5 Describe how chemical substances are used based on their chemical properties.</td></tr>
</table>

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim C: Investigate the factors involved in the rate of chemical reactions			
1C.6 Identify the factors that can affect the rates of chemical reactions.	2C.P6 Describe the factors that can affect the rates of chemical reactions.	2C.M5 Explain how different factors affect the rate of industrial reactions.	2C.D4 Analyse how different factors affect the rate and yield of an industrial reaction.
1C.7 Identify reactants and products, including state symbols in chemical equations, and whether reactions are reversible or irreversible.	2C.P7 Identify the number and types of atoms in balanced chemical equations.*	2C.M6 Explain the terms ‘yield’ and ‘atom economy’ in relation to specific chemical reactions.	
Learning aim D: Understand the factors that are affecting the Earth and its environment			
1D.8 Identify the human activities that affect the Earth and its environment.	2D.P8 Describe the human activities that affect the Earth and its environment.	2D.M7 Discuss the extent to which human activity has changed the environment, in comparison to natural activity.	2D.D5 Evaluate possible solutions to changes in the environment, occurring from natural or human activity.
1D.9 Identify natural factors that have changed the surface and atmosphere of the Earth.	2D.P9 Describe natural factors that have changed the surface and atmosphere of the Earth.		

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

There are no special resources needed for this unit.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson.

Please read this guidance in conjunction with *Section 8 Internal assessment*.

The contents of this unit should be approached from a practical point of view as far as possible, e.g. through scientific investigative assignments. Industrial and related contexts for assessment should be locally relevant where possible and could include:

- for learning aims A and B, choices of materials for industrial applications based on their chemical and physical properties
- for learning aim C, approaches that can be used to improve the effectiveness of industrial reactions
- for learning aim D, investigating the mitigation of the local or global environmental impact of a process.

Level 1 exemplifies partial achievement within a level 2 learning aim.

Learning aim A: **Investigate chemical reactivity and bonding**

For 1A.1, learners must classify and categorise at least two elements from group 1 and at least two elements from group 7 based on their physical properties (e.g. boiling point, melting point, electrical conductivity, thermal conductivity, solubility with water and non-polar solvents).

For 2A.P1, learners must build on their evidence for 1A.1 by describing the physical and chemical properties of the group 1 and 7 elements.

For 2A.M1, 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.

For 2A.D1, learners should explain the trend in chemical properties that they have described for 2A.M1 using their understanding of electronic structure.

For 1A.2, learners must describe four typical properties of ionic substances and four typical properties of covalent substances.

For 2A.P2, learners should build on their evidence for 1A.2 by comparing the properties identified.

For 2A.M2, learners must explain the properties identified in 1A.2 and 2A.P2 in terms of the bonding and structure of ionic and covalent substances.

For 1A.3, from data provided or through practical investigation, learners must classify at least six different substances as being either covalent or ionic in nature.

For 2A.P3, learners must draw dot-and-cross diagrams for all substances listed in the unit content for learning aim A, topics A.2b and A.2c as a minimum.

For 2A.M3, learners could use their diagrams for 2A.P3 to describe how ions, molecules and chemical bonds are formed.

For 2A.D2, learners must give three examples of substances (one giant ionic, one giant covalent tand 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.

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

For 1B.4, learners could discuss the different types of physical properties of some common chemical substances. They must give brief descriptions of these properties.

For 1B.5, this could be covered by giving learners access to secondary data or research, or they could carry out practical work looking at a variety of chemical changes involving common chemical substances. They must classify at least two changes that are chemical (e.g. interaction with water).

For 2B.P4, learners must link the use of chemical substances to their physical properties and must describe at least two examples.

For 2B.P5, learners must list some common useful chemical products. They may produce a leaflet or poster to do this. 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.

For 2B.M4, 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 2B.D3, 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.

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

For 1C.6, learners could discuss the factors that can affect the rate of a reaction, to establish what the possible factors could be. They may do this after carrying out some practical investigations. This could be reported in the form of a table.

For 2C.P6, learners must describe the effect on rate of these factors. Learners 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.

For 2C.M5, learners should explain how changing the rates of reactions affects certain industrial processes.

For 1C.7, learners can be given at least three balanced chemical equations. They must identify the reactants and the products in each of these equations, to include their symbols, state and if the reaction is reversible.

For 2C.P7, they must identify the number and types of atoms in these equations.

For 2C.M6, they must explain the terms 'atom economy' and 'yield' in relation to at least one of these three equations.

For 2C.D4, 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.

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

For 1D.8, learners must identify at least two human activities that have environmental consequences, as outlined in the content.

For 2D.P8, they must describe the effects of the activities identified in 1D.8.

For 2D.M7, 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 identified in 1D.8. 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 identified in 1D.9, which have happened over millions of years.

For 1D.9, learners must identify at least two natural factors, for example, volcanic eruption or movement of tectonic plates.

For 2D.P9, learners must describe the two factors identified for 1D.9.

To achieve 2D.D5, 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 identified in 1D.8 and/or the factors identified in 1D.9.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 2A.P1, 2A.M1, 2A.D1 1A.2, 1A.3, 2A.P2, 2A.P3, 2A.M2, 2A.M3, 2A.D2	Manufacture and quality control of Compounds	You are a chemist working for a large chemical company that has just employed a number of new science technicians. You have been asked to prepare support materials for the new employees explaining the trends in the group 1 and group 7 elements. The support materials are to be given out to the new employees as an introduction to what elements the company uses in its manufacture of products. It is important for quality control laboratory technicians to understand how chemical substances are bonded together, in order for them to carry out laboratory tests on products as they are produced. As part of the induction day for new laboratory technician recruits to your chemical company, you will need to present material showing how compounds and molecules are formed through ionic or covalent bonding, and how their properties are related to the bonding and structure. A visit to a chemical company who manufacture products or a visiting speaker would help put this topic into context.	Prepare a written practical report showing the characteristic features of group 1 and group 7 elements. The report should describe the trends within these groups and explain these trends in terms of electronic structure. Prepare a practical/written report with scientific diagrams and tables on ionic and covalent substances. Include a table comparing at least four properties of each. Include dot-and-cross diagrams of the substances listed to explain how the bonds are formed. Properties must be explained in terms of the bonding and structure, and three examples of substances should be given to explain how the application of these substances relies on their specific properties.

Criteria covered	Assignment	Scenario	Assessment evidence
1B.4, 1B.5, 2B.P4, 2B.P5, 2B.M4, 2B.D3	Useful Chemical Products	You work as the senior laboratory technician at a chemical company as part of the quality control team. Your company wants to recruit a number of junior quality control technicians. As part of the induction day your team have been asked to produce information on useful chemical products that the company produces.	Produce an information document on the properties of four useful chemical products and how these properties relate to the application of these products.
1C.6, 1C.7, 2C.P6, 2C.P7, 2C.M5, 2C.M6, 2C.D4	Controlling Industrial Reactions	As one of the production chemists working at the local chemical plant, you have been asked to explain to the chemical plant operatives the factors that affect rate, yield and atom economy of reactions. A visit to a chemical company who manufacture products or a visit from a research chemist or plant chemist would help put this topic into context.	You must provide 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. Produce your findings in a practical scientific report.
1D.8, 1D.9, 2D.P8, 2D.P9, 2D.M7, 2D.D5	Affecting the Environment	The editor of the local paper has asked you, as the chemist responsible for the environmental impact of the company's processes, to respond to an alarmist article written by an environmental group. A visit to an environmental centre or a visit from an environmental scientist would help put this topic into context.	Write a scientific article to present a balanced view of the likely environmental impact of your company and how this may be minimised. The article should also explain the environmental impact of natural events.

Unit 3: Energy and Our Universe

Level: **1 and 2**

Unit type: **Mandatory**

Guided learning hours: **30**

Assessment type: **Internal**

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, you will explore ionising radiations, their uses and sources, including alpha, beta, gamma and X-rays. You 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. You will be introduced to the basics of electrical circuits, power supplies and the transmission of electrical energy. You will also investigate how this important form of energy is brought to homes.

Our Universe is a fascinating place, which is evolving over time. You 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 you 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, you 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 the National Grid 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.

Learning aims and unit content

What needs to be learnt	
Learning aim A: Understand ionising radiation, its uses and sources	
A.1	The structure of nuclei using the terms 'atomic (proton) number' and 'mass (nucleon) number', and using symbols in the format: $^{7}_{3}\mathrm{Li}$
A.2	Alpha, beta and gamma radiations are emitted from unstable nuclei in a random process.
A.3	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.
A.4	Ionising radiations cause atoms to gain or lose electrons to form ions.
A.5	Alpha, beta and gamma radiations are compared in terms of their abilities to penetrate and ionise.
A.6	Effects of different radiations on living cells.
A.7	Uses of ionising radiations, including alpha, beta, gamma and X-rays.
A.8	Investigate radioactive decay in terms of reducing activity and amount of radioactive material.
A.9	Investigate half-life of radioactive isotopes in terms of reducing activity.
A.10	Calculations involving half-life and their graphical representations.
A.11	Nuclear fission is large nuclei breaking down to form small nuclei.
A.12	Nuclear fusion is the creation of larger nuclei from smaller nuclei.
A.13	Energy release by the process of controlled nuclear fission.
A.14	Energy release by nuclear fusion in stars and the difficulty in harnessing energy from nuclear fusion on Earth.
A.15	Environmental issues associated with nuclear energy (storage of waste products, uncontrolled release of radioactive material).

What needs to be learnt
Learning aim B: Know how electrical energy produced from different sources can be transferred through the National Grid to homes and industry
B.1 Electric circuits: a. the need for a complete circuit b. electrical symbols (battery, cell, switch, fuse, voltmeter, ammeter, resistor, filament lamp) c. current (A, mA) d. voltage (V, mV) e. resistance (Ω, kΩ) f. construct simple series and parallel circuits g. measure current and voltage using meters h. use the equation: voltage (volts) = current (amps) × resistance (ohms) $V = IR$ i. direct current (d.c.) and alternating current (a.c.). B.2 Power supplies: a. types of batteries b. solar cell c. simple generators – rotating a coil in a permanent magnetic field d. production of electricity – basic alternating current generator, batteries as a source of direct current (rechargeable and non-rechargeable) e. environmental impact – comparison of environmental impact of electricity generation from renewable and non-renewable sources f. electrical power and the equation: power (watts) = voltage (volts) × current (amps) $P = VI$ g. efficiency of electricity generation from different sources h. National Grid – used to transmit electrical energy (power) i. step-up and step-down transformers and the reduction of energy losses during transmission.

What needs to be learnt
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.1 The Universe: a. the structure and dynamic nature of the Universe (Solar System, stars and galaxies, large-scale structure) b. looking back in time. C.2 The Solar System: a. composition – stars, planets, dwarf planets and natural satellites, comets and meteors, asteroids b. formation of the Solar System c. space tourism and the future of space flight. C.3 Observing the Universe: a. optical, radio, infrared, UV, X-ray and gamma telescopes b. reflecting, ground-based and space-based telescopes c. space probes and robots. C.4 The changing Universe: a. the Big Bang theory b. evidence for an expanding Universe (galaxies moving away from each other (red shift)) c. cosmic microwave background radiation as support for the Big Bang theory.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Understand ionising radiation, its uses and sources			
1A.1 Describe the structure of atomic nuclei.	2A.P1 Describe half-life in terms of radioactive decay.	2A.M1 Use graphs to explain radioactive decay and half-life.*	2A.D1 Calculate the half-life of radioactive isotopes.*
1A.2 Identify the types of ionising radiation.	2A.P2 Describe the different types of ionising radiation.	2A.M2 Compare the benefits and drawbacks of using radioactive isotopes in the home or workplace.	2A.D2 Justify the selection of a radioactive isotope for a given use within the home or workplace.
1A.3 Identify the problems associated with the use of radioactive isotopes.	2A.P3 Describe the problems associated with the use of radioactive isotopes.		
1A.4 Describe nuclear fission and fusion.	2A.P4 Describe how controllable nuclear fission and fusion reactions are.	2A.M3 Describe the environmental impact of radioactive material from nuclear fission reactors released into the environment.	2A.D3 Evaluate the environmental impacts of a nuclear fission reactor accident, in terms of half-life.*

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim B: Know how electrical energy produced from different sources can be transferred through the National Grid to homes and industry			
1B.5 Identify methods of producing electricity from different sources.	2B.P5 Describe methods of producing a.c. and d.c. electricity.	2B.M4 Compare the efficiency and environmental impact of electricity generated by different sources.*	2B.D4 Assess, in quantitative terms, ways to minimise energy losses either when transmitting electricity or when transforming electricity into other forms for consumer applications.*
1B.6 Demonstrate building simple series and parallel circuits.	2B.P6 Use *V* = *IR* to predict values in electric circuit investigations.*	2B.M5 Assess, in qualitative terms, ways to minimise energy losses when transmitting electricity.	
1B.7 Describe electrical power in terms of voltage and current.	2B.P7 Describe how electricity is transmitted to the home or industry.		
Learning aim C: Know the components of the Solar System, the way the Universe is changing and the methods we use to explore space			
1C.8 Identify the components of our Solar System.	2C.P8 Describe the structure of the Universe and our Solar System.	2C.M6 Describe how the Universe and the Solar System were formed.	2C.D5 Evaluate the evidence leading to the Big Bang theory of how the Universe was formed.
1C.9 Identify methods of observing the Universe.	2C.P9 Describe the suitability of different methods for observing the Universe.	2C.M7 Explain how evidence shows that the Universe is changing.	
1C.10 Describe the dynamic nature of our Solar System and Universe.	2C.P10 Identify evidence that shows the dynamic nature of the Universe.		

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

There are no special resources needed for this unit.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson. Please read this guidance in conjunction with *Section 8 Internal assessment*.

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.

Level 1 exemplifies partial achievement within a level 2 learning aim.

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

For 1A.1, learners must show the structure of the atomic nuclei, most probably pictorially, using numbers and symbols.

For 2A.P1, only a description of half-life is required in terms of radioactive decay; there is no requirement for a qualitative or quantitative explanation.

For 2A.M1, learners are given the opportunity to describe, in words and mathematically, radioactive decay and half-life. Following on from this, in 2A.D1 the learner is 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 the 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.

For 1A.2, the learner is required to identify types of ionising radiation; this could be done in the form of a list or table.

For 2A.P2, the learner will need to show an understanding of atomic structure and the different types of ionising radiation, related to the structure described in 1A.1.

For 1A.3, the learners could give uses of radioactive isotopes in a table with a column identifying at least two problems with these uses.

For 2A.P3, the learners would need to describe at least two problems with the use of radioactive isotopes.

For 2A.M2, 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).

For 2A.D2, learners will need to justify the selection of one radioactive isotope.

For 1A.4, learners can use simple atomic nuclei structure diagrams to describe nuclear fission and fusion.

2A.P4 requires a description of how controllable nuclear fission and fusion reactions are, and it would be expected that learners would refer to examples from nuclear reactors and the Solar System to aid their description. They are not being asked to compare these two reactions.

For 2A.M3, 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 2A.D3, learners need to evaluate the impact of an accident in terms of using half-life diagrams.

Learning aim B: **Know how electrical energy produced from different sources can be transferred through the National Grid to homes and industry**

For 1B.5, learners need to identify four different methods of producing electricity. This could be done after having been given a case study of methods of producing electricity.

For 2B.P5, learners will need to describe the four different methods identified for 1B.5.

For 1B.6 and 1B.7, learners can be observed carrying out the tasks to gain these assessment criteria. Note that it is stipulated they must be done correctly. Observation sheets and/or witness statements are required as evidence.

It is assumed that practical work has been done on circuit building etc. in order to underpin the learners' ability in 2B.P6 to use the equation $V = IR$. Teachers may feel that the assessment of 2B.P6 and 2B.P7, where an understanding of a.c. and d.c. currents and the transmitting of electricity is required, can be linked together.

2B.M4 requires learners to carry out a comparison in relation to efficiency. More able learners could include calculations to aid their arguments, rather than just giving a description. 2B.M5 asks for qualitative assessments on minimising energy losses. In doing this, learners may well include quantitative arguments, which the assessor needs to look at for assessment as part of 2B.D4.

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

For 1C.8, learners need to identify the components of our Solar System; this could be done in the form of a diagram or model, including planets, stars, natural satellites, etc.

For 2C.P8, 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.

To achieve 2C.M6, learners need to give a simple description of the Big Bang theory and formation of the Solar System.

For 1C.9, learners must identify three different methods of observing the Universe.

For 2C.P9, learners need to describe the suitability of the three different methods provided for 1C.9.

For 1C.10, learners should provide a simple description of the dynamic nature of the Solar System and Universe, such as stars evolving and the Universe expanding.

For 2C.P10, evidence needs to be identified by looking at the red shift of galaxies.

2C.M7 can be achieved by using evidence of an expanding Universe and cosmic microwave background radiation.

For 2C.D5, this may be covered by the learners in one answer. The answer in 2C.D5 must be an evaluation as the expectation is that the ideas and evidence which led to the Big Bang theory are explored, not just described.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1A.2, 1A.3, 1A.4, 2A.P1, 2A.P2, 2A.P3, 2A.P4, 2A.M1, 2A.M2, 2A.M3, 2A.D1, 2A.D2, 2A.D3	Do They Always Glow in the Dark?	Working as a physicist for a government science department, you are required to produce a report to explain the topic of radiation to schools and colleges in reaction to bad publicity associated with using radioactive materials.	A report with graphs, example calculations, benefits, advantages and drawbacks to be distributed to schools and colleges.
1B.5, 2B.P5, 2B.M4 2B.P5, 2B.P7, 2B.M5, 2B.D4 1B.6, 1B.7, 2B.P6	Making Electricity – Really!	You are a trainee electrical physicist working for the National Grid. Produce a presentation with scientific diagrams and tables describing how electricity can be produced. You have been asked to promote the company by producing a scientific report explaining how electrical energy is generated and transferred to a factory or a customer’s home. (A visit to an energy company or a visiting speaker from an energy company would help put this topic into context.) You must show your supervisor that you have a practical understanding of circuits and can carry out calculations.	A presentation with scientific diagrams and tables. A scientific report with diagrams, calculations and tables. Report including calculations/observation of practical work/presentation from experiment results.

Criteria covered	Assignment	Scenario	Assessment evidence
1C.8, 1C.9, 1C.10, 2C.P8, 2C.P9, 2C.P10, 2C.M6, 2C.M7, 2C.D5	Where Is All that Space?	Working for the Royal Observatory at Greenwich, you have been asked to produce models and diagrams to give a talk to the public to describe the Universe. A visit to an observatory or a visiting astronomer would help put this topic into context.	A presentation, including models and diagrams.

Unit 4: Biology and Our Environment

Level: **1 and 2**

Unit type: **Mandatory**

Guided learning hours: **30**

Assessment type: **Internal**

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.

You will study the different activities that humans carry out that cause damage to the environment. You 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 you 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 your study of this unit, you will investigate the causes of disease, including genetic disease, and how various diseases can be prevented and treated. You 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.

You will study and compare the adaptations of different organisms and how these adaptations determine the success of organisms in their environment. You 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 your understanding of the core concepts you have learnt in Unit 1 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 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.

Learning aims and unit content

What needs to be learnt	
Learning aim A: Investigate the relationships that different organisms have with each other and with their environment	
A.1	The characteristics of organisms vary within and across species: a. genetic variation – variation in characteristics can be caused by genes, including genetic mutation b. environmental variation – some characteristics can be influenced by the environment.
A.2	Evolution is a gradual process, involving gene mutation and natural selection, that can lead to the development of new species: a. populations or organisms show variation b. organisms less well adapted to their environment are less likely to survive due to competition for resources, predation and environmental influences c. organisms best adapted to their environment will survive to breed and pass on their genes to the next generation d. over a period of time the proportion of individuals with the favourable adaptation will increase and the individuals without the adaptation may disappear altogether.
A.3	Interdependence of organisms can be illustrated using food chains and webs, and by predator–prey relationships.
A.4	Organisms are classified depending on their characteristics: a. the main characteristics of the five kingdoms b. division of the animal kingdom into vertebrates and invertebrates c. the main characteristics of vertebrates.
A.5	Construct and use keys to show how organisms can be identified.

What needs to be learnt	
Learning aim B: Demonstrate an understanding of the effects of human activity on the environment and how these effects can be measured	
B.1	How human activities alter ecosystems through: a. deforestation to supply timber and clear land for agriculture b. agriculture to meet an increasing demand for food c. transportation – of food and for travel.
B.2	How pollutants produced as a result of human activity can affect ecosystems: a. overuse of fertiliser causing eutrophication b. toxic herbicides and pesticides that can bioaccumulate and disrupt terrestrial and aquatic food chains.
B.3	Living and non-living indicators can be used as a measure of the level of pollution in an ecosystem: a. lichens are sensitive to sulfur dioxide b. algae and freshwater shrimps as indicators of water pollution c. dissolved oxygen and nitrate concentration in water as non-living indicators of water pollution d. limestone buildings can be eroded by acid rain.
B.4	There are measures that can be taken to counteract or reduce the impact of pollutants on ecosystems: a. recycling and reusing materials saves natural resources and reduces the amount of waste produced b. conservation techniques of reforestation, replacement planting and breeding programmes c. use of renewable resources d. using organic fertilisers and biological pest control as an alternative to chemical fertilisers and pesticides.

What needs to be learnt	
Learning aim C: Explore the factors that affect human health	
C.1	Infectious disease can be caused by microorganisms (bacteria and viruses) that affect living cells: a. bacteria produce toxins that harm living cells b. viruses invade living cells causing cell death.
C.2	The methods used to prevent and treat disease: a. vaccinations can be used to prevent disease b. antibiotics can be used to treat disease caused by bacteria.
C.3	Bacteria can become resistant to antibiotics.
C.4	Non-infectious disease can be caused by lifestyle or the environment: a. misuse of recreational drugs can lead to mental illness b. inadequate diet can lead to deficiency diseases c. cigarette smoke can cause diseases of the circulatory system d. ultraviolet light can cause skin cancer e. excessive consumption of alcohol can lead to liver disease f. poor air quality can lead to asthma.
C.5	Influence of genes on human health: a. genetic disorders can affect human health b. pedigree analysis can be used to show the inheritance of genetic disease.
C.6	Physical activity helps to keep the body healthy.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Investigate the relationships that different organisms have with each other and with their environment			
1A.1 Distinguish between variation due to genes and variation due to environmental factors.	2A.P1 Describe the role of genes and the environment in variation.	2A.M1 Explain the role of genes and the environment in evolution.	2A.D1 Evaluate the impact of genes and the environment on the survival or extinction of organisms.
1A.2 Construct simple keys to classify organisms.	2A.P2 Describe how characteristics are used to classify organisms.	2A.M2 Discuss the factors that affect the relationship between different organisms.	
1A.3 Construct food chains and food webs.	2A.P3 Describe the different ways in which organisms show interdependence.		

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim B: Demonstrate an understanding of the effects of human activity on the environment and how these effects can be measured			
1B.4 Identify human activities that affect an ecosystem.	2B.P4 Describe the impact that different human activities have on ecosystems.	2B.M3 Analyse the effects of pollutants on ecosystems.	2B.D2 Explain the long-term effects of pollutants on living organisms and ecosystems.
1B.5 Identify living and non-living indicators and the type of pollution they measure.	2B.P5 Describe how living and non-living indicators can be used to measure levels of pollutants.	2B.M4 Discuss the advantages and disadvantages of methods used to reduce the impact of human activity on ecosystems.	2B.D3 Evaluate the success of methods to reduce the impact of human activity on an ecosystem, for a given scenario.
1B.6 Describe how recycling and reusing materials can reduce the impact that human activities have on an ecosystem.	2B.P6 Describe the different methods used to help reduce the impact of human activities on ecosystems.		

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim C: Explore the factors that affect human health			
1C.7 List the different biological, social and inherited factors that affect human health.	2C.P7 Describe how pathogens affect human health.	2C.M5 Explain how bacteria can become resistant to antibiotics.	2C.D4 Evaluate the use of antibiotics, pedigree analysis and vaccination programmes in the treatment and prevention of childhood illnesses.*
1C.8 Identify measures that can be taken to prevent and treat infectious disease.	2C.P8 Describe two different treatment regimes: one used to prevent a disease and one used to treat a disease.	2C.M6 Explain the use of pedigree analysis.	
1C.9 List some benefits of exercise on health.	2C.P9 Describe how lifestyle choices can affect human health.	2C.M7 Discuss the advantages and disadvantages of vaccination programmes.	

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

There are no special resources needed for this unit.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson. Please read this guidance in conjunction with *Section 8 Internal assessment*.

The contents of this unit should be approached from a practical point of view as far as possible, e.g. through scientific investigative assignments. Industrial and related contexts for assessment should be locally relevant where possible and could include:

- for learning aims A and B, approaches to monitoring the impact of industry on local species
- for learning aim C, approaches to ensuring best use of antibiotics and vaccinations by local health organisations.

Level 1 exemplifies partial achievement within a level 2 learning aim.

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

For 1A.1, learners will be expected to identify the different ways in which organisms vary and how this variation is brought about. They will be able to distinguish between simple genetic characteristics and characteristics that are a result of the environment. At this level, learners will not be expected to describe characteristics that are influenced by both genes and the environment. The information that learners submit could be presented in a simple, clear table.

For 2A.P1, 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 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 affects these characteristics.

Learners at Merit grade, 2A.M1, 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.

For 1A.2, learners will be able to pick out key characteristics of organisms and use these characteristics to classify the organisms into appropriate groups. Learners will be expected to know the main characteristics of the five kingdoms, as well as the main characteristics of the vertebrates and invertebrates, giving examples of organisms that fall into each group. This will involve the construction and use of keys to cover the criterion for 1A.3 to help identify organisms, food chains and food webs.

For 2A.P2, learners need to classify organisms using characteristics and describe how to do this. Learners may link this information to the interdependence of organisms to provide evidence for 2A.P3 by stating how the characteristics of organisms determine their place in food chains and webs. Further evidence for this criterion could be provided in annotated diagrams, posters or flow charts that give details on 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 relationships, which will include the detail derived from food chains and webs.

At Merit level, 2A.M2, learners need to discuss how different factors affect the relationship between different organisms.

At Distinction level, 2A.D1, learners will provide clear evidence in their evaluation of how genes and the environment impact on 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.

Coverage of learning aim A could be obtained by producing wall displays, presentations or information leaflets that provide learners with the opportunity to use their imagination and creative talents, as well as to encourage tiered learning that promotes access to the higher grades.

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

The study of learning aim B should lead learners to realise why it is important for us to take measures to ensure that the future of our planet is safe, and that there are practices that can be put in place to reduce or counteract the effects of the pollutants that are released into ecosystems.

For 1B.4, learners could produce a table of information that details various human activities, the pollutants produced as a result of these activities and brief details on how these pollutants affect an ecosystem. It is expected that learners will cover the material listed in B.1 a, b and c and B.2 a and b of the content to meet this criterion. Less able learners can be supported by being provided with named pollutants that they can research to find out their effects on the environment.

To meet 2B.P4, learners will need to identify the different human activities that affect ecosystems and describe how the polluting effects of these activities cause harm to living organisms and ecosystems.

Learners have the opportunity to carry out investigative work to meet this criterion which could also allow greater access to the Merit grade criterion, 2B.M3, where learners are expected to use data to support the fact that human activities do have polluting effects. For this criterion, learners may wish to study global temperature change over time and relate this to the concentration of carbon dioxide released, or analyse the effects of the overuse of fertiliser on ecosystems.

Learners working at Distinction grade, for 2B.D2, 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 remaining unchecked, will affect humans.

For 1B.5, level 1 learners need to have a knowledge of what living and non-living indicators are. They should be able to distinguish between the two and give examples of each, stating the type of pollution that they can be used to indicate.

For 2B.P5, 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.

To meet the criterion for 1B.6, learners will be able to identify modern methods used to help reduce the impact of human activity on an ecosystem. They should be able to identify the types of household materials that can be recycled and reused, and describe very simply why these methods help to reduce the effects of human activity on an ecosystem. Learners may be able to provide information from their own experiences, such as reusing plastic bags, and some may develop their learning by naming national initiatives such as the use of ‘bags for life’ that could allow them to access higher grades.

For 2B.P6, learners may focus their study on local schemes that may have been put in place, 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’s ecosystems and provide evidence to show how sustainable activities, such as recycling and reusing materials, will help to conserve natural resources for future generations.

For 2B.M4, 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 2B.P6.

For 2B.D3, learners will provide evidence in their evaluation 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 also be expected to extend their understanding to methods not covered at the lower grades, such as coppicing and reforestation techniques.

Learning aim C: Explore the factors that affect human health

To meet the criterion for 1C.7, learners will produce evidence to show their knowledge of the factors that affect human health. Learners will be expected to know the effects of at least two pathogens on human health: one bacteria and one virus. It is expected that learners will give brief details of the effects of these factors on the body; this could be produced in the form of a leaflet, a presentation or a report that can provide the opportunity for a vocational context to be incorporated into their work.

Learners will meet the criterion for 2C.P7 by identifying and describing the pathogen that affects human health; this will be limited to bacteria and viruses. A description of the action of bacteria and viruses and how this impacts on human health is required.

At Merit grade, 2C.M5, learners will need a 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. The work that learners submit for 2C.M5 should include information on how bacteria have become resistant to treatments and what implications this may have in the future.

Information to meet the criterion for 1C.8 could also be included here where learners will provide evidence to show their knowledge of the use of vaccinations in the prevention of disease and the use of antibiotics in the treatment of disease. Learners do not need to provide details of how vaccinations instigate an immune response or how antibiotics work to destroy bacteria. Other methods in preventing disease will be covered to provide evidence for 1C.8, limited to personal hygiene and brief details on the safe storage and cooking of food.

For 2C.P8, learners will provide evidence to show their knowledge of how disease can be prevented using vaccination programmes and treated using antibiotics.

At Merit grade, 2C.M6, learners will need to show one example of the use of pedigree analysis.

For 1C.9, learners will produce evidence to show their knowledge of how exercise benefits health.

For 2C.P9, learners will need a knowledge of how lifestyle choices can affect human health both positively and negatively. This includes smoking, diet, exercise and recreational drug use.

For 2C.M7, high profile examples such as MMR safety concerns balanced against the dangers of measles give an excellent context for learners to discuss using widely available information.

For 2C.D4, 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.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1A.2, 1A.3, 2A.P1, 2A.P2, 2A.P3, 2A.M1, 2A.M2, 2A.D1	Threat to the Ecosystem	You are a council officer who has been asked to advise on the impact of a declining population of an organism on other organisms in an ecosystem. A visit from an environmental scientist would help put this topic into context.	Report or fieldwork evidence with scientific diagrams and flow charts.
1B.4, 1B.5, 1B.6, 2B.P4, 2B.P5, 2B.P6, 2B.M3, 2B.M4, 2B.D2, 2B.D3	Advising Industry About Impact on Ecosystems	You are an environmental scientist advising an industrial company. You have been asked to present to the company the possible impact on local ecosystems of some suggested new schemes, and recommend what can be done to monitor and limit the impact on the environment.	Report or fieldwork evidence with scientific diagrams.
1C.7, 1C.8, 1C.9, 2C.P7, 2C.P8, 2C.P9, 2C.M5, 2C.M6, 2C.M7, 2C.D4	Improving the Use of Medicines	You are a government scientist who has been asked to present your views on how to improve the use of antibiotics and vaccinations in the local area. A visit to a hospital pharmaceutical department or visit from a pharmacist would help put this topic into context.	Scientific report with appropriate diagrams and tables.

Unit 5: Applications of Chemical Substances

Level: **1 and 2**

Unit type: **Mandatory**

Guided learning hours: **30**

Assessment type: **Internal**

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, you will measure the amount of heat that some reactions give out and other reactions take in. You 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. You will look at how crude oil is distilled to produce different fractions. Many of these have uses as fuels. You will study the structure, reactions and uses of some important organic chemicals.

Chemists are constantly finding and developing new types of materials 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 you have learnt in Units 1 and 2 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.

Learning aims and unit content

What needs to be learnt
Learning aim A: Investigate and understand enthalpy changes associated with chemical reactions
A.1 Exothermic and endothermic reactions: a. exothermic reactions as reactions that give out heat energy b. endothermic reactions as reactions that take in heat energy c. measurement of temperature changes for straightforward exothermic and endothermic reactions d. classification of temperature changes as positive or negative e. temperature changes linked to heat energy evolved or absorbed f. 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 g. heat/enthalpy change associated with bond-breaking and bond-making h. overall enthalpy change for a reaction as a combination of bond-breaking and bond-making enthalpy changes i. use the equation: $q = m C \Delta T$ heat energy absorbed by water (J) = mass of water (g) x specific heat capacity (J °C^{-1} g^{-1}) x temperature change (°C) to determine the amount of heat energy absorbed by water in contact with the reaction j. simple energy profile diagrams k. heat packs/cold packs.

What needs to be learnt
Learning aim B: Investigate organic compounds used in society
B.1 Fractional distillation of crude oil: a. fractional distillation of crude oil based on boiling ranges of components b. link between boiling ranges of hydrocarbons and length of hydrocarbon chain c. uses of fractions based on sizes of molecules – gases, petrol, kerosene, diesel oil, fuel oil, bitumens, waxes d. uses of alkanes as fuels – natural gas (methane), bottled gas (propane and butane), petrol, diesel, kerosene. B.2 Structural and displayed formulae of organic molecules: a. alkanes – methane, ethane, propane, butane b. alkenes – structure of ethene, propene c. other organic molecules – poly(ethene), ethanol, ethanoic acid, chloroethene, poly(chloroethene) (PVC), dichloromethane d. 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. B.3 Test tube reactions to identify classes of organic molecules: a. alkenes decolourise bromine water (addition) b. carboxylic acids effervesce when sodium carbonate is added (neutralisation) c. alcohols oxidised by acidified dichromate (VI) solution which changes from orange to green (oxidation). B.4 Uses of organic molecules in society: a. ethene in the manufacture of poly(ethene) and ethanol b. ethanol (made by fermentation/from ethene) in alcoholic drinks, biofuels, solvents, cosmetics c. ethanoic acid in vinegar and making esters d. dichloromethane in paint stripper and solvents e. chloroethene in polymerisation to PVC and uPVC f. Teflon™ (PTFE) in non-stick coatings and low-friction bearings g. problems of organic molecules (toxicity of compounds and products formed on combustion, flammability and non-biodegradability).

What needs to be learnt
Learning aim C: Explore the uses of nanochemicals and new materials
C.1 Introduction to nanochemistry: a. nanoscale b. carbon nanostructures (fullerenes – buckyballs and nanotubes) c. production of nanotubes. C.2 Uses of nanochemistry (sun creams, mascara, textiles, sports equipment, single crystal nanowires for processors, mobile phone batteries). C.3 Implications of nanochemistry: a. safety and environmental issues b. ethical issues surrounding the use of nanochemicals whose properties are not fully understood. C.4 Smart materials whose properties change in response to an external stimulus. C.5 Examples of materials that are highly specialised and their properties, e.g. Kevlar®, GORE-TEX®, Thinsulate®, titanium dioxide.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Investigate and understand enthalpy changes associated with chemical reactions			
1A.1 Measure the temperature changes associated with chemical reactions.*	2A.P1 Investigate temperature changes associated with exothermic and endothermic reactions using primary data.*	2A.M1 Explain why an overall reaction is exothermic or endothermic.*	2A.D1 Calculate the energy changes that take place during exothermic and endothermic reactions.*
Learning aim B: Investigate organic compounds used in society			
1B.2 Identify the uses of the main fractions from the distillation of crude oil.	2B.P2 Describe the fractional distillation of crude oil to produce a range of useful products.	2B.M2 Explain how fractional distillation separates compounds due to different boiling ranges.	2B.D2 Analyse the relationship between the boiling range and the length of carbon chain of fractions.*
1B.3 Name alkanes and alkenes from structural and displayed formulae.	2B.P3 Draw accurately the structural and displayed formulae of organic molecules.	2B.M3 Describe the bonding and structure of organic molecules.	2B.D3 Explain the results of experiments to identify organic compounds in terms of their reaction type, structural and displayed formulae, and bonding.
1B.4 Identify an alkene and an alkane using primary observations.	2B.P4 Identify an alkene and a carboxylic acid using primary observations.	2B.M4 Explain how a series of experiments can be used to identify organic compounds based on their solubility and reactions.	
1B.5 Identify uses of ethene, ethanol and ethanoic acid.	2B.P5 Describe the uses of organic compounds in our society.	2B.M5 Explain the problems associated with the use of organic molecules.	2B.D4 Evaluate the benefits and drawbacks of using organic materials.

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim C: Explore the uses of nanochemicals and new materials			
1C.6 Define nanochemicals.	2C.P6 Describe a use of nanochemicals, smart and specialised materials.	2C.M6 Explain the benefits of using nanochemicals, smart and specialised materials.	2C.D5 Evaluate the benefits and drawbacks of using nanochemicals, smart and specialised materials.

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources required for this unit are a laboratory with at least one fume cupboard and samples of specialised materials.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson. Please read this guidance in conjunction with *Section 8 Internal assessment*.

The content of this unit should be approached from a practical point of view as far as possible, e.g. through scientific investigative assignments.

Level 1 exemplifies partial achievement within a level 2 learning aim.

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

To achieve 1A.1, learners should carry out at least one exothermic and one endothermic reaction, measure the temperature changes and record these changes. Learners should correctly identify that the temperature increased or decreased but do not need to make the link to the reaction taking in heat or giving out heat. A proforma could be used to allow learners to achieve this criterion. More understanding is required at level 2.

To achieve 2A.P1, 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.

To achieve 2A.M1, 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.

To achieve 2A.D1, learners must be able to calculate the heat absorbed by or taken from the water, in contact with the reaction using the equation $mC\Delta T$ and relate this to the enthalpy changes for reactions in terms of breaking bonds (which requires heat) and making bonds (which releases heat).

Learning aim B: Investigate organic compounds used in society

To achieve 1B.2, learners should research and identify the uses of crude oil fractions. They must specifically state the uses of the gases: propane and butane. This could be done by the preparation of a poster or by detailed labelling of a fractional distillation diagram.

To achieve 2B.P2, 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.

To achieve 2B.M2, 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.

To achieve 2B.D2, learners must be able to analyse and explain the link between the boiling point of the fractions and the length of their carbon chains.

To achieve 1B.3, learners must be able to name, from a representation of the structural and displayed formulae, methane, ethane, propane, butane, ethene and propene.

To achieve 2B.P3, learners must be able to accurately draw/provide a representation of straight chain alkanes, with 1–6 carbon atoms, ethene, chloromethanes, chloroethene, poly(ethene), ethanol and ethanoic acid.

To achieve 2B.M3, 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.

To achieve 1B.4, learners should, under supervision, identify an alkane and an alkene from primary observations. The alkane and alkene may be identified on the basis of being insoluble in water. The alkene may be identified by its ability to decolourise bromine water rapidly.

To achieve 2B.P4, learners should follow guidance to identify an alkene and a carboxylic acid (for example, ethanoic acid) from primary observations. Learners will be expected to identify an alkene in the way described in 1B.4. For ethanoic acid this is by its pH and its reaction with sodium carbonate. The guidance given to the learners could be in the form of a flowchart.

To achieve 2B.M4, learners should be able to explain the basis on which the identifications were made for an unknown alkane, alkene and carboxylic acid compound using their practical observations.

To achieve 2B.D3, 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 and carboxylic acid functional group.

To achieve 1B.5, learners should state or provide a very brief description of a use of ethene, a use of ethanol and a use of ethanoic acid.

To achieve 2B.P5, learners should provide a brief account of the use 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.

To achieve 2B.M5, learners should explain the problems of at least two of these uses/applications in detail.

To achieve 2B.D4, 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.

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

It is important for learners to understand that scientific research has always included the discovery of new materials and their applications.

To achieve 1C.6, learners should be able to define the term 'nanochemical'.

To achieve 2C.P6, 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.

To achieve 2C.M6, learners should be able to explain the benefits of using these nanochemicals, smart and specialised materials.

To achieve 2C.D5, 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).

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 2A.P1, 2A.M1, 2A.D1	Hot or Cold?	You are a technical science representative for a company that makes heat packs and cold packs to treat minor injuries. You must explain to your customers how the products work. A visiting speaker from industry could be asked to give a talk on exothermic and endothermic reactions.	Experimental reports, including diagrams and graphs.
1B.2, 2B.P2, 2B.M2, 2B.D2 1B.3, 1B.4, 2B.P3, 2B.P4, 2B.M3, 2B.M4, 2B.D3 1B.5, 2B.P5, 2B.M5, 2B.D4	The Importance of the Fractions of Crude Oil	You work as an environmental scientist. You have been asked to research how the crude oil used in Britain is currently refined and used at present. A visiting speaker could be invited in or a visit to a refinery would help put this into context. You have received several drums of organic waste from a company. You need to confirm what is in the drums in order to treat the waste correctly and present your findings to your manager. A visiting analytical chemist or visit to a waste company would help put this into context.	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.

Criteria covered	Assignment	Scenario	Assessment evidence
		A new organic chemical company produces organic chemicals that are used widely in society. The company is keen to show that these chemicals can be produced from sustainable sources in the future. It is also keen to make the public aware of environmental concerns associated with certain organic compounds, like PVC and they have asked you to help them. As a first step, you need to research a range of organic chemicals and their uses so that you can prepare information to present to the public, on behalf of the company.	
1C.6, 2C.P6, 2C.M6, 2C.D5	New Materials that Change the Way We Live	You work as a materials scientist for a large company that produces a vast range of quality products. To stay ahead of its competitors, the company needs to use the latest technology in its products. You have been asked to provide information about how the company has done this over the years. You are going to research when certain materials were first used. You are going to find out about how innovative materials have been used, why these materials are special and why the public may be worried about products that use nanochemicals. A visit by a materials scientist from a university or research department may help to put this topic into context.	A report showing uses, benefits, safety issues and drawbacks of a range of innovative materials.

Unit 6: Applications of Physical Science

Level: **1 and 2**

Unit type: **Mandatory**

Guided learning hours: **30**

Assessment type: **Internal**

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. You will develop an understanding of motion and how it relates to road safety. You 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, you will develop your 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.

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

Finally, you 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 learnt in Units 1 and 3. In this unit you will apply your 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.

Learning aims and unit content

What needs to be learnt	
Learning aim A: Investigate motion	
A.1	Measurement of distance and time in simple investigations.
A.2	Use the equation: distance (m) = speed (m/s) x time (s).
A.3	Use the equation: displacement (m) = velocity (m/s) x time (s).
A.4	Acceleration relates to a change in velocity of an object.
A.5	Use the equation: acceleration (m/s^2) = change in velocity (m/s) / time taken (s).
A.6	Graphical representations of uniform and non-uniform motion (for objects that are stationary, moving at a constant speed, moving with increasing or decreasing speed).
A.7	Conservation of energy in simple experiments, including energy transformation diagrams.
A.8	Calculations of kinetic energy of moving objects in simple situations, using the following equation: KE = ½ x mass (kg) x (speed (m/s))^2.
A.9	Calculate change in gravitational potential energy using the following equation: GPE = mass (kg) x acceleration (m/s^2) due to gravity x change in height (m).
A.10	Energy changes affecting transportation and stopping distance.
Learning aim B: Investigate forces	
B.1	Forces arise from an interaction between two objects.
B.2	The effect of balanced and unbalanced forces on objects.
B.3	Work is done when a force moves through a distance.
B.4	Use the equation: work done (J) = force (N) x distance (m).
B.5	Use the equation: force (N) = mass (kg) x acceleration (m/s^2).
B.6	Identify 'pairs' of forces that act on different objects and understand that these forces are equal in size and opposite in direction.
B.7	Applications of compressive and tensile forces.
B.8	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.
B.9	Forces on a: a. rocket during various stages of flight b. parachutist c. car during braking and acceleration.

What needs to be learnt	
Learning aim C: Investigate light and sound waves	
C.1	Light rays to represent light moving in straight lines.
C.2	Laws of reflection, applied to plane mirrors.
C.3	Reflection of sound (echoes).
C.4	Ray diagrams showing refraction of light in prisms and lenses: a. convex b. concave.
C.5	Total internal reflection in prisms and optic fibres.
C.6	A lens or mirror with a highly curved surface is more powerful than one with a less curved surface.
C.7	The eye lens focuses light onto the retina and the use of optical lenses to correct simple eye problems.
C.8	The need for a medium for the transmission of sound waves.
C.9	The propagation of sound waves and the subsequent air pressure changes: a. compression b. rarefaction.
C.10	Applications of light: a. clear sightlines at road junctions b. plane and convex mirrors as a rear-view mirror c. using lenses and mirrors in telescopes d. how a simple periscope functions.
C.11	Applications of total internal reflection: a. fibre optic cables used to provide a light source for keyhole surgery b. reflectors for road safety.
C.12	Applications of sound waves: a. voice recognition b. ultrasound c. sonar d. breaking down kidney stones using ultrasound.

What needs to be learnt	
Learning aim D: Investigate electricity	
D.1	Electricity: a. series circuits b. parallel circuits.
D.2	Connect meters in circuits to measure voltages and currents.
D.3	Use the equation: resistance (Ω) = voltage (V) / current (A).
D.4	Ohm's law (voltage, current and resistance relationships at a constant temperature).
D.5	Measure currents and voltages, and perform calculations to find resistance.
D.6	The rules governing voltage and current when components are connected to a battery in series.
D.7	The rules governing voltage and current when components are connected to a battery in parallel.
D.8	Voltage-current characteristics of a negative temperature coefficient (NTC) thermistor or a light-dependent resistor.
D.9	Applications: thermistors (NTC) as a means of sensing temperature, or light-dependent resistors as a means of sensing the brightness of light.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Investigate motion			
1A.1 Produce accurate graphs to represent uniform motion using primary data.*	2A.P1 Produce accurate graphs to represent uniform and non-uniform motion using primary data.*	2A.M1 Interpret graphs to identify objects that are stationary, moving at a constant speed and moving with increasing or decreasing speed.*	2A.D1 Calculate the gradient for distance–time graphs and the gradient and area of speed–time graphs.*
1A.2 Measure distance for simple experiments.*	2A.P2 Calculate speed and velocity for simple experiments.*		
1A.3 Draw energy transformation diagrams for simple experiments.*	2A.P3 Describe the conservation of energy for simple experiments, including energy transformation diagrams.*	2A.M2 Calculate kinetic energy and changes in gravitational potential energy.*	2A.D2 Explain how changes in energy will affect transportation and stopping distances.

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim B: Investigate forces			
1B.4 Identify the forces on objects.	2B.P4 Describe the effects of balanced and unbalanced forces on objects.*	2B.M3 Calculate the force on objects, in relation to their mass and acceleration for an application.*	2B.D3 Explain the various forces involved, and their approximate sizes, in a variety of applications.
1B.5 Describe work done in terms of forces moving through a distance.	2B.P5 Calculate the work done by forces acting on objects for simple experiments.*		
1B.6 Identify friction forces and situations where they occur.	2B.P6 Describe how friction and normal reaction forces are produced in response to an applied force.	2B.M4 Explain how friction and normal reaction forces are produced in response to an applied force.	
Learning aim C: Investigate light and sound waves			
1C.7 Describe, using diagrams, reflection of light in plane mirrors for simple applications.	2C.P7 Describe, using diagrams, reflection and refraction of light for simple applications.	2C.M5 Describe how lenses and mirrors can affect rays of light.	2C.D4 Explain how reflection and refraction of light can be used in applications.
1C.8 Describe how sound is reflected for simple applications.	2C.P8 Describe the importance of a medium for the transmission of sound waves through a variety of substances for simple applications.	2C.M6 Describe the propagation of sound waves, including compression and rarefaction.	2C.D5 Explain how sound waves can be applied in everyday uses.

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim D: Investigate electricity			
1D.9 Describe, using diagrams, how to build series and parallel circuits.	2D.P9 Measure currents and voltages in series and parallel electric circuits.	2D.M7 Calculate resistances from measured currents and voltages.*	2D.D6 Analyse an everyday life situation in which the resistance of a conducting wire is not constant.
1D.10 Describe the use of a thermistor or LDR for an application.	2D.P10 Investigate an application of thermistors or LDRs using primary data.	2D.M8 Mathematically or graphically process the results of the investigation into thermistors or LDRs to draw conclusions.*	2D.D7 Evaluate the investigation into thermistors or LDRs, suggesting improvements to a real-life application.

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

There are no special resources needed for this unit.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson. Please read this guidance in conjunction with *Section 8 Internal assessment*.

The content of this unit should be approached from a practical point of view as far as possible, e.g. through scientific investigative assignments.

Level 1 exemplifies partial achievement within a level 2 learning aim.

Learning aim A: Investigate motion

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. rollercoaster rides
- investigate objects moving through different liquids or gases
- investigate energy changes affecting transportation and stopping distance.

At level 1, learners are expected to carry out simple investigations, the conclusions of which should be clear from direct observations with no processing of data.

At level 2, learners are expected to design and carry out more complex investigations that require processing of data before a conclusion can be made.

To achieve 1A.1, learners are expected to produce graphs using primary data from simple uniform motion experiments as shown in the content A.6 for uniform motion.

To achieve 2A.P1, learners are expected to extend the investigation they carried out in 1A.1 and include graphs for non-linear/non-uniform motion.

For 1A.2, learners must measure distance for simple experiments, along with their units that will be recorded during the investigation.

For 2A.P2, learners must use measurements from experiments and use the correct formulae and units to calculate speed and velocity.

For 2A.M1, learners need to be able to interpret graphs to enable them to label/identify which objects are stationary, moving at constant speed and moving at an increasing or decreasing speed.

For 2A.D1, learners need to use their distance–time and speed–time graphs in order to work out the gradient of any slopes. Additionally speed–time graphs should be used to work out the area under the graph.

For 1A.3, learners need to be able to carry out simple energy conservation experiments and draw energy transformation diagrams.

For 2A.P3, this needs to be extended to describing the conservation of energy and applying this to energy transformation diagrams.

For 2A.M2, learners need to calculate kinetic energy and changes in gravitational potential energy in simple situations using appropriate formulae and units.

For 2A.D2, learners must explain how changes in energy will affect transportation and stopping distances.

Learning aim B: Investigate forces

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

- 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.

To achieve 1B.4, learners must provide evidence to identify at least two examples of balanced and two examples of unbalanced forces on objects.

For 2B.P4, learners need to extend what they have done in 1B.4 by describing the effect on objects of balanced and unbalanced forces.

For 1B.5, learners need to describe the work done by forces acting on objects for at least three different forces through different distances.

For 2B.P5, learners need to calculate the work done by objects for at least three simple experiments, using the appropriate formulae and units.

To achieve 2B.M3, learners need to use the equation in B.5 of the content to calculate the force on objects, in relation to their mass and acceleration for a real-life application.

For 1B.6, learners need to identify friction forces and situations where they occur. This could be written in the form of a table.

For 2B.P6, learners can further develop 1B.6 and carry out a friction experiment to demonstrate friction and normal reaction forces in response to an applied force, and then write a description.

To achieve 2B.M4, learners would then need to apply what they have learnt to explain how friction and normal reaction forces are produced in response to an applied force.

For 2B.D3, learners need to apply their understanding of forces to a variety of applications by explaining the various forces involved, and their approximate sizes as shown, for example, in content B.8 and B.9.

Learning aim C: Investigate light and sound waves

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

- investigate the use of light waves with regard to mirrors, lenses and prisms
- investigate the use of sound waves with regard to reflection and transmission.

To achieve 1C.7, learners need to draw diagrams to show the reflection of light in plane mirrors and demonstrate an understanding of how plane mirrors are used for simple applications.

For 2C.P7, learners need to extend 1C.7 by using plane mirrors and glass blocks/prisms to show reflection and refraction by drawing ray diagrams and understanding their use for simple applications.

For 2C.M5, learners need to describe how lenses and mirrors, which are concave and convex, can affect rays of light.

For 2C.D4, learners need to apply their knowledge from 2C.M5 to explain how reflection and refraction of light can be used as in content C.10 and C.11.

To achieve 1C.8, learners need to describe how sound is reflected, and how it is used by bats and in simple applications such as echo sounding and on submarines.

For 2C.P8, learners 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.

For 2C.M6, learners need to describe the propagation of sound waves, including compression and rarefaction.

For 2C.D5, learners need to apply their knowledge to explain how sound waves can be applied in everyday uses, as shown in content C.12.

Learning aim D: Investigate electricity

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

- investigate thermistors
- investigate light-dependent resistors (LDRs)
- investigate parallel and series circuits.

To achieve 1D.9, learners could carry out some simple experiments and draw circuit diagrams to describe how to connect electrical series and parallel circuits.

For 2D.P9, learners need to connect meters to measure current and voltage of their series and parallel circuits.

For 2D.M7, learners could use their results from 2D.P1 to calculate resistance from measured current and voltage from the series and parallel circuits, using resistance = voltage / current.

For 2D.D6, 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).

To achieve 1D.10, learners need to describe the role of a thermistor or LDR for an application.

For 2D.P10, learners need to investigate practically an application of thermistors or LDRs to generate data on their effectiveness in a range of conditions.

For 2D.M8, 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 2D.D7, 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.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1A.2, 2A.P1, 2A.P2, 2A.M1, 2A.D1 1A.3, 2A.P3, 2A.M2, 2A.D2	How Speed Cameras Can Be Used to Improve Road Safety	You are working as a road safety scientist for the local council. You have been asked to: ● demonstrate experiments that show how speed can be measured on local roads ● improve the 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 the council would like to reduce it. ● report on the conservation of energy when applied to transportation. A visit by a road safety scientist/officer would help put this topic into context.	An article or report for a local journal, including a description of the speed measurement investigation, predictions, graphs, calculations, results, conclusion and improvements to the speed cameras to calculate acceleration. An article or report detailing relevant information with regard to energy conservation.
1B.4, 1B.5, 1B.6, 2B.P4, 2B.P5, 2B.P6, 2B.M3, 2B.M6, 2B.D4	Investigating Forces	Working as a physicist for a civil engineering company, you have been asked to investigate a number of different forces with regard to road transportation, frictional forces, stopping times and car accidents.	An article or report detailing your findings and results from experiments.

Criteria covered	Assignment	Scenario	Assessment evidence
1C.7, 2C.P7, 2C.M7, 2C.D6 1C.8, 2C.P8, 2C.M6, 2C.D7	Applications of sound and light	As an optical physicist working in quality control, you are testing a batch of optical components including mirrors, prisms and lenses for accuracy. You must make and compare measurements of the incident and reflected/refracted angles. You are a research sound physicist 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 visit from a university research physicist or a materials scientist would help put this topic into context.	A report showing the results of experiments. 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 transmission of sound.

Criteria covered	Assignment	Scenario	Assessment evidence
1D.9, 2D.P9, 2D.M7, 2D.D6 1D.10, 2D.P10, 2D.M8, 2D.D7	Circuits and components.	You are working as a research physicist for a toy company that makes toys containing lights in series and parallel circuits. The company also makes resistors of a specified value to reduce the brightness of the lights in the toys. You have been given three tasks. 1. Produce a 'test card' for the current in each light and the voltage across each light, in a series circuit. 2. Produce a 'test card' for the current in each light and the voltage across each light, in a parallel circuit. 3. Produce a customised resistor, from resistance wire, at room temperature, not at the working temperature (e.g. a 5-ohm resistor).	Produce a practical report, including diagrams, graphs and the effect of temperature on resistance.
		You are working as a scientist for a company that produces temperature sensors. You have been asked to investigate the applications for thermistors for the product development department. OR You are working as a scientist for a company that produces lighting sensors. You have been asked to investigate the applications for LDRs for the product development department.	Produce a report on your findings and recommendations for applications that the company could publish.

Unit 7: Health Applications of Life Science

Level: **1 and 2**

Unit type: **Mandatory**

Guided learning hours: **30**

Assessment type: **Internal**

Unit introduction

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

You will consider both the positive and negative aspects of diet and exercise, and the learning programme should encourage you 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 also a good opportunity for you 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 you 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 you will be able to build on your understanding of the fundamental concepts of biology that you have learnt in previous biology units. This unit enables you to develop and use your 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.

Learning aims and unit content

What needs to be learnt
Learning aim A: Investigate factors that contribute to healthy living
A.1 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: a. under-eating and over-eating b. age and level of activity. A.2 The impact of exercise on the health of the human body, to include: a. physical effects of exercise (stress, cardiovascular health) b. weight-related issues c. physical mobility issues. A.3 Measures taken to improve the health of the population, in relation to unhealthy eating, smoking and alcohol intake.
Learning aim B: Know how preventative measures can be used to support healthy living
B.1 Principles of the immune system and immune response as the human body's first line of defence, to include: a. physical barriers b. chemical defences c. non-specific responses (inflammation, phagocytosis) d. specific responses (antibodies) e. potential advantages and disadvantages of vaccination. B.2 Screening programmes on the human body and their advantages and disadvantages, to include: a. screening programmes to detect cancer (breast and prostate) b. screening programmes for antenatal (Down's syndrome) c. screening programmes for the newborn (phenylketonuria (PKU)) d. vascular screening programmes (atherosclerosis).

What needs to be learnt
Learning aim C: Investigate how some treatments are used when illness occurs
C.1 Principles, advantages/disadvantages and the use/misuse of simple treatments of disorders, to include: a. antibiotics b. anti-fungal treatments c. antiviral treatments d. analgesics.
C.2 Principles and the uses of: a. blood grouping and blood transfusion b. organ donation c. stem cell therapy.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Investigate factors that contribute to healthy living			
1A.1 Explain the importance of a balanced diet and exercise.	2A.P1 Describe the possible effects of diet and exercise on the functioning of the human body.	2A.M1 Explain how the diet and exercise plan will affect the functioning of the human body.*	2A.D1 Evaluate the diet and exercise plan, and justify the menus and activities chosen.*
1A.2 Identify a balanced diet for teenagers.*	2A.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.*		
1A.3 Identify measures taken to improve the health of the population.	2A.P3 Describe the ways in which health improvement measures are intended to improve the health of the population.	2A.M2 Analyse rates of disease in the population in relation to lifestyle choices.	2A.D2 Evaluate measures taken to improve the health of the population.

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim B: Know how preventative measures can be used to support healthy living			
1B.4 Identify the role of the immune system in defending the body.	2B.P4 Describe how the immune system defends the body in relation to specific and non-specific immune responses.	2B.M3 Compare the different defence mechanisms the immune system uses to protect the human body.	2B.D3 Evaluate the effectiveness of human vaccination and screening programmes.
1B.5 Identify how a vaccine aids in defending the body.	2B.P5 Describe the changes in the human body following vaccination.		
1B.6 Identify screening programmes.	2B.P6 Describe the role of specific health screening programmes.	2B.M4 Discuss the advantages and disadvantages of a specific health screening programme.	
Learning aim C: Investigate how some treatments are used when illness occurs			
1C.7 Describe how antibiotics are prescribed for use.	2C.P7 Investigate the use and misuse of antibiotics using secondary data.	2C.M5 Analyse the effectiveness of different kinds of medical treatment in health care using secondary data.	2C.D4 Evaluate the use of different kinds of medical treatments, justifying your opinions.
1C.8 Identify pathogens that cannot be treated by antibiotics.	2C.P8 Describe the use of anti-fungal, antiviral and analgesic treatments.		
1C.9 Identify the different blood groups.	2C.P9 Explain the importance of blood group matching in blood transfusions.	2C.M6 Describe organ donation and approaches used to reduce rejection.	2C.D5 Evaluate the potential benefits of stem cell therapy.

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

There are no special resources needed for this unit.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson. Please read this guidance in conjunction with *Section 8 Internal assessment*.

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

Level 1 exemplifies partial achievement within a level 2 learning aim.

Learning aim A: Investigate factors that contribute to healthy living

Learning aim A of this unit requires the learner to investigate a range of factors that can contribute to healthy living. Learners should be able to identify the main food groups (proteins, carbohydrates, fats, vitamins and minerals) and the functions of each group. Consideration should be given to the effects of over- and under-eating and there is a clear opportunity for learners to enter into discussions of eating disorders. The positive and potential negative effects of exercise should also be covered and learners should be encouraged to take part in practical work where possible. Learners may carry out investigations into the effects of exercise on the circulatory and respiratory systems. Learners will also need to consider lifestyle and the health of the population.

For 1A.1 and 1A.2, learners should be able to explain the importance of a healthy balanced diet and exercise to enable them to identify the ingredients of a balanced diet and exercise plan for teenagers. This could be done in the form of a table.

For 2A.P1 and 2A.P2, 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, which covers the following: balanced food groups (fats, carbohydrates, protein, vitamins and minerals); recommended daily intake; exercise (frequency, type and appropriate level to life stage).

For 2A.M1, learners need to develop their understanding of diet and health to explain how the diet and exercise plan will affect the functioning of the body.

This will be followed, for 2A.D1, by the learner justifying the food choices for the diet plan and justifying the activities chosen for the exercise plan. This will allow learners to link age and lifestyle to the choices given.

For 1A.3, learners need to identify measures taken by relevant bodies to educate in order to improve the health of the population.

For 2A.P3, learners need to describe and link specific health improvement measures to how they may reduce the rates of non-infectious disease.

For 2A.M2, learners could investigate and analyse the rates of disease in the population in relation to lifestyle choices; this could be done from a case study or information given to learners by the teacher.

For 2A.D2, learners need to evaluate measures taken to improve the health of the population by looking at different lifestyle choices, including alcohol intake, 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.

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

Learning aim B requires learners to further their study of the immune system. This should lead on to consideration of immunisation programmes. The controversy over the MMR vaccine provides a good discussion point for learners to apply scientific principles, while taking into account public perceptions. Learners should research a selection of health screening programmes. It is expected that learners should then clearly identify the role that these programmes have in maintaining health.

For 1B.4, 1B.5 and 1B.6, learners need to investigate and identify the role of the immune system, vaccinations and screening programmes in relation to the content sections B.1 and B.2.

For 2B.4, 2B.P5 and 2B.P6, this needs to be extended to descriptions of the role of screening, the immune system and how it defends the body, and the effects of vaccinations on the human body.

For 2B.M3 and 2B.M4, learners need to develop their understanding further by comparing specific and non-specific immune responses, physical barriers and chemical defences. Vaccines should be explained in order to identify the changes that result in the body following vaccination. Learners need to discuss health screening programmes as in content B.2, in the context of their advantages and disadvantages. This could be done in the form of a report or table.

2B.D4 should allow learners to evaluate the effectiveness of vaccination and screening programmes. Learners should evaluate at least three of the screening programmes identified in the learning aim.

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

For 1.C7, 1C.8, 1C.9 and 2C.P7, 2C.P8 and 2C.P9, learners should consider some treatments that are available when the body ceases to be healthy. Learners should understand standard guidelines on treatment regimes and guidance to complete the course of antibiotics. When practical work is undertaken, health and safety issues relating to laboratory work in the centre or workplace must be emphasised. Risk assessments, the use of COSHH and other regulations in place in laboratories must be followed, and all practical work must be supervised by a teacher or a lab technician. Witness statements/observation records must be completed as evidence that practical work has been carried out safely and appropriately.

For 2C.M5, learners could carry out a further investigation using the internet or other resources. Learners should appreciate that one factor influencing the increase in hospital-acquired infections is the overuse of antibiotics. The effectiveness of the treatments covered in the unit content can then be considered.

For 2C.M6, learners need to give a description of the principles and uses of organ donation and the methods used to reduce organ rejection.

For 2C.D4, learners should evaluate different types of medical treatment investigated and justify the choice of treatment for different disorders.

For 2C.D5, learners need to investigate stem cell therapy and evaluate the possible benefits, including current benefits and future potential benefits.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1A.2, 1A.3, 2A.P1, 2A.P2, 2A.P3, 2A.M1, 2A.M2, 2A.D1, 2A.D2	A Healthy Lifestyle	You are a dietician working for the NHS and have been asked to write a report about the effects of lifestyle choices, diet and exercise for your hospital trust. A visit by an NHS dietician or a visit to a hospital trust would help to put this topic into context.	A report with appropriate diagrams, tables and graphs.
1B.4, 1B.5, 1B.6, 2B.P4, 2B.P5, 2B.P6, 2B.M3, 2B.M4, 2B.D4	Preventative Measures	You are a medical health science practitioner at a health centre who has been asked to prepare a presentation on measures that can be taken to help maintain health. A visit by a medical scientist from a university or a visit to a medical health centre would help to put this topic into context.	Written presentation or audio/visual presentation, with appropriate data analysis.
1C.7, 1C.8, 1C.9, 2C.P7, 2C.P8, 2C.P9, 2C.M5, 2C.M6, 2C.D4, 2C.D5	Medical Treatments	You are working as a medical scientist and are asked to prepare a portfolio of information that can be used to demonstrate balanced views of various medical treatments, including stem cell therapy. A visit by a medical scientist from a university or a visit to a medical health centre would help to put this topic into context.	Portfolio of information containing secondary data.

Unit 8: Scientific Skills

Level: **1 and 2**

Unit type: **Mandatory**

Guided learning hours: **30**

Assessment type: **External**

Unit introduction

The aim of this unit is to further develop your knowledge and understanding of the scientific process and build on the scientific investigation skills you 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 examination will contain questions on planning, processing, presenting and analysing data, drawing conclusions and evaluating methodology and conclusions.

You will need to demonstrate the application of the skills learnt in this unit, based on familiar and unfamiliar contexts given in an examination paper.

This unit can draw on your knowledge and understanding from Units 5, 6 and 7 of this qualification.

When developing investigative skills learners can work together, however during the examination the learners will work independently under examination conditions.

Learning aims

In this unit you will:

A understand how to produce a good plan for an investigation

B process, present and analyse data, and draw evidence-based conclusions

C evaluate evidence and investigative methods.

Learning aims and unit content

This unit can draw on your knowledge and understanding from Units 5, 6 and 7 of this qualification.

What needs to be learnt	
Learning aim A: Understand how to produce a good plan for an investigation	
A.1	Produce a good plan: a. identify relevant equipment and give reasons for these choices b. identify risks that are relevant to the method and describe how they will be managed (risk assessment) c. identify appropriate variables (dependent and independent) and describe how they will be controlled d. give a suitable range and number of measurements and explain why these were chosen e. outline a logically ordered method appropriate to a given hypothesis.
A.2	Provide a hypothesis based on relevant scientific ideas, which is quantitative or qualitative where appropriate.

What needs to be learnt
Learning aim B: Process, present and analyse data, and draw evidence-based conclusions
B.1 Tabulate data in a clear, logical way: a. with appropriately headed columns b. with units c. in ascending order of independent variables. B.2 Identify anomalous results in tabulated data. B.3 Identify approaches to deal with anomalous results in tabulated data. B.4 Calculations from tabulated data: a. excluding anomalous results where appropriate b. calculating averages c. calculations using given equations d. calculations from Units 5, 6 and 7. B.5 Demonstrate appropriate use of significant figures and application of the correct level of accuracy to which a result can be used. B.6 Draw graphs: a. bar charts b. line graphs c. pie charts. B.7 Identify anomalous results on graphs. B.8 Draw lines of best fit on graphs: a. appropriate to the data, excluding any anomalies where appropriate b. straight line of best fit c. curve of best fit. B.9 Obtain data from a given graph to find a specific value. B.10 Obtain data from a given graph to carry out calculations. B.11 Explain why anomalous results occur: a. do not fit the pattern of results b. errors in the experimental process. B.12 Describe the trends and patterns identified in tabulated data and graphs: a. directly and indirectly proportional b. positive and negative correlation c. quantitative relationships. B.13 Analyse evidence to draw a conclusion.

What needs to be learnt	
Learning aim C: Evaluate evidence and investigative methods	
C.1	Draw inferences from a conclusion.
C.2	Comment on the extent to which the evidence supports the conclusion.
C.3	Comment on the extent to which the hypothesis is supported by evidence.
C.4	Evaluate the method, suggesting improvements or ways of extending the investigation to support the hypothesis further.

Teacher guidance

Resources

There are no special resources needed for this unit.

Assessment guidance

This unit is assessed externally using a paper-based exam marked by Pearson.

Examination format

The learner will complete a 1 hour and 15 minute examination worth 50 marks. The examination will contain questions on planning, processing, presenting and analysing data, drawing conclusions and evaluating methodology and conclusions.

The learner will need to demonstrate the application of the skills learnt in this unit, based on the contexts given in the examination paper.

Unit 9: Practical Scientific Project

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **30**

Assessment type: **Internal**

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; safely carrying out practical work; 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 you will choose and plan an appropriate scientific project, including identifying risks and health and safety considerations. You will be given opportunities to explore and investigate areas of scientific theory that you may have come across in your studies or in your workplace.

This does not need to be a piece of original work. However, you will be given the opportunity to investigate areas of interest that excite and extend your learning. You may be asked to carry out a practical investigation designed by somebody else or to suggest ways of carrying out an investigation of your own design.

The scientific project is designed so you can show your scientific knowledge and practical skills. After a discussion with your teacher, you will be asked to plan, carry out and analyse the results of your investigation and present it as a scientific report. You will need to make a record of your activities as you carry out the project and monitor your progress against the original plan that you gave to your teacher.

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

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

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.

Learning aims and unit content

What needs to be learnt
Learning aim A: Plan a practical scientific project
A.1 Project plan: a. aim b. scientific research c. hypothesis d. resources and equipment* needed e. outline of the activities suggested with a timetable. A.2 Identification of health and safety risks and how to carry out an appropriate risk assessment*. A.3 Elimination and minimisation of any health and safety risk in accordance with: a. Health and Safety at Work Act b. Control of Substances Hazardous to Health (COSHH) Regulations c. risk assessment d. Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) e. codes of practice f. Good Laboratory Practice (GLP) and/or Good Manufacturing Practice (GMP) and/or Good Clinical Practice (GCP) as appropriate. A.4 Methodology and how to ensure accurate and valid results, how variables will be controlled*. A.5 Use of information resources: a. identification of suitable information sources b. location and extraction of relevant information sources (background reading, observations, previous investigations) c. recording of information sources as a resource list.

*This builds on the content in Unit 8.

What needs to be learnt	
Learning aim B: Use practical skills for scientific projects	
B.1	Experimental techniques, assembly of relevant equipment and materials.
B.2	Adherence to health and safety requirements: a. Health and Safety at Work Act b. Control of Substances Hazardous to Health (COSHH) Regulations c. risk assessment d. Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) e. codes of practice f. Good Laboratory Practice (GLP) and/or Good Manufacturing Practice (GMP) and/or Good Clinical Practice (GCP) as appropriate.
B.3	Practical skills: a. appropriate use of equipment b. techniques for taking measurements c. observational skills when carrying out practical work d. repeating measurements when necessary.
B.4	Recording results: a. accuracy b. suitable range and repeats of measurements c. maintenance of working laboratory logbooks and record keeping with integrity.

What needs to be learnt	
Learning aim C: Analyse and present results	
C.1	Collection of practical data and organisation into an appropriate format.
C.2	Methods of data processing and analysis, for example, using mean, standard deviation, or other appropriate methods.
C.3	Use of correct units of experimental quantities.
C.4	Assessment of experimental accuracy* and precision along with accurate calculations.
C.5	Validation of method and results.
C.6	Identification of sources of systematic and random errors and magnitude of errors in readings taken, including error and accuracy in terms of the instruments being used.
C.7	Identification of ways of minimising errors.
C.8	How to draw conclusions* using scientific principles.
C.9	How to carry out and record literature investigations.
C.10	Consideration of the validity of the original hypothesis.
C.11	Evaluation of methodology and conclusions.
C.12	How to write a scientific report of the investigation following correct scientific protocol in terms of structure, format, correct scientific language and terminology.
C.13	How to include relevant references in the final report.

*This builds on the content in Unit 8.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Plan a practical scientific project			
1A.1 Outline a project plan proposal	2A.P1 Plan a project in detail, using information from secondary sources	2A.M1 Produce a project plan and methodology which identifies and minimises any health and safety risks and uses suitable information resources.	2A.D1 Produce a project plan which ensures the practical work can be completed safely and fully tests the hypothesis, using suitable information resources.
1A.2 Identify the health and safety risks that affect a practical scientific project.	2A.P2 Describe the health and safety risks associated with implementing a scientific project.		
Learning aim B: Use practical skills for scientific projects			
1B.3 Use equipment safely to collect scientific data for a project.	2B.P3 Assemble and use appropriate equipment safely to collect reliable scientific data.	2B.M2 Carry out practical work independently using appropriate equipment and techniques, and accurately recording results. *	2B.D2 Carry out practical work independently using appropriate equipment and techniques, using a suitable range of measurements, repeating measurements when necessary. *
1B.4 Record collected scientific data. *	2B.P4 Record scientific data, with appropriate headings, units, and accuracy of data. *		

<table>
<tr><th>Level 1</th><th>Level 2 Pass</th><th>Level 2 Merit</th><th>Level 2 Distinction</th></tr>
<tr><td colspan="4">Learning aim C: Analyse and present results</td></tr>
<tr><td>1C.5 Describe the data collected in a scientific project.</td><td>2C.P5 Explain the results of a scientific project.</td><td rowspan="3">2C.M3 Draw own conclusions from scientific data following mathematical processing. *#</td><td rowspan="3">2C.D3 Evaluate the methodology and conclusions of the project, identifying any modifications that would improve the practical procedures and data collected. *#</td></tr>
<tr><td>1C.6 Present a simple conclusion to a scientific project. *</td><td>2C.P6 Present conclusions to a scientific project. *#</td></tr>
<tr><td>1C.7 Present the outline to a scientific report. #</td><td>2C.P7 Produce an accurate scientific report following accepted protocol. *#</td></tr>
</table>

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

There are no special resources needed for this unit.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson. Please read this guidance in conjunction with *Section 8 Internal assessment*.

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

Level 1 exemplifies partial achievement within a level 2 learning aim.

Learners must observe safe practice when they are carrying out practical work. It is the responsibility of centres to carry out risk assessments for all practical work that they undertake with their learners. Learners should collect their data under full supervision for health and safety reasons.

Observation records should be provided for all practical assessments in this unit.

Learning aim A: Plan a practical scientific project

For 1A.1, learners must produce an outline of a working project plan, including an outline of a method and equipment needed. The plan should be detailed enough so the learner could carry out the project.

For 1A.2, learners must consider any health and safety risks that could be associated with the proposed project and practical investigation. They should show evidence of having carried out a risk assessment.

For 2A.P1, learners must produce a detailed realistic working project plan. The plan must clearly identify the aim of the investigation, any research from secondary sources necessary to allow completion of the project, an appropriate list of resources and equipment needed and an outline of the methodology. The plan should also incorporate a number of milestones or identified review points.

For 2A.P2, learners should consider 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.

For 2A.M1, learners are expected to produce a project plan and methodology. This should include a summary of their research and relate it to their planned investigation. Learners will need to identify a number of research sources, including at least two different types, and show how the information obtained affected their plans. Learners should show how the methodology is linked to the hypothesis.

For 2A.D1, learners will be assessed by the teacher and this includes the learners being aware of constraints when using a laboratory. Learners need to ensure that their practical work fully tests the hypothesis, so if the initial data collected doesn't allow this, then further data will need to be collected.

It is expected that the learner will have conducted some research, using resources of their own choosing. A suitable method of recording resources used should be adopted. Learners will then utilise this researched information to help them draw up a hypothesis for their investigation. The relevant scientific theory must be clearly outlined.

Learning aim B: Use practical skills for scientific projects

Teachers should monitor individual learners' progress with their plans at appropriate intervals dependent on the complexity of the investigation.

The project plan must be submitted along with a health and safety assessment. Each one may be the result of considerable help from the teacher. It may be necessary to modify each one to ensure that it leads to a viable investigation.

For 1B.3, learners will be assessed performing the investigation in the laboratory. Assessors must use observation records to satisfy this grading criterion.

For 1B.4, the recording of results and observations must be done through a working laboratory log.

For 2B.P3, learners will be assessed performing the investigation in the laboratory. Learners must be observed as they assemble and use equipment and materials they need. Assessors must use observation records to satisfy this grading criterion.

For 2B.P4, 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.

For 2B.M2, 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 2B.D2, learners need to ensure that the practical work allows collection of a suitable range of measurements, which are repeated as necessary.

Learning aim C: Analyse and present results

For 1C.5, learners should describe the trend in the data collected qualitatively, using correct scientific language.

For 1C.6, the conclusion given by the learner must be based on their experimental results. It is expected that the conclusion can be reasonably drawn from the results obtained.

For 1C.7, a written report is produced, which follows the major headings expected in a scientific report.

For 2C.P5, 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 criterion 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.

For 2C.P6, learners must draw together the results of their work, clearly stating conclusions drawn from the data they obtained during the practical investigation.

For 2C.P7, a scientific report is produced which 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 correctly labelled. Errors caused by instruments and the accuracy of measurements must be discussed.

For 2C.M3, 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 2C.D3, learners must evaluate the success, or otherwise, of their project. They must 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 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 show a detailed understanding of the concepts involved in the project. Practical work will be well planned and carried out and reviewed with the minimum of support.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is for guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1A.2, 2A.P1, 2A.P2, 2A.M1, 2A.D1	Planning a Scientific Project	You are a science research assistant employed within a medical science organisation in the research and development department. They are interested in finding out about how far your skills have developed in devising practical project work. A visiting science project manager speaker or a visit to a science laboratory to observe technicians/scientists carrying out projects at work would be helpful to motivate learners and gather information towards their evidence.	Write a project plan which includes risk assessments and timelines, and links to information found through use of identified resources.
1B.3, 1B.4, 2B.P3, 2B.P4, 2B.M2, 2B.D2	Carrying Out the Investigation	After completing the project plan and getting it signed off by the senior research technician, you are given the task of carrying out the experiment you designed and collecting the results.	Working laboratory log Observation of practical work
1C.5, 1C.6, 1C.7, 2C.P5, 2C.P6, 2C.P7, 2C.M3, 2C.D3	Reporting Findings	You are to report back to the senior research technician about the practical work you have done and convince them you can collect and analyse reliable data, draw proposed conclusions and write a scientific report.	Written scientific report of the project

Unit 10: World Energy

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **30**

Assessment type: **Internal**

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

You 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.

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

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

You will also be introduced to new 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 your 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 you to build on and apply fundamental energy concepts that you have learnt in Units 1, 3 and 6.

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.

Learning aims and unit content

What needs to be learnt	
Learning aim A: Investigate present-day energy resources	
A.1	Uses of energy: a. electricity (homes, industry) and the implications of not having electricity b. fuels (transport, industry, manufacturing).
A.2	Energy resources: a. general principles of formation of fossil fuels (coal, oil, gas) b. nuclear c. hydroelectric power (HEP) d. renewable (wind, geothermal, solar, biomass and waste, wave, tidal).
A.3	Relative costs (comparisons of fossil fuels with renewable energy resources).
A.4	Estimated availability of fossil fuels in the major producing countries (Saudi Arabia, United States of America (USA), Russia and Caspian region, Iraq).

What needs to be learnt
Learning aim B: Investigate energy demands
B.1 The increasing demand for energy: a. the significance of world population increase in the last 200 years and geographical placement in effecting energy demands b. the 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) c. relative usage and dependence on fossil fuels of major countries and emerging super-economies (China and India) d. impact of increasing energy demand on the environment B.2 Managing the increasing demand for energy: a. 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) b. improving energy efficiency (lighting, managing energy, insulation, low power electronics) c. improving resource efficiency (recycle, reduce packaging, less energy-intensive manufacturing, sustainable agriculture, low carbon materials) d. increasing use of renewable energies. B.3 Key terminology: a. low carbon economy (low dependence on fossil fuels) b. carbon footprint (our production of greenhouse gases in tonnes/kg) c. global emissions (the production of greenhouse gases by all countries).

What needs to be learnt	
Learning aim C: Explore future energy sources and energy storage	
C.1	Future energy demands.
C.2	Potential use of unconventional fossil fuels sources: a. shale oil b. Canadian sands c. Venezuelan ‘extra heavy’ d. Caspian region oil and gas production e. implications of using high carbon dioxide (CO_2) emission sources f. implications of continued use of fossil fuels.
C.3	Reducing energy requirements: a. low carbon buildings b. low energy buildings c. efficient industrial equipment d. improved and sustainable alternatives (solar panels, wind turbines) e. public acceptance of renewable energy f. political will power and funding g. emission control technology h. future plans for nuclear power i. carbon pricing policy for big companies.
C.4	Developments in biofuels.
C.5	Storage of energy produced: a. hydrogen economy and fuel cells b. improved batteries c. flywheel technology and capacitors (electrical energy) d. heat storage methods.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Investigate present-day energy resources			
1A.1 Identify the energy resources currently in use.	2A.P1 Describe current energy resources, their relative costs and how the energy produced is used.	2A.M1 Explain how current energy resources are obtained and how this is reflected in their cost.	2A.D1 Evaluate the energy resources currently available.
Learning aim B: Investigate energy demands			
1B.2 Identify the factors associated with energy demand.	2B.P2 Describe the factors associated with energy demand using key terminology.	2B.M2 Explain how energy demand has changed in the last 200 years.	2B.D2 Evaluate methods available to manage increasing energy demand.
Learning aim C: Explore future energy sources and energy storage			
1C.3 Identify future energy sources.	2C.P3 Describe future energy demands, storage and sources.	2C.M3 Explain future energy requirements and the potential of future energy sources, including developments in storage technology.	2C.D3 Evaluate the potential usage of unconventional and other sources of energy.
1C.4 Identify ways to reduce energy requirements.	2C.P4 Describe how energy requirements can be reduced.		

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

There are no special resources needed for this unit.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson. Please read this guidance in conjunction with *Section 8 Internal assessment*.

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

Level 1 exemplifies partial achievement within a level 2 learning aim.

Learners must observe safe practice when they are carrying out practical work. It is the responsibility of centres to carry out risk assessments for all practical work that they undertake with their learners. Learners should collect their data under full supervision for health and safety reasons.

Observation records should be provided for all practical assessments in this unit.

Learning aim A: **Investigate present-day energy resources**

To complete 1A.1, learners need to identify a full list of energy resources. This could also take the form of diagrams or images.

To achieve 2A.P1, each of these energy resources needs to be described, along with its relative costs. The ways in which the energy produced from these resources is used must be included.

For 2A.M1, learners must explain how the energy sources from 2A.P1 are obtained and how the process of obtaining these resources is reflected in their cost.

For 2A.D1, 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, 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.

Learning aim B: Investigate energy demands

For 1B.2, learners must identify factors associated with energy demand, and they must give descriptions of these factors to achieve 2B.P2. 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.

For 2B.M2, learners must explain the developments in energy demand using a timeline of events. 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 present-day developing industrial nations.

Achievement of 2B.D2 is best completed as a case study that expands on 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 draw upon the points raised by the International Energy Agency (IEA) and G20 plans to reduce subsidies on fossil fuels. Low carbon economies, better buildings etc should feature.

Learning aim C: **Explore future energy sources and energy storage**

For 1C.3, learners must provide a list that identifies where future energy may come from, such as new technologies or further oil exploration.

For 2C.P3, learners must give a description of future energy demands and sources. This could include further details to 1C.3 on possible energy sources, such as heavy oils and fuels that are termed 'unconventional', such as Canadian Sands. Learners must describe how energy may be stored. Developments made in this area could be included.

For 1C.4, learners must identify ways of reducing energy requirements, such as using lower energy appliances and the use of energy management tools.

For 2C.P4, learners also need to describe ways to reduce energy requirements.

For 2C.M3, learners must give an explanation of the potential of future energy sources and requirements, including storage technology. 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 2C.D3, 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.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 2A.P1, 2A.M1, 2A.D1	Earth's Resources	You are working for an energy supplier as a junior project manager scientist and have been asked to put together a report on the energy resources currently available and their relative costs. This is in order for the managers of the company to review their energy suppliers. A speaker from an energy supplier or non-governmental organisation would be helpful to motivate learners and assist them in gathering information towards their assignment evidence.	Report on oil, coal and gas and other energy resources and their costs Describe the factors associated with energy demand using key terminology
1B.2, 2B.P2, 2B.M2, 2B.D2	The Human Problem	You are working as an environmental science technician. As part of your professional development you have been asked by your mentor to put together a report on the factors associated with energy demand due to population growth and the methods being employed to counteract the growth in demand.	An environmental science report on energy demand Explain future energy sources and requirements, including developments in storage technology
1C.3, 1C.4, 2C.P3, 2C.P4 2C.M3, 2C.D3	To the Future	As an environmental science journalist you have been employed by an environmental charity to produce an article on future energy sources and ways of reducing energy requirements.	A report describing how future energy demands may be met by reducing energy requirements and using unconventional sources, including storage of energy to meet peak demands

Unit 11: How Scientific Theories are Formulated

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **30**

Assessment type: **Internal**

Unit introduction

Scientific theories have been formulated and added to 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 in astronomy, medicine and environmental science. It is important to study scientific theories to enable scientists to apply their knowledge, use established scientific theory stages with a systematic and logical approach, test whether a theory is correct and valid, and ask questions about the validity.

This unit will help you understand how scientific theories have been developed and the time and effort it has taken for many of our most well-known theories to become established. In addition, this unit will show you 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 scientific characters.

There is an opportunity for you to carry out independent research into theories past and present and to learn how to ask the right questions in science. In this unit, you will be given an opportunity to express your 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 you an introduction to investigative science by allowing you to study the fundamental processes that have been the cornerstone of scientific development and understanding for thousands of years.

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.

Learning aims and unit content

What needs to be learnt
Learning aim A: Investigate historical scientific theories
A.1 Definition of a theory. A.2 Key scientific theories (general aspects, scientists involved and a timeline of important developments): a. Darwin's theory of evolution b. the Big Bang theory c. Einstein's theory of relativity d. Newton's theory of gravitation e. Mendeleev's periodic table of elements and atomic structure f. particle theory of matter g. plate tectonics h. germ theory of disease i. cell theory.

What needs to be learnt
Learning aim B: Explore the processes involved in developing a scientific theory
B.1 Definitions of hypothesis, validity and reliability. B.2 Identification of the characteristic stages in theory development: a. questioning from observation b. hypothesis c. experimenting d. sharing findings e. repeated results (how results in science must be repeatable for the work to be recognised) f. theory. B.3 Identifying theories where the stages are not so obvious. B.4 Data collection methods: a. correct means of collecting data (including computer automation and manual collection) that is useful to the investigation b. controls and placebos in medical research c. reducing bias.
Learning aim C: Investigate the testing of theories and peer review
C.1 The scientific community (scientists and details of the groups of people who make up ethics committees). C.2 How a general consensus of opinion is arrived at within the scientific community. C.3 Scrutiny of a science investigation by other scientists: a. the peer review process b. the difficulties of promoting a theory to other scientists c. the processes of testing the theory using correct scientific protocols.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Investigate historical scientific theories			
1A.1 Identify the main points in a historic scientific theory.	2A.P1 Describe a historic scientific theory.	2A.M1 Explain the main developments in the history of a scientific theory.	2A.D1 Evaluate the strengths and weaknesses of a scientific theory.
Learning aim B: Explore the processes involved in developing a scientific theory			
1B.2 Identify the characteristic stages of a current scientific theory.	2B.P2 Describe the stages in development of a current scientific theory.	2B.M2 Compare the stages in development of different scientific theories.	2B.D2 Evaluate the validity of collected data to test a scientific theory.
1B.3 Identify data collection methods.	2B.P3 Describe data collection methods.	2B.M3 Explain the methods used to ensure reliable scientific data collection.	
Learning aim C: Investigate the testing of theories and peer review			
1C.4 Identify the members who make up a scientific community.	2C.P4 Describe the processes by which theories are accepted by the scientific community.	2C.M4 Explain the purpose of a peer review.	2C.D3 Evaluate the strengths and weaknesses of peer review and its role in the acceptance of a scientific theory.

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

There are no special resources needed for this unit.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson. Please read this guidance in conjunction with *Section 8 Internal assessment*.

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

Level 1 exemplifies partial achievement within a level 2 learning aim.

Learners must observe safe practice when they are carrying out practical work. It is the responsibility of centres to carry out risk assessments for all practical work that they undertake with their learners. Learners should collect their data under full supervision for health and safety reasons.

Observation records should be provided for all practical assessments in this unit.

Learning aim A: Investigate historical scientific theories

For 1A.1, learners must identify a historic scientific theory and the main points in that theory.

For 2A.P1, 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.

For 2A.M1, 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 2A.D1, 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.

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

For 1B.2, learners must list the current stages in theory development in the correct order to achieve this criterion.

For 2B.P2, 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.

For 2B.M2, 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.

For 1B.3, learners need to list the methods that are used to collect data. No further details are needed.

For 2B.P3, learners 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 way and by different methods, the necessity of repetition, controls, etc. Both computer-collected data and manually collected data must be covered.

For 2B.M3, learners are required to explain methods for reliable data collection, which may have also been covered in 2B.P3 where repeat results are used, and controls, methods to reduce bias, blind trials, etc, are given.

For 2B.D2, 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 if enough data was collected, were the correct controls in place, etc.

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

For 1C.4, learners should identify members who make up a scientific community, which could include science teachers in schools/colleges, university lecturers and researchers, those involved in scientific publications, technological institutes, industry, and government.

For 2C.P4, 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.

For 2C.M4, 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 2C.D3, 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 criterion for 2C.D3. 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.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 2A.P1, 2A.M1, 2A.D1	Evolving Theories	You are working as a junior science researcher for an educational materials firm, which will be publishing a small book on a historic scientific theory. A speaker who is a science historian from a museum or university or institution/society would be helpful to motivate learners and assist them in gathering information towards their assignment evidence.	A report to include timeline of events, annotated tables, written account
1B.2, 2B.P2, 2B.M2, 2B.D2 1B.3, 2B.P3, 2B.M3, 2B.D2	Scientific Theory Stages	You are working as a reporter for a science journal and are writing an article about the stages in scientific theory, questioning the best way to develop a theory.	Itemised lists, diagrams, research logs and news article, presentation, photo evidence Describe the processes by which theories are accepted by the scientific community. Large annotated diagram or chart showing the different stages
1C.4, 2C.P4, 2C.M4, 2C.D3	Testing, Testing	As a junior journalist you have been given the task of writing an article about how scientific theories are accepted by the scientific community through peer review.	Diagrams, spider diagram, presentation, written articles to include the above

Unit 12: The Living Body

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **30**

Assessment type: **Internal**

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 by the nervous and endocrine systems.

You 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. You 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.

This unit will help you to further your knowledge and understanding of how the human body systems interact. It will support you to progress to more advanced courses such as the BTEC Level 3 qualifications in Applied Science (Medical Science), Sport and Exercise Sciences, Beauty Therapy Services and Health and Social Care. It will also support you if you wish to enter employment in the health, beauty or sports science sector.

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.

Learning aims and unit content

What needs to be learnt	
Learning aim A: Develop a knowledge of the structure and function of individual body systems	
A.1	The structure and function of the digestive system in terms of: a. mechanical and chemical digestion b. absorption and assimilation (fate of nutrients, storage of excess nutrients, use of nutrients to maintain cell and body functions) c. enzymes as catalysts that help in the digestion, absorption and assimilation of food in the body.
A.2	The respiratory system described in terms of the main functions of the structures that enable the exchange of gases: a. between the lungs and atmosphere b. between the lungs and blood stream.
A.3	The structure and function of the circulatory system in terms of maintaining cell and body functions.
A.4	The renal system described in terms of the main functions of the structures in regulating: a. fluid b. salt balance c. pH levels.
A.5	The structure and function of the reproductive system in terms of: a. sperm production b. ovulation c. fertilisation.

What needs to be learnt	
Learning aim B: Develop a knowledge of how body systems are coordinated	
B.1	The nervous system: a. as a coordinator of the human body b. a simple reflex arc as an instant reaction to possible danger c. in terms of regulating visceral activities automatically.
B.2	Endocrine/hormone-producing glands in terms of the regulatory functions of the hormones they produce: a. pituitary gland b. thyroid gland c. adrenal gland d. pancreas e. testes f. ovaries.
B.3	The relationship between the nervous system and the endocrine system.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Develop a knowledge of the structure and function of individual body systems			
1A.1 Identify the main components of the digestive system involved in mechanical digestion.	2A.P1 Outline the role of enzymes as catalysts in the digestive system.	2A.M1 Explain how the components of a system are specialised to carry out their function.	2A.D1 Evaluate the impact on the human body if one of the systems malfunctions.
1A.2 Outline the main respiratory structures involved in exchanging gases.	2A.P2 Describe the functions of the main respiratory structures.		
1A.3 Outline the structure of the circulatory system.	2A.P3 Describe how the circulatory system transports materials to the cells.		
1A.4 Identify the main structures of the renal system.	2A.P4 Outline how the renal system regulates fluid in the body.		
1A.5 Identify the main components of the male and female reproductive systems.	2A.P5 Describe the functions of the components of the male and female reproductive systems.		

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim B: Develop a knowledge of how body systems are coordinated			
1B.6 Describe how a simple reflex arc functions.	2B.P6 Describe how the nervous system controls and coordinates a body system.	2B.M2 Compare and contrast the way in which the nervous system and the endocrine system coordinate body functions.	2B.D2 Explain how the nervous and endocrine systems can work together to regulate body functions.
1B.7 Identify a hormone produced by each of the endocrine glands.	2B.P7 Describe how a chosen endocrine gland regulates a body system.		

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

There are no special resources needed for this unit.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson. Please read this guidance in conjunction with *Section 8 Internal assessment*.

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

Level 1 exemplifies partial achievement within a level 2 learning aim.

Learners must observe safe practice when they are carrying out practical work. It is the responsibility of centres to carry out risk assessments for all practical work that they undertake with their learners. Learners should collect their data under full supervision for health and safety reasons.

Observation records should be provided for all practical assessments in this unit.

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

For 1A.1, learners have to identify the main components of the digestive system, including mechanical digestion. If they include chemical digestion, involving enzymes etc, the assessor should not penalise them. For instance it would be expected that the learners will mention amongst other things mastication and peristalsis (or a description of it). A set of annotated diagrams could be assessed here.

For 2A.P1, learners must demonstrate the knowledge required about the role of enzymes as digestive catalysts. This should be based not only on research but the practical work carried out by the learner. The learner will also be expected to include the enzymes involved in absorption and assimilation as they are also part of the digestive system. A list of enzymes and where they are in the digestive system will not be sufficient; it is their role (function) that must be given.

For 1A.2, learners could be assessed using annotated diagrams of the respiratory structures required with an outline. The chemistry of respiration is not required here but learners should include structures involved in gaseous exchange between the lungs and the environment and between the lungs and the blood vessels.

For 2A.P2, learners will give the structures of the respiratory system only as an aid to describing the functions of the main respiratory structures. It is possible to use a series of annotated diagrams of the respiratory system to meet this criterion.

For 1A.3, learners are required to outline the structures of the circulatory system. The best way of achieving this could be by annotated diagrams where the structures are correctly identified. It should be noted that functions are not required but if given the learner should not be penalised.

For 2A.P3, learners are required to describe the structure of the circulatory system in terms of its function as a transport system. It is the transportation of materials to cells around the human body that must be described. One or a series of annotated diagrams would meet this criterion.

For 1A.4, learners are required to identify the main structures of the renal system, detailed descriptions of structures and functions are not required. It is sufficient for the learners to list the main structures to gain 1A4.

For 2A.P4, learners will need to know the structure of the renal system but it is its role in regulating fluid in the body that must be outlined here. In discussing the regulating of fluid the learner should also mention the salt balance and pH levels as they are part of this regulatory system.

For 1A.5, learners are required to identify the main components of the male and female reproductive systems. This does not require cellular or functional details to be included. Diagrams with correct labelling can be used to identify the main reproductive components.

For 2A.P5, learners are required to give a description of the functions of the main reproductive components for this criterion. There is no requirement for detailed cellular information but correctly identifying the structures and their functions is required. Again, this can be achieved by correctly annotating diagrams. 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.

For 2A.M1, learners can choose a system from those studied. They will be required 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 2A.D1, learners are required to choose one of the body systems. For example, they might choose the renal system and its role in controlling pH values. The learners should be able to evaluate what happens if this system does not function correctly, i.e. there could be a rise in pH values, and the subsequent effect, e.g. on cell functions due to biochemical processes being sensitive to pH values.

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

For 1B.6, learners are required to produce an annotated diagram for a reflex arc. Most learners will opt for either the knee jerk or finger being pricked but other examples will meet the requirement. 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.

For 2B.P6, learners can choose which body system they want to use to show how the autonomic system functions. The assessor is looking for the learners to describe, for instance, how the secretions of the salivary glands are controlled by the nervous system. A simple diagram of the link between the salivary glands and the CNS with some description will be sufficient.

For 1B.7, learners need to identify one product from each of the following: pituitary, thyroid, adrenal, pancreas, testes and ovaries. There is no requirement for a description of what the product does in the body. The learners must correctly identify one product from each of the glands.

For 2B.P7, learners must choose an endocrine gland, state what it produces and 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 blood flow, heartbeat etc.

For 2B.M2, learners are required 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 2B.D2, learners may find it easier to use one body function, such as respiration, circulation or digestion to explain the coordination of the nervous and endocrine systems in regulating a body function. If they do this, learners should also mention other body functions and their regulation by both systems.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 2A.P1 1A.2, 2A.P2 1A.3, 2A.P3 1A.4, 2A.P4 1A.5, 2A.P5, 2A.M1, 2A.D1	What Does This Do – What's it For?	You have started work in a medical science laboratory in a hospital as an assistant laboratory technician. Many school learners in year 10/11 visit the laboratory and the supervisor wants you to produce a series of leaflets/booklets or on-screen information packs. They will need to be signed off as appropriate and cover the following sections: Section 1: Enzymes and the digestive system Section 2: Respiration Section 3: Circulation Section 4: The renal system Section 5: The human reproductive system. A visiting speaker from a medical laboratory or a visit to a medical laboratory (or one where they deal with human body systems) to observe technicians/scientists at work would be helpful to motivate learners and gather information towards their evidence.	Written – booklets, leaflets, on-screen presentation

Criteria covered	Assignment	Scenario	Assessment evidence
1B.6, 2B.P6 1B.7, 2B.P7, 2B.M2, 2B.D2	Hormones or Nerves	As a junior technician, you work in a hospital laboratory where tests are carried out on patients who may have endocrine or nervous system problems. The patients are often very anxious and do not understand the concept of endocrine glands or the nervous system. You have suggested to the senior technician and a member of the nursing staff that it would help the patients if they had something to read on the subject while they wait to see the consultant or to take away with them after the consultation. The nurse agrees and your senior technician supervisor gives you the task. The information will need to cover the following sections and needs to be supported by relevant diagrams: Section 1: The endocrine system Section 2: The nervous system. The information needs to be signed off by both the senior technician and nurse.	The work can be presented as information sheets either on paper or to read on a screen. It could be a set of leaflets, handouts or booklets including diagrams that can then be used for assessment.

Unit 13: Monitoring the Environment

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **30**

Assessment type: **Internal**

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, are more effectively achieved.

In this unit, you will study how the components of ecosystems function by interrelating with each other to maintain balance. You 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 you a better understanding of the outcomes of your practical investigations.

You 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, safely collecting samples, following techniques and procedures, recording and analysing data, and reporting on monitoring activities.

As a consequence of the knowledge and skills acquired, you 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.

Learning aims and unit content

What needs to be learnt
Learning aim A: Investigate ecosystems
A.1 Definition of terms: a. flora b. fauna c. populations d. biodiversity e. producers, primary, secondary and tertiary consumers f. food chains and food webs g. habitat. A.2 Ecosystems: a. the interrelationships between producers, primary and secondary consumers b. examples of ecosystems local to learners c. examples of ecosystems in tropical rainforests, polar and desert regions. A.3 How ecosystems may change as a result of the following changes to the environment: a. food demands* of increasing populations b. energy demands of increasing populations c. increasing volume of waste, causing increased use of landfill d. different effects of lifestyles on the environment e. how deforestation* changes habitats for animals, affects global warming and influences water use and erosion f. climate change linked to increased amounts of carbon dioxide in the air g. acid rain, resulting from burning of fossil fuels, and its effects h. overuse of fertilisers*, resulting in growth of algae, deoxygenation of water and reduced fish populations.

*This builds on the content in Unit 4.

What needs to be learnt	
Learning aim B: Measure features of an ecosystem	
B.1	Measurement of features of an ecosystem: a. soil composition in terms of water, organic matter, air and a mineral component b. soil analysis – description of how a known mass mixed with a known volume of water settles out in a measuring cylinder c. water analysis – pH, suspended solids, dissolved nitrates and dissolved chlorides d. measurement of aspects of rainfall, temperature, humidity, wind speed e. estimation of biodiversity – use of quadrats, trapping, identification of species, recording percentage cover f. estimation of particulates in the air.
Learning aim C: Explore environmental protection	
C.1	Role of government bodies: a. Department of the Environment, Food and Rural Affairs (DEFRA) – responsible for policy and regulations on the environment, food and rural affairs b. Environment Agency – responsible for rivers, pollution and flooding c. local authorities – responsible for local air quality reports and for regulating less seriously polluting processes.
C.2	Role of other organisations in raising awareness of specific environmental issues: a. Friends of the Earth b. Greenpeace c. International Union for Conservation of Nature (IUCN) d. Natural England e. The World Wide Fund for Nature (WWF).

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Investigate ecosystems			
1A.1 Identify the trophic structure of an ecosystem.	2A.P1 Describe how energy is transferred through an ecosystem.	2A.M1 Explain how human activities have influenced ecosystems.	2A.D1 Evaluate the scale and scope of specific human activities affecting an ecosystem.
Learning aim B: Measure features of an ecosystem			
1B.2 Identify techniques used in monitoring an ecosystem.	2B.P2 Correctly demonstrate techniques used in monitoring an ecosystem.	2B.M2 Analyse and present conclusions from an investigation of an ecosystem. *	2B.D2 Evaluate the reliability of an investigation of an ecosystem. *
1B.3 Record the results of an investigation of an ecosystem. *	2B.P3 Collate and present the results of an investigation of an ecosystem. *		
Learning aim C: Explore environmental protection			
1C.4 Identify how an aspect of the environment is monitored by different types of organisation.	2C.P4 Describe the role of different types of agencies in environmental protection.	2C.M3 Explain how a specific agency is engaged in environmental protection.	2C.D3 Select and justify a strategy for improving the quality of the environment on behalf of an agency.

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

Learners will need access to a suitable ecosystem for investigation.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson. Please read this guidance in conjunction with *Section 8 Internal assessment*.

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

Level 1 exemplifies partial achievement within a level 2 learning aim.

Learners must observe safe practice when they are carrying out practical work. It is the responsibility of centres to carry out risk assessments for all practical work that they undertake with their learners. Learners should collect their data under full supervision for health and safety reasons.

Observation records should be provided for all practical assessments in this unit.

Learning aim A: Investigate ecosystems

For 1A.1, learners should focus on one ecosystem. This could be the ecosystem used for the practical investigation or could be an ecosystem in another country, e.g. a rainforest. Learners should identify flora and fauna in the ecosystem and show an awareness of the interdependence of species, for example by constructing simple food chains and food webs. This should enable the learners to identify the trophic structure of the ecosystem.

For 2A.P1, learners should use an ecosystem they have studied to describe how energy is transferred through that system. Learners 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.

For 2A.M1, 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 2A.D1, learners must evaluate the effect of specific human activities on an ecosystem that may have been covered as part of 2A.M1. Note that 2A.D1 only requires an evaluation of one ecosystem, although learners must refer to the scale and scope of specific human activities.

Learning aim B: Measure features of an ecosystem

For 1B.2, learners are required to identify the techniques used to monitor ecosystems, which could be based on practical work done as part of field trips or outside activities. Detailed descriptions are not required but learners should be able to identify the technique and say what it is used for. For example, using a meter to measure the pH value of water or using quadrats to discover the distribution of a plant species in a field.

For 2B.P2, 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 the learners are on a field trip. It is not expected that every technique listed in the unit content under B.1 will be covered but at least one technique from each category should be observed.

For 1B.3, learners will be expected to write up the results of their investigation into an ecosystem, but they are not required to write up details of the apparatus and methods used or the conclusions. Rough work in notebook etc should be handed in. If learners want to make their results neater, then the original notebook should still be presented.

For 2B.P3, 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.

For 2B.M2, learners will use the results collected from the practical work in 2B.P2 and 2B.P3. 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. The learners must show evidence of analysis of their results in order to come to reasonable conclusions.

For 2B.D2, learners will evaluate the reliability of an investigation into an ecosystem. It is possible for the learners to do the evaluation using a published piece of research but this should not be the first choice for this assessment criterion. The learners must provide an evaluation of the reliability of the work and not just an account of what was done during the investigation.

Learning aim C: Explore environmental protection

For 1C.4, learners are not required to list different organisations and what they do. Rather, one aspect of the environment is chosen and then the learners should identify how various organisations monitor it. For example, water quality might be selected and then the learners identify the various organisations involved in its monitoring. Details on how the monitoring takes place or how the organisation works, are not required.

For 2C.P4, learners must describe the role of different types of agencies that are involved in environmental protection. Just to list 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 is not relevant. The learners would need to describe Greenpeace's role in protecting whales etc from over-fishing by some nations.

For 2C.M3, learners are required to explain one of the named agencies and its role in environmental protection. The learners can choose any agency, for example, governmental, political, non-political etc. The learners must put in sufficient detail to explain what the chosen agency does and its role in protecting the environment.

For 2C.D3, learners will carry out extensive research in order 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 the learners to build on one of the agencies already mentioned in previous assessment criteria. The learners must select a suitable strategy and also justify it.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 2A.P1, 2A.M1, 2A.D1	How Do Human Activities Impact on Ecosystems?	You are a freelance environmental science writer submitting an article for publication in an environmental magazine. A visit from an environmental scientist speaker or a visit to an environmental trust site would be helpful and allow learners to gather evidence towards their assignments.	An illustrated scientific article on the structure of an ecosystem, its energy and how human activity affects the ecosystem
1B.2, 1B.3, 2B.P2, 2B.P3, 2B.M2, 2B.D2	Investigating an Ecosystem	You are an ecologist working for an environmental consultancy, which has been employed by a construction company to carry out an investigation/assessment of an ecosystem on the land they have purchased.	Observation report, practical scientific report of investigation Proformas and written report on the investigation
1C.4, 2C.P4, 2C.M3, 2C.D3	Saving the Planet	You are working for an environmental charity called ‘Eco-world’ whose members are concerned about the environment. To give the group a focus for action, you have been asked to find out and report on what the charity could do to improve the environment. You need to produce a strategy to improve the environment.	Leaflet on how the charity protects the environment

Unit 14: Growing Plants for Food

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **30**

Assessment type: **Internal**

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 you 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 you 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 Units 1 and 2 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 you 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.

Learning aims and unit content

What needs to be learnt
Learning aim A: Investigate plant growth conditions
A.1 Factors that affect plant growth: a. light b. temperature c. water d. growth media e. pH f. fertiliser (organic and artificial) g. chemical pesticides h. weed competition. A.2 Growth rates of a plant under optimal conditions of light, water and carbon dioxide. A.3 Monitoring plant growth under different conditions of light, carbon dioxide, water, minerals and pH of soil.
Learning aim B: Investigate the relationship between food production and population size
B.1 Food production issues relating to: a. population and the increasing demand for available food b. climate change and how changing temperatures and rainfall influence what can be grown and where c. market and retail influences, including personal preference and the competition between retailers and how this influences what is sold. B.2 Collapse of food production due to: a. climate change b. lack of fertilisers c. water d. competition for agricultural land for other uses e. removal of eco-stability due to logging, planting unsuitable crops and poor farming practices. B.3 Political and economic issues relating to: a. relevant or British or UK policies b. fair trade c. cash crops d. biofuels e. food crops.

What needs to be learnt	
Learning aim C: Explore plant breeding for commercial success	
C.1	Selective breeding of food plants: a. the effect of the technology involved on the environment b. time span in terms of plant breeding (takes time and is not an immediate solution to famine problems) c. the loss of some species that may be valuable in the future and the need for 'seed banks'.
C.2	Genetic modification of food crops explained as: a. gene transfer and manipulation b. polyploidy in food crops c. chemically and physically induced mutations.
C.3	The effects of genetic modification of food crops on food production and on humans and animals: a. the loss of different species b. interbreeding between modified and other species, which may cause short-term and long-term problems c. the varying attitudes of people in Europe and America to modified crops and the possible reasons for this.
C.4	The advantages and disadvantages of genetic alterations.
C.5	Plant breeding technologies used to produce: a. uniform and disease-resistant food crops b. plug plants for nurseries and gardeners c. commercially valuable plants.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Investigate plant growth conditions			
1A.1 Identify the different conditions that give optimal growth for plants.	2A.P1 Investigate the different conditions that give optimal growth for plants from primary data.	2A.M1 Explain results from plant growth investigations in terms of optimum growing conditions for the plants grown.	2A.D1 Compare the optimum plant growth conditions found in investigations with those found in a farmer's field. *
1A.2 Identify measurements that can be used to monitor plant growth. *	2A.P2 Describe how plant growth is monitored.		
1A.3 Identify plant growth rates from secondary data.	2A.P3 Compare primary data for plant growth rates with secondary data. *		
Learning aim B: Investigate the relationship between food production and population size			
1B.4 Identify factors that influence food production.	2B.P4 Explain how factors affect food production in developed countries.	2B.M2 Compare how different countries have tried to increase their food production. *	2B.D2 Evaluate the impact of policy and economics on food production.

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim C: Explore plant breeding for commercial success			
1C.5 Identify technology used in plant breeding.	2C.P5 Describe the technology used in plant breeding.	2C.M3 Explain how plant breeding technologies have affected variation in major food crops.	2C.D3 Evaluate the effectiveness of plant breeding technologies. *
1C.6 Describe how the genetic modification of plants has altered food production.	2C.P6 Explain how the genetic modification of plants has altered food production.		

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

There are no special resources needed for this unit.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson. Please read this guidance in conjunction with *Section 8 Internal assessment*.

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

Level 1 exemplifies partial achievement within a level 2 learning aim.

Learners must observe safe practice when they are carrying out practical work. It is the responsibility of centres to carry out risk assessments for all practical work that they undertake with their learners. Learners should collect their data under full supervision for health and safety reasons.

Observation records should be provided for all practical assessments in this unit.

Learning aim A: Investigate plant growth conditions

The learner should be observed at least once and evidence should be in the form of a tutor observation record. This can be supplemented by witness statements by competent staff when the tutor is not present.

For 1A.1, learners are required to identify the best conditions for plant growth.

For 2A.P1, learners will need to show that they have identified what factors affect plant growth and have investigated them practically. The learners must also present written evidence of their work and results.

For 1A.2, learners will do some research and then give a list of the measurements which can be used to monitor plant growth. Some learners may also explain how or why particular measurements are used but the criterion only requires them to identify what measurements are taken. The learners do not have to give further details.

For 2A.P2, learners are required to carry out some research so they can describe how plant growth is monitored. They should include in their description how they monitored plant growth in their experiments, as well as how it is done in plant research laboratories and in commercial nurseries.

For 1A.3, learners must identify secondary data on plant growth rates, following on from their research. It would be expected they consulted at least two sources and would mention that not all sources agree. The sources could be the results of their researches or ones given to them by the teacher. Learners need only give one list of secondary data for plant growth rates.

For 2A.P3, learners need to compare plant growth rates from their experimental work and published growth rates. This requires analytical skills to be shown. This will mainly be a descriptive exercise but comparisons between growth graphs, for instance, could be used by the more able learner.

For 2A.M1, learners need to have carried out some research on optimal plant growth conditions. Using this knowledge they need to explain how closely their results reflect the optimum growth conditions usually quoted for plants to grow.

For 2A.D1, learners must carry out research on optimal plant growth conditions but to achieve this criterion the findings are now 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, influence growth.

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

For 1B.4, learners are required to list factors, not completely or extensively but sufficiently, to show they understand there are several things, for example the weather, condition of soil, application of fertilisers that can influence food production. Learners should identify the reasons why some countries cannot feed their population, including physical conditions, such as drought and also social and political factors.

For 2B.P4, learners must choose the main factors that affect food production. Having done this they need to explain how food production is affected. For instance, they might identify the availability of fertilisers and then explain why quality, quantity, source of fertiliser, etc, all affect the amount of food produced. Learners will be expected to include factors, such as the ability to control market forces, access to fertilisers, etc. The learners must explain these factors and relate them to developed countries as asked for in the criterion.

For 2B.M2, learners need to compare the increases in food production between different countries. The learners could list the ways in which food production can be increased but must compare the different approaches used by the countries mentioned.

For 2B.D2, learners will need to establish what policies and economic ideas are involved in food production. Then they will have to 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.

Learning aim C: Explore plant breeding for commercial success

For 1C.5, learners need to identify at least two pieces of technology related to plant breeding, such as the use of polytunnels or cloning. It is sufficient just to list a piece of technology. The assessor should note that the use is related to plant breeding.

For 2C.P5, learners need to describe how breeding plants now requires high technology systems where optimum growth conditions can be given, pests and diseases excluded, and maximum yields guaranteed. The learners should give at least two examples of technology used in plant breeding and, importantly, describe the technology. Lists are not sufficient to meet this criterion.

For 1C.6, learners are required to describe genetic modification in relation to food production. They are not required to go into details about genetic structures, different types of mutations or the techniques used in splicing DNA, etc. It is a piece of descriptive work in which the learner shows 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 resistance to pests, better crop yields, better resistance to drought/wet conditions, etc.

For 2C.P6, learners are required to show some understanding of genetics. The learners are being asked to apply their knowledge of genetic alterations in order to show how to improve food production. It is the application of genetic modification that the learners are being asked to explain. They do not need to give detailed descriptions of genetic manipulations.

For 2C.M3, learners need to focus on the plant breeding technologies that have affected variation in major food crops. The learners must explain the technologies used and the variation that has resulted. Lists of plant breeding technologies are not acceptable. The requirement is for an explanation of how the technologies have affected major food crops.

For 2C.D3, learners need to evaluate the effectiveness of plant breeding technologies, building on the explanations given in 2C.M1. This requires the learners to look at the disadvantages and advantages of using the plant breeding technologies that have been developed. The learners are required to evaluate whether advantages outweigh disadvantages when using these technologies to produce food for a country's population.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment evidence
1A.1, 1A.2, 1A.3, 2A.P1, 2A.P2, 2A.P3, 2A.M1, 2A.D1	What Do I Need to Grow?	You have been employed by a horticultural centre as a science technician and have been asked to investigate the growth of a number of new plants. You need to produce a report on what these plants require to grow well. A visiting speaker from a horticultural centre or a visit to a horticultural laboratory would be of value to learners.	Written report
1B.4, 2B.P4, 2B.M2, 2B.D2	How Much Food is Needed?	An environmental adviser has written a newspaper article case study about food production, demand and its problems. As a junior food scientist you have been asked to write a report about the case study to discuss with colleagues at work.	Written report or online blog about the newspaper article
1C.5, 1C.6, 2C.P5, 2C.P6, 2C.M3, 2C.D3	How Should We Breed Plants?	As a horticultural technician you have been asked to produce a talk and handouts for a group of learners visiting your workplace.	Possible oral presentation using slides and computer-generated or written handouts

Unit 15: Investigating a Crime Scene

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **30**

Assessment type: **Internal**

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 will be needed at many different crime scenes, such as road accidents, burglaries and murder scenes. It 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, you will take on the identity of someone employed within the forensic science industry or organisation. In a criminal investigation, scene 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.

You will be introduced to the concept of the criminal justice system and expert witness testimony. You will also 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. You 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 applied biology, applied chemistry and applied physics core units and will extend your knowledge of a range of practical applications.

The aim of this unit is to further develop your science 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 the criminal justice system

B process the information at a crime scene

C analyse evidence collected from a crime scene.

Learning aims and unit content

What needs to be learnt
Learning aim A: Understand the role of crime scene investigation and forensic science and their relevance to the criminal justice system
A.1 Key stages in forensic science investigations: a. scene of crime – where evidence is collected and recorded b. forensic science analysis – biological, chemical and physical techniques used to analyse evidence c. interpretation of analysis – of biological, chemical and physical results d. forensic science and the law and criminal justice system. A.2 Forensic science as science, which is used as evidence in court. A.3 Types of crime: a. murder b. assault c. robbery d. drug crime e. fraud f. arson. A.4 Other situations where science contributes to legal action: a. pollution b. food standards c. trading standards.

What needs to be learnt	
A.5	Types of job involved in forensic science: a. forensic scientist b. forensic analyst c. scene of crime officer (SOCO) d. pathologist e. toxicologist f. odontologist g. detective h. police officer i. archaeologist.
A.6	The criminal justice system: a. criminal law b. magistrate's court and the role of magistrates c. county court and the role of judge and jury d. prosecution e. defence f. victim g. accused h. the trial process i. rules of evidence.
A.7	Criminal Prosecution Service (CPS) and the need for enough valid and reliable evidence to be able to bring about a successful conviction.
A.8	Types of evidence: a. chemical, physical and biological b. photographs and facial recognition from CCTV and mobile phones c. interview d. documents e. computer f. expert witness testimony.
A.9	Value placed on different types of evidence.

What needs to be learnt	
Learning aim B: Process the information at a crime scene	
B.1	Different types of evidence that may be found at crime scenes and that may be used in criminal cases: a. biological evidence: 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 b. physical evidence: 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) c. chemical evidence: toxicology (drugs, alcohol, poisons, identification, weight and purity, body fluid tests), trace evidence (fibres, glass, paint and ink, components, identification and comparison), types of firearms, bullets and gunshot residue.
B.2	Planning to investigate the crime scene: a. identifying the equipment and materials that will be needed b. identifying the order in which tasks should be carried out.
B.3	Identification of potential hazards and estimation of risks at the crime scene: a. presence of suspect b. chemical hazards c. flammable material d. explosives e. biohazards f. sharps.
B.4	Securing the crime scene: a. taping off the scene b. preventing people from entering it c. use of protective clothing to prevent contamination.
B.5	Measuring the scene.
B.6	Sketches and photographs as appropriate to the scene and resources available.
B.7	Searching for evidence: awareness of trace evidence, awareness of the possible variety of evidence.
B.8	Flags to indicate the position of evidence.
B.9	Packaging: suitable packaging should be used to protect the sample from damage and contamination.
B.10	Labelling should show where and when the evidence was found and by whom.
B.11	Transporting evidence in a way that prevents damage and contamination and preserves the chain of continuity.

What needs to be learnt	
Learning aim C: Analyse evidence collected from a crime scene	
C.1	Crime scene analysis techniques: a. 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 b. chemical tests: use of flame tests, spot tests in a test tube, chromatography and colorimetry c. toxicology: identification of drugs such as paracetamol, aspirin, caffeine, alcohol and poisons d. 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 e. the use of DNA profiling, DNA fingerprinting, the national DNA database, DNA extraction and the polymerase chain reaction (PCR) process f. entomology: an understanding of the lifecycle of insects and how the insect population may be used to indicate time and location of death g. 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 h. blood pattern analysis: the blood splatter pattern and volume may give useful information about the direction and force of a blow to a person.
C.2	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.
C.3	Statement of witness: a. personal identification b. date and time of the investigation c. details of steps to secure the crime scene d. location of evidence e. analysis of evidence f. factual conclusions.
C.4	Assess whether there is sufficient evidence to convict.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Understand the role of crime scene investigation and forensic science and their relevance to the criminal justice system			
1A.1 Describe the key stages relating to forensic investigation.	2A.P1 Describe the key stages and the types of jobs relating to forensic investigation and the criminal justice system.	2A.M1 Explain the role of forensic investigation and analysis within the criminal justice system.	2A.D1 Evaluate the usefulness of different types of evidence in convicting a criminal.
1A.2 List types of evidence used in forensic investigation.	2A.P2 Describe how different types of evidence are used in forensic investigation.	2A.M2 Explain the different types of evidence used in convicting a criminal.	

Level 1	**Level 2 Pass**	**Level 2 Merit**	**Level 2 Distinction**
Learning aim B: Process the information at a crime scene			
1B.3 Identify potential health and safety hazards associated with processing a crime scene.	2B.P3 Plan the processing of a crime scene, including an assessment of the potential health and safety risks.	2B.M3 Discuss potential errors in processing a crime scene.	2B.D2 Evaluate the effectiveness of processing a specific crime scene.
1B.4 Describe the steps that are taken to secure and record details of the crime scene.	2B.P4 Explain why the steps are taken to secure and record details of the crime scene.		
1B.5 Collect evidence from a crime scene.	2B.P5 Collect and identify different types of evidence from the crime scene. *		

Level 1	**Level 2 Pass**	**Level 2 Merit**	**Level 2 Distinction**
Learning aim C: Analyse evidence collected from a crime scene			
1C.6 Conduct an analysis of evidence collected from a crime scene and present a summary. *	2C.P6 Conduct analyses on different types of evidence from the crime scene and draw conclusions. *	2C.M4 Link conclusions from analysis of different types of evidence. *	2C.D3 Evaluate whether the evidence collected and analysed would be sufficient to bring about a successful prosecution.
1C.7 Record the results of the analysis of crime scene evidence. *	2C.P7 Present the results of the analysis with interpretation. *		
1C.8 Question a witness to gather evidence of importance to the investigation.	2C.P8 Prepare an outline of a statement of witness, based on the collection and analysis of evidence from the crime scene. #	2C.M5 Write a detailed statement of witness, based on the processing of a crime scene and the analysis of the evidence. #	

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

For this unit an area where a simulated crime scene may be set up and laboratory facilities for analysing evidence are required.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson. Please read this guidance in conjunction with *Section 8 Internal assessment*.

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

Level 1 exemplifies partial achievement within a level 2 learning aim.

Learners must observe safe practice when they are carrying out practical work. It is the responsibility of centres to carry out risk assessments for all practical work that they undertake with their learners. Learners should collect their data under full supervision for health and safety reasons.

Observation records should be provided for all practical assessments in this unit.

The main emphasis in this unit is on carrying out an investigation of a simulated crime scene and exploring the usefulness of the evidence in supporting the conviction of a criminal.

Learning aim A: Understand the role of crime scene investigation and forensic science and their relevance to the criminal justice system

For 1A.1, learners could produce a poster or presentation, describing the key stages involved in a forensic investigation. The number of stages should be limited to the four stages in the unit content. Similarly, a poster or presentation that describes the key stages involved in a forensic investigation could be prepared to allow learners to achieve 2A.P1. This would include a description of the role of individuals and organisations within forensic investigations and the criminal justice system.

For 2A.M1, an explanation of the role of forensic investigation and analysis within the criminal justice system is needed.

For 1A.2, learners could produce a list of the sort of evidence that could be recovered from a crime scene.

For 2A.P2, learners could produce a description of the sort of evidence that could be recovered from a crime scene.

For 2A.M2, learners should be able to explain the different types of evidence in securing convictions. A case study could be provided for this.

For 2A.D1, an evaluation of the usefulness of different types of evidence is required. Learners 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.

Learning aim B: Process the information at a crime scene

Since it would never be known in advance what might be found at a crime scene, learners should be prepared for potential hazards that they might encounter.

For 1B.3, learners should simply list realistic potential hazards, whereas for 2B.P3 they should be able to suggest the precautions necessary to minimise the risks from the 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. 2B.P3 also requires learners to plan the other aspects of processing a crime scene, such as what materials and equipment to prepare and the anticipated stages of the process.

For 1B.4, learners need to 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.

For 2B.P4, learners need to explain why these steps are taken to secure the crime scene. The learners need to explain why the steps in 1B.4 are important, for example, the use of protective clothing to prevent contamination of the crime scene.

A detailed observation report would be good evidence to support achievement of 1B.4 and 2B.P4. This should include observation of the learners taking photographs of where evidence was found and these photographs should be included in the learners' work. Learners should be observed 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 the learners to collect for analysis in the simulated crime scene, in relation to 1B.5.

For 1B.5 and 2B.P5, learners must be observed using handling techniques that minimise possible contamination and transportation damage and must label evidence carefully, identifying the different types of evidence for 2B.P5.

For 2B.M3, learners should discuss potential errors in processing a crime scene. They must identify the consequences of following or not following some aspect of good practice.

For 2B.D2, learners need to reflect on their own effectiveness in processing the crime scene. They should identify what they did well and what they did badly and justify the consequences that their actions would have in relation to the reliability/validity of the evidence collected.

Learning aim C: Analyse evidence collected from a crime scene

For 1C.6 and 2C.P6, there must be appropriate documentation to record the analysis undertaken, linking the samples to the results clearly.

Because the level 2 learners have collected more evidence for 2B.P5, more analysis would be undertaken for 2C.P6 and more recording needed for 2C.P7. Learners could be given a simple proforma to complete for both 1C.7 and 2C.P7. However, learners would be expected to produce more useful and detailed records for 2C.P7 that are appropriate for the analysis. Learners could design their own recording documentation for 2C.P7.

For 2C.M4, 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 no obvious links between the conclusions drawn from the analysis.

For 1C.8 , it should be possible for learners to question a witness to gather evidence of importance to the investigation. To do this, learners should prepare the questions they need to ask a witness. An observation record is required as evidence for meeting this assessment criteria. Writing a formal statement of witness is likely to be too advanced for level 1 learners.

For 2C.P8, 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. Learners should produce more detail, descriptions, rather than lists, in their statements in order to achieve 2C.M5.

For 2C.D3, 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.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1A.2, 2A.P1, 2A.P2, 2A.M1, 2A.M2, 2A.D1	A Small Matter of Evidence	You are a junior journalist specialising in science/technical issues for a local paper. You have been asked to produce information for a youth club about how the criminal justice system works. A visiting speaker who has a knowledge of forensic science or from the police would be of value to learners.	Presentation and handouts outlining key terms and showing links between organisations Written leaflet to cover the greater amount of detail required for 2A.M1, 2A.M2, 2A.D1
1B.3, 1B.4, 1B.5, 1C.6, 1C.7, 1C.8, 2B.P3, 2B.P4, 2B.P5, 2C.P6, 2C.P7, 2C.P8, 2B.M3, 2C.M4, 2C.M5, 2B.D2, 2C.D3	Who Stole the Painting?	You have two roles - as a scene of crime officer and as a forensic analyst. A valuable painting has been stolen. You have been asked to investigate the crime scene and analyse the evidence. You will have to decide whether there is useful evidence and analyse the scene. You may also have to write a statement of witness.	Observation report for as many criteria as possible Plan (1B.3 and 2B.P3) Photographs and sketches, records of evidence collected, analysis records Proformas covering 1B.4, 1B.5, 1C.6, 1C.7, 1C.8 Evaluation (2B.M3, 2C.M4, 2B.D2, 2C.D3) Statement of witness (2C.P8, 2C.M5)

Unit 16: Science in Medicine

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **30**

Assessment type: **Internal**

Unit introduction

Medical science is an important field of study and medical scientists in their different roles are required to have many scientific skills, such as observation, analysis, diagnosis, laboratory techniques, keeping logs and report writing. You should have the chance to see realistic working environments, such as diagnostic laboratories, doctors' practices with diagnostic facilities, medical walk-in centres and hospital laboratories. A lot of the work is now automated but interpretation of results by a qualified person is still needed.

Your knowledge, understanding and, where practicable, skills will be developed in the 'detective work' aspect of diagnosing problems in human body systems. You will learn about a range of available treatments, and the principles of treatment selection based on diagnosis, cost, ethics and availability.

You will investigate the diagnosis and treatment of diseases or conditions that occur when human body systems malfunction, including how pharmaceutical and physical treatments are used to deal with them. You will also look at ethical issues around the availability of treatments.

You will gain a better understanding of the processes involved in diagnosis of illness, different options for treatment, and factors that influence the treatment chosen. You will need to make judgements based on evidence about the likely diagnosis and will be given scenarios that influence the administration of treatment. All examples will require knowledge of the UK system of health administration.

The problems of 'ethical judgements and decisions' will be introduced so you can contribute to contemporary and medically related debates.

The concept of using scientific knowledge and procedures to work out when a human biological system malfunctions is introduced, i.e. the process of diagnosis, and subsequently the use of scientific knowledge and scientific procedures in the treatment of illness. The assumption that all known treatments are available to all people is challenged and you are encouraged to have a view on current issues.

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.

Learning aims and unit content

What needs to be learnt	
Learning aim A: Explore the scientific procedures used in diagnosing illness	
A.1	Physical diagnosis using external appearances, including rashes and swelling.
A.2	Normal range of body temperature measurements.
A.3	Blood pressure measurements and the significance of deviations from these norms.
A.4	Body scans using: a. X-rays b. computerised tomography (CT) scans c. magnetic resonance imaging (MRI) scans.
A.5	Endoscopy procedures (gastroendoscopy).
A.6	Biological diagnosis (pathology) of microbiological organisms causing disease: a. bacteria b. viruses c. parasites.
A.7	Haematology, including the cellular structure of blood, and abnormalities (leukaemia).
A.8	Chemical analysis of: a. blood, including blood cholesterol levels b. sputum c. urine, including urine sugar levels d. faeces.
A.9	Cytology (cell appearance) used in cervical smear tests.
A.10	Genetic investigations, involving DNA analysis and family history counselling, for genetically controlled diseases.

What needs to be learnt	
Learning aim B: Investigate the scientific principles of treating illnesses and health conditions	
B.1	Analgesics and their uses.
B.2	The use of anti-inflammatories.
B.3	The use of antibiotics.
B.4	The use of antihistamine.
B.5	Chemical replacement treatments involving drugs such as insulin.
B.6	Other groups of drugs used for various treatments: a. cytological chemotherapy b. antidepressants c. stimulants d. sedatives e. heart drugs.
B.7	Drug formulations, including cream, ointment, patch, tablet, capsule, oral liquid, injection liquid.
B.8	Administration of therapeutic drugs by various routes: a. topical b. oral c. inhalation d. intravenous injection e. subcutaneous injection.
B.9	Types of surgery (appendectomy).
B.10	Other forms of treatment: a. using radiotherapy for cancer treatment b. laser therapy for short sightedness and removal of skin blemishes.
B.11	Different forms of therapy: a. physiotherapy used in muscular sport injuries b. osteopathy for back injuries c. alternative therapies (acupuncture).
B.12	Replacement and preventative therapies.
B.13	The use of blood and plasma transfusions.
B.14	The use of vaccinations.
B.15	Organ transplants.

What needs to be learnt	
Learning aim C: Know the factors affecting treatments	
C.1	Risk factors associated with treatments: a. side effects b. age c. allergies d. addictive properties e. antagonistic treatment regimes f. anaesthesia g. surgical procedures.
C.2	Social and ethical considerations about cultural beliefs and 'right to life' involving: a. judgement of benefit b. judgement of continuation of life support c. abortions.
C.3	Cost of treatments to the NHS to include: a. financial considerations about cost of treatment to the National Health Service b. allocation of finite resources c. regional availability of resources d. waiting lists e. private medicine.
C.4	Religious views concerning: a. contraception b. blood transfusions.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Explore the scientific procedures used in diagnosing illness			
1A.1 Identify some of the types of investigations used to diagnose illnesses.	2A.P1 Describe biological and physical procedures used to diagnose illness.	2A.M1 Explain the scientific principles underlying the biological and physical procedures used to diagnose illness.	2A.D1 Evaluate the advantages and disadvantages of using biological and physical procedures to diagnose illness.
Learning aim B: Investigate the scientific principles of treating illnesses and health conditions			
1B.2 Identify the physical therapies used to treat given illnesses.	2B.P2 Describe the scientific principles of physical therapies used to treat given illnesses.	2B.M2 Discuss the advantages of having physical and therapeutic treatments available, alongside preventative measures.	2B.D2 Evaluate, using scientific evidence, which physical therapies, therapeutic drugs and preventative measures are effective in the treatment of illnesses.
1B.3 Identify therapeutic drugs available to treat a specific illness.	2B.P3 Describe the scientific principles of therapeutic drugs used to treat given illnesses, and their methods of delivery.		
1B.4 Describe the term ‘preventative medicine’.	2B.P4 Describe techniques used within preventative medicine and their role in healthcare.		

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim C: Know the factors affecting treatments			
1C.5 Identify risks associated with some types of treatments.	2C.P5 Identify general risks of specified treatments and the factors affecting patient choice.	2C.M3 Explain the relationship between available treatments and what is offered to patients.	2C.D3 Discuss why some individuals may choose not to take advantage of all types of available treatments.
1C.6 Identify factors affecting the choice and availability of treatments to patients.	2C.P6 Describe the factors affecting the choice and availability of treatments to patients.		

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

There are no special resources needed for this unit.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson. Please read this guidance in conjunction with *Section 8 Internal assessment*.

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

Level 1 exemplifies partial achievement within a level 2 learning aim.

Learners must observe safe practice when they are carrying out practical work. It is the responsibility of centres to carry out risk assessments for all practical work that they undertake with their learners. Learners should collect their data under full supervision for health and safety reasons.

Observation records should be provided for all practical assessments in this unit.

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

For 1A.1, learners may have carried out investigations into how diseases are diagnosed but this criterion requires them only to list the types of investigations that can be carried out. They are not expected to include everything that is listed in the content but representative examples should be given so the assessor can see the learners are aware of the range of diagnostic tools available.

For 2A.P1, learners are required to describe the diagnostic procedures that are both physical and biological. The descriptions given should include what the procedure involves, although detailed descriptions of the workings of body scanners etc are not required. The focus is on the principles needed and the diagnosis the machine can help the physician with.

For 2A.M1, learners are required to show that they understand the principles behind the diagnostic procedures used and can explain them. Again, details of how the machines work are not required; it is the scientific principles that are important. They should be able, for example, to explain the science behind an X-ray machine as opposed to a CT scanner. Learners should not forget that genetic investigations are a diagnostic tool.

For 2A.D1, learners are required to evaluate the use of different diagnostic procedures, following on from the work done in 2A.M1. 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, for example, that they appreciate the dangers of constant exposure to X-rays, the limitations X-rays have in soft tissue diagnosis etc. They should be able to compare, for instance, the use of X-rays to CT or other types of scanners. The learner must evaluate the advantages and disadvantages of the procedures used as examples.

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

For 1B.2, learners will have researched physical therapy treatments and they are required to identify physical therapies used to treat a given illness. The learners must name the illness being treated and identify physical therapies that are appropriate for the illness named.

For 2B.P2, the learners are involved in looking at the scientific principles of physical therapies. A list of such therapies is not sufficient. The learners must name some given illnesses and then describe the appropriate physical therapies for each named illness.

For 1B.3, learners need to name an illness and then identify what therapeutic drugs are available to treat it. The learners will be expected to give more than one drug used in the treatment. The formulation of the drug, how it is administered and possible side effects do not need to be included.

For 2B.P3, learners must identify some illnesses and what therapeutic drugs can be used for them. Following on from this, the learners must describe the scientific principles behind the drugs being used and how they are delivered. It would be expected that correct terminology such as intravenous injections, oral administration, etc will be used. The scientific principles do not need to include the molecular structure of drugs.

For 1B.4, learners need to describe preventative medicine. Assessors should remind learners before they begin the assignment that often treatment that is started because of an illness can help prevent it recurring. The most obvious example is asthma where the inhalers help the person's breathing and if continued can prevent further asthmatic attacks.

For 2B.P4, learners need to describe the techniques that can be used within preventative medicine. The learners then need to relate these to how they are used in healthcare, giving some actual examples of their uses.

For 2B.M2, learners need to show an understanding of physical and therapeutic treatments plus preventative measures. The learners will probably find it easier to use an illness, such as cancer, as an example of the use of different treatments and preventative measures. The assessor will be looking for the learners to show how a patient undergoing treatment may also be given advice about how to avoid further outbreaks of the problem. One of the obvious examples will be the treatment of lung cancer and the advice to stop smoking.

For 2B.D3, learners need to provide evidence of research into the scientific evidence, supporting therapies and preventative treatments. The learners have to use the scientific evidence to evaluate how effective treatments are. The treatments must cover physical therapies, therapeutic drugs and preventative measures.

Learning aim C: Know of the factors affecting treatments

A lot of modern diagnostic work involves automated equipment, which a centre may not have, however, learners do need to see and hopefully use such equipment. Video evidence is possible but most laboratories will probably not allow filming.

It is not expected that learners will be involved in making and distributing drugs to patients but they do need to know the different physical formats of drugs, for example, creams, pills, etc and the reasons for the different formulations (physical not chemical, i.e. why something comes as a pill instead of a cream, tablet, capsule or lotion, etc) as well as how each is administered. This is a large section in this unit as it also covers different types of surgery and other types of treatments to treat a diagnosed illness. The learners should not lose sight of preventative medicine and therapies in this section. All of this section has to be vocationally related and outside speakers are essential at the delivery stage. Nurses, health workers and medical technicians will have a lot to offer here.

For learning aim C on the factors affecting treatment, other health professionals may provide an insight into the NHS and its financial constraints and how they affect treatments. Interesting discussions could be held regarding social and ethical considerations involved in medicine, plus who has the right to make decisions.

For 1C.5, learners must identify treatments and the risks associated with them must be given correctly.

For 2C.P5, learners are required to identify what general risks are associated with some named treatments. Additionally the learners must state what factors might affect a patient's choice of treatment.

For 1C.6, learners are required to identify factors that affect a patient's choice of treatment. Additionally the factors affecting the availability of treatments must also be listed.

For 2C.P6, learners need to describe the factors affecting the choice and availability of treatments to patients.

For 2C.M3, learners need to discuss a variety of treatments that may be available but explain that there are numerous factors that affect the treatment offered. They are not asked to make judgements about whether such things are right or wrong but just to explain what happens.

For 2C.D3, learners should not make judgements about whether the patient is right or wrong in the decisions they make. They are being asked to discuss why they make decisions to have one kind of treatment rather than another. The ethical side of access to medicine requires an awareness of the variations of treatment due to geographical area and availability of finances, which can be discussed using role play and written reports.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 2A.P1, 2A.M1, 2A.D1	How Many More Tests?	As a junior medical science technician you are learning about the basic diagnostic tests. You have been asked to write a report as part of your probationary year. A visit to a medical laboratory or a visit from a medical laboratory scientist from a hospital would be helpful.	Research and information from visits, as a report or presentation.
1B.2, 1B.3, 1B.4, 2B.P2, 2B.P3, 2B.P4, 2B.M2, 2B.D2	What is the Best Treatment – Do I Have a Choice?	As a junior medical scientist you have been asked to look at the types of treatments and preventative measures available to patients so they are aware of what could be offered by the doctor. Write a report with a table of treatments.	Report with a table of treatments against the illnesses and the reasons why they are used, along with preventative measures being offered.
1C.5, 1C.6, 2C.P5, 2C.P6, 2C.M3, 2C.D3	What Other Treatments are Available?	The nurses in a hospital would like to give patients some kind of handout about types of treatments. They have also come across patients who are suspicious that they are not being given the most effective treatment because of cutbacks. The managers have asked you as the junior medical scientist to produce some pamphlets (or videos, booklets etc) for the nurses to give to patients.	This could be a table of non-drug treatments against the illness and the reasons why they are used. The learners may prefer to do a series of booklets, or a short video presentation for patients to watch with a booklet to summarise the information.

Unit 17: Understanding Human Behaviour

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **30**

Assessment type: **Internal**

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 the National Health Service, social services and education.

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

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

You 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, etc. You will be looking for evidence to support these various theories. You 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.

Learning aims and unit content

What needs to be learnt
Learning aim A: Explore different ways to understand human behaviour
A.1 Different approaches in psychology: a. biological approach b. cognitive approach c. social psychology d. behavioural approach. A.2 Understanding human behaviour: a. origins of behaviour b. outcomes and patterns of behaviour c. treatment and changing behaviour d. whether behaviour is innate (nature) or learned (nurture).
Learning aim B: Investigate biological influences on behaviour
B.1 Biological influences: a. how the brain can influence behaviour (brain lateralisation, gender) b. hormones and the nervous system (gender, fight or flight, relationships) c. genes and evolutionary psychology (gender, individual differences, survival behaviours) d. development (effect of illness, autism) e. aggression f. stress. B.2 Methods of investigating biological influences on behaviour: a. experiments b. longitudinal studies c. twin studies d. adoption studies e. brain scans.

What needs to be learnt	
Learning aim C: Investigate social influences on behaviour	
C.1	Social influences: a. role models (Bandura) b. families c. television, internet and games.
C.2	Learning behaviour: a. conditioning b. social learning (obedience, group behaviour) c. Social Learning Theory (SLT).

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Explore different ways to understand human behaviour			
1A.1 Outline two different approaches to understanding human behaviour.	2A.P1 Describe four different approaches to understanding human behaviour.	2A.M1 Compare and contrast the different approaches to understanding human behaviour.	2A.D1 Evaluate the limitations and benefits of methods used in different approaches to understanding changes in human behaviour.
1A.2 Identify a way in which human behaviour can be changed.	2A.P2 Describe a way in which human behaviour can be changed.	2A.M2 Explain a way in which human behaviour can be changed.	
Learning aim B: Investigate biological influences on behaviour			
1B.3 Identify one way the nervous system influences behaviour.	2B.P3 Describe how the nervous system influences behaviour.	2B.M3 Explain, using relevant examples, how the nervous system influences behaviour.	2B.D2 Evaluate how behaviour can be considered innate, using examples.
1B.4 Identify methods to investigate biological influences on behaviour.	2B.P4 Describe different methods to investigate biological influences on behaviour.	2B.M4 Explain advantages and disadvantages of different methods of investigating biological influences on behaviour.	
1B.5 Identify a way that genetics affect behaviour.	2B.P5 Describe how genetics affect behaviour, using an example.	2B.M5 Explain why studies of twins and adoption are useful to investigate behaviour.	

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim C: Investigate social influences on behaviour			
1C.6 Identify the social influences that affect our behaviour.	2C.P6 Describe how social influences affect our behaviour.	2C.M6 Explain how behaviour can be learnt from others, using examples.	2C.D3 Evaluate how behaviour can be considered learnt, using examples.
1C.7 Identify examples of Social Learning Theory.	2C.P7 Describe Social Learning Theory.	2C.M7 Explain how Social Learning Theory can explain behaviour, using examples.	

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

There are no special resources needed for this unit.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson. Please read this guidance in conjunction with *Section 8 Internal assessment*.

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

Level 1 exemplifies partial achievement within a level 2 learning aim.

Learners must observe safe practice when they are carrying out practical work. It is the responsibility of centres to carry out risk assessments for all practical work that they undertake with their learners. Learners should collect their data under full supervision for health and safety reasons.

Observation records should be provided for all practical assessments in this unit.

Learning aim A: Explore different ways to understand human behaviour

For 1A.1, learners must outline two different approaches used in psychology to understand human behaviour. This must include the main concepts/focus of the approach, e.g. the biological approach explores how the human body determines how we think and behave.

For 2A.P1, learners must describe each of the four different approaches used in psychology to understand human behaviour; biological, cognitive, social and behavioural.

For 2A.M1, learners must develop their understanding of the different approaches by comparing and contrasting the methodologies that each approach uses.

For 1A.2, identifying a way in which human behaviour can be changed could be in reference to a case study.

For 2A.P2, learners must describe one example of how human behaviour can be changed, for example, in relation to a phobia.

For 2A.M2, learners must extend their work for 2A.P2 by explaining how the behaviour can be changed, for example, how the phobia was treated.

For 2A.D1, learners build on their work from the other criteria by considering how different approaches view the nature/nurture debate, using examples to construct their argument.

Learning aim B: Investigate biological influences on behaviour

Building on the investigation in learning aim A, learners will focus on the biological approach in psychology and explore how the brain, nervous system and genetics affect our behaviour. This can be assessed through the study of one aspect of behaviour, for example, stress or aggression, comparing studies of the brain, the nervous system, genetic differences and methodologies.

Learners should be aware of how hormones and the brain affect our behaviour, using case studies or concepts from given experiments.

For 1B.3, learners must give one example only of how the nervous system influences behaviour, and this does not have to be related to a real-life case.

For 2B.P3, learners must describe how the nervous system affects our behaviour. This could relate to the brain or to hormone responses.

For 2B.M3, learners need to explain how the nervous system affects our behaviour, giving relevant examples by referring to specific case study materials.

For 1B.4, a list of methods used to investigate the biological influences on behaviour will be sufficient. Explanations about the methods and how they are used is not required.

For 2B.P4, learners are required to produce a description of the different methods used in investigating biological influences on behaviour. A list is not sufficient and each method given must be described accurately.

For 2B.M4, learners need to explain the advantages and disadvantages of the methods given in 2B.P4 by providing details and giving reasons and/or evidence to clearly support their explanation.

For 1B.5, learners are required to give one way in which genetics affects behaviour. Although they have to identify this most learners will give a short explanation to make it relevant.

For 2B.P5, learners are required to describe one example showing how genetics affects behaviour. If no example is given then an explanation by itself does not meet the criterion.

For 2B.M5, learners need to explain what the studies of twins and adoptees involve. The assessor must make sure that the learners have explained why such studies are useful in investigating behaviour. A description of what happened is not sufficient; the explanation must include the importance of such studies.

For 2B.D2, learners must give an evaluation of how behaviour could be considered innate, with examples from genetic, brain-based and hormonal influences on our behaviour, based on referenced studies. Learners could consider any disadvantages of each study.

Learning aim C: Investigate social influences on behaviour

For 1C.6, learners must identify how social influences affect our behaviour. The learner will probably give some examples that will help in their identification.

For 2C.P6, learners are required to give a description of how social influences affect our behaviour and the learners will probably use examples to illustrate their work.

For 2C.M6, learners are required to explain learnt behaviour, but it must be illustrated, using more than one example. If no example or only one example is given, then the criterion will not be met.

For 1C.7, learners should give examples of behaviours that can be attributed to the Social Learning Theory, e.g. smoking. More than one example must be given

For 2C.P7, learners must describe Social Learning Theory. For learners it will be easier if they state the theory and then describe it, but the criterion asks for a description rather than just a definition so assessors should be aware of this.

For 2C.M7, examples form the basis of the explanation required. Learners can use the example to explain how Social Learning Theory is used in explaining behaviour. Assessors should ensure the learners have access to suitable examples for this criterion.

For 2C.D3, learners must give an evaluation of how behaviour could be considered learnt, with at least two examples from Social Learning Theory. These examples could come from case studies. Learners should consider the advantages and disadvantages of each study, and show evidence of considering opposing views on the matter. Learners should then complete their evaluation by saying how each case study could have been improved. The learner must evaluate the work and not just give an explanation.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment evidence
1A.1, 1A.2, 2A.P1, 2A.P2, 2A.M1, 2A.M2, 2A.D1	Approaches in Psychology	You have started to work in a school as a new psychology teacher. You have been asked to support the science section of the learning resources department to produce materials on: How can we understand human behaviour? Compile a case study for your class to use in investigating different approaches in psychology, including: ● what each approach is ● how it investigates behaviour ● how behaviour can be changed. A psychologist speaker from a university or psychology society would be helpful to motivate learners and assist them in gathering information towards their assignment evidence.	Case study or presentation

Criteria covered	Assignment title	Scenario	Assessment evidence
1B.3, 1B.5, 2B.P3, 2B.P5, 2B.M3 1B.4, 2B.P4, 2B.M4, 2B.M5, 2B.D2	How We Behave.	You are a human biology expert, specialising in psychology and working for the NHS. You have been asked to prepare resources for training new junior nurses on: How does our body explain behaviour? Put a case study together for one type of behaviour (e.g. response to stress) to show: ● how the nervous system affects how we behave ● how our genes affect how we behave ● how this type of behaviour has been investigated. As a psychology assistant in a behavioural unit of a health institution, you have been asked to investigate: ● how behaviour has been investigated ● advantages and disadvantages of the methods used ● innate behaviour.	Case study, presentation Case studies to illustrate investigative methods, presentation

Criteria covered	Assignment title	Scenario	Assessment evidence
1C.6, 2C.P6, 2C.M6 1C.7, 2C.P7, 2C.M7, 2C.D3	How Do the People Around Us Affect the Way We Behave?	You have started to work as a psychologist and have been asked by your mentor to put together a script and storyboard using the title below: How do people around us affect our behaviour? Write a script and a storyboard for a TV programme to explain how humans influence each other's behaviour. You should include: ● examples of how behaviours are learnt ● examples of Social Learning Theory. Your script should describe the key ideas from each type of approach, and aim to explain these ideas to an audience of your peers. A visiting psychology speaker would be helpful to motivate learners and assist them in gathering information towards their assignment evidence. Your mentor has also asked you to put together a report on 'social influences'. You need to consider learning behaviour in terms of: ● conditioning ● social learning, such as obedience ● Social Learning Theory.	Script, outline storyboard of scenes Report, presentation

Unit 18: Designing and Making Useful Devices in Science

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **30**

Assessment type: **Internal**

Unit introduction

Recent 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 you to develop your 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. You will learn about the simplicity of the design process and appreciate the essential science involved.

You will realise the importance of time considerations, costs and availability of materials during the planning, designing, building and testing stages you encounter before creating an effective product. You 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 provide you with 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 you to apply many of the fundamental concepts that you have learned in Units 1, 3 and 6, 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.

Learning aims and unit content

What needs to be learnt	
Learning aim A: Design and build a hydrometer	
A.1	Consideration of equipment and materials to be used: a. specific properties of materials – density b. implications of costs c. flexibility d. shape.
A.2	Health and safety aspects.
A.3	Calibration.
A.4	Pre-testing.
A.5	Suitability of materials
A.6	Outline planning and drawings.
A.7	Construction using materials from the planning stage.
A.8	Testing and evaluating effectiveness for measuring the concentration of sugar solutions and making improvements.

What needs to be learnt	
Learning aim B: Design and build a polarimeter	
B.1	Consideration of equipment and materials to be used: a. specific properties of materials – transparency b. implications of costs c. flexibility d. shape e. light source f. sugar solutions g. Polaroid film.
B.2	Health and safety aspects.
B.3	Calibration.
B.4	Pre-testing.
B.5	Suitability of materials
B.6	Outline planning and drawings.
B.7	Construction using materials from the planning stage.
B.8	Testing and evaluating effectiveness for measuring the concentration of sugar solutions and making improvements.

What needs to be learnt	
Learning aim C: Design and build a cell	
C.1	Consideration of equipment and materials to be used: a. specific properties – malleable, ductile, brittle, porous, conductive, non-conductive b. acids/alkalis (fruit or chemical solutions) c. sandpaper d. coins e. voltmeter f. LED g. copper and zinc sulfate solutions.
C.2	Health and safety aspects.
C.3	Producing results tables.
C.4	Outline planning and drawings.
C.5	Construction using materials from planning stage.
C.6	Testing and evaluating effectiveness and making improvements.

What needs to be learnt	
Learning aim D: Design and build a microbalance	
D.1	Consideration of equipment and materials to be used: a. specific properties – malleable, ductile, brittle, porous b. U-shaped metal c. small squares of graph paper d. scissors e. straws f. base g. pin h. clamp and stand (or equivalent).
D.2	Health and safety aspects.
D.3	Calibration.
D.4	Pre-testing.
D.5	Suitability of materials: a. paper b. card c. plastics d. metal e. wood f. tape.
D.6	Outline planning and drawings.
D.7	Construction using materials from the planning stage.
D.8	Testing and evaluating effectiveness and making improvements.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Design and build a hydrometer			
1A.1 Construct a hydrometer from secondary evidence, including how to determine its effectiveness. *	2A.P1 Design, construct, calibrate and test a working hydrometer to accurately measure the concentration of a sugar solution, recording primary data. *	2A.M1 Explain how scientific principles influenced the design considerations of the hydrometer.	2A.D1 Evaluate the hydrometer, commenting on its performance and suggesting improvements to the finished product. *
Learning aim B: Design and build a polarimeter			
1B.2 Construct a polarimeter from secondary evidence, including how to determine its effectiveness. *	2B.P2 Design, construct, calibrate and test a working polarimeter to accurately measure the concentration of a sugar solution, recording primary data. *	2B.M2 Explain how scientific principles influenced the design considerations of the polarimeter.	2B.D2 Evaluate the polarimeter, commenting on its performance and suggesting improvements to the finished product. *

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim C: Design and build a cell			
1C.3 Construct different cells from secondary evidence, including how to determine their effectiveness. *	2C.P3 Design, construct and test different working cells, recording primary data. *	2C.M3 Explain how scientific principles influenced the design considerations of different cells.	2C.D3 Evaluate the cells, commenting on their performance and suggesting improvements to the finished products. *
Learning aim D: Design and build a microbalance			
1D.4 Construct a microbalance from secondary evidence, including how to determine its effectiveness. *	2D.P4 Design, construct and test a working microbalance, recording primary data. *	2D.M4 Explain how scientific principles influenced the design considerations of the microbalance.	2D.D4 Evaluate the microbalance, commenting on its performance and suggesting improvements to the finished product. *

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources required for this unit are:

- Equipment to construct and test the four devices (hydrometer, polarimeter, battery and microbalance).

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson. Please read this guidance in conjunction with *Section 8 Internal assessment*.

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

Level 1 exemplifies partial achievement within a level 2 learning aim.

Learners must observe safe practice when they are carrying out practical work. It is the responsibility of centres to carry out risk assessments for all practical work that they undertake with their learners. Learners should collect their data under full supervision for health and safety reasons.

Observation records should be provided for all practical assessments in this unit.

Learning aim A: Design and build a hydrometer

For 1A.1, learners must build a hydrometer, which could be based on secondary evidence. Learners must propose how they will test the hydrometer to determine its effectiveness for measuring the concentration of sugar solutions.

For 2A.P1, 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.

For 2A.M1, 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 2A.P1. The choice of materials must also be explained, as well as any safety considerations.

For 2A.D1, 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.

Learning aim B: Design and build a polarimeter

For 1B.2, learners must build a polarimeter, which could be based on secondary evidence. Learners must propose how they will test the polarimeter to determine its effectiveness.

For 2B.P2, 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.

For 2B.M2, 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 2B.P2. A detailed understanding of polarisation is not expected. The choice of materials must also be explained, as well as any safety considerations.

For 2B.D2, 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.

Learning aim C: Design and build a cell

For 1C.3, learners must build two different types of cell, for example a Daniell cell and a fruit cell. Learners must propose how they will test the cells to determine their effectiveness.

For 2C.P3, learners must provide a suitable design for two different types of cells, 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.

For 2C.M3, 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 2C.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 2C.D3, 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 used electrolytes or fruit, as opposed to freshly made solutions or ripe fruit.

Learning aim D: Design and build a microbalance

For 1D.4, learners must build a microbalance, which could be based on secondary evidence. Learners must propose how they will test the microbalance to determine its effectiveness. The microbalance should be able to measure, to some degree of accuracy, the mass of a 1 mm^2 piece of paper by using calculation and measurement of 1000 sheets of graph paper on a laboratory top pan balance.

For 2D.P4, 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.

For 2D.M4, 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 2D.P4. The choice of materials should be explained, as well as any safety considerations.

For 2D.D4, 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.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 2A.P1, 2A.M1, 2A.D1	Wine Quality	You are working in the wine industry and have been asked to design, build and test a hydrometer to measure the sugar content in batches of wine. A visiting technical design speaker or a visit to a design centre would help to motivate learners and enable them to gather information towards their evidence.	Design/plan, labelled diagram, product report, witness statement, photographs, observation records
1B.2, 2B.P2, 2B.M2, 2B.D2	Sugar Sweet!	You are a quality technician for a sweet manufacturing company. You have been asked to design, build and test a simple polarimeter to measure the concentration of sugar solutions that are used to produce sweets. A visiting technical design speaker or a visit to a design centre would help to motivate learners and enable them to gather information towards their evidence.	Design diagram with labels, product report, news article for polarimeter designs, witness statement, photographs, observation records
1C.3, 2C.P3, 2C.M3, 2C.D3	Solving the Battery Crisis	You are a journalist for ‘Science Future’, writing an article for ‘fewer but longer-lasting cells’.	Cutaway diagrams, photographs, presentation of cell design, product evaluation, observation records, witness statement
1D.4, 2D.P4, 2D.M4, 2D.D4	Saving Costs on Equipment	You are working as a junior science technician in school, looking for ways to use simple materials to make an accurate balance.	Article related to saving money in science laboratories, ‘How to...’ report for book section, comparison topic of cheap versus expensive devices, witness statement, observation records

Unit 19: Chemical Analysis and Detection

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **30**

Assessment type: **Internal**

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.

You will learn how to identify unknown compounds, using more than one type of analytical technique. Your teacher may present the unit with a forensic slant or from an environmental health standpoint. Your 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? You will learn techniques that will allow you 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 Units 1 and 7) of the periodic table, atomic structure and bonding.

pH is also used in the identification and classification of chemicals. You 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 you 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 your chemistry knowledge and skills in chemical analysis and detection and build on the basic chemistry concepts that you learnt in Units 1, 2 and 5.

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.

Learning aims and unit content

What needs to be learnt	
Learning aim A: Classify substances on the basis of pH	
A.1	Terminology: a. acid, acidic, alkali, alkaline b. weak acid/alkali, strong acid/alkali c. neutral d. pH gives a measure of the concentration of H^+ ions.
A.2	Chemical techniques for measuring pH and acidity: a. red cabbage juice b. litmus paper c. universal indicator (solution and paper).
A.3	Use and calibration of a pH meter.
A.4	Sources of error in techniques for measuring pH in A.2 and A.3.
A.5	Recognise that the greater the concentration of a strong acid, the lower the pH.
A.6	Compare the pH of ethanoic acid and hydrochloric acid of the same concentration and draw conclusions about the concentration of hydrogen ions in each solution.
A.7	Solutions to test: a. familiar solutions: tea, coffee, soft drinks, lemon juice, orange juice, vinegar, wine, water, bleach, milk, soap, washing-up liquid, salt, baking soda, soap, washing powder, washing liquids b. solutions commonly found in the laboratory: sodium hydroxide, hydrochloric acid, ethanoic acid, sodium chloride.

What needs to be learnt	
Learning aim B: Use chemical tests to identify ions and gases	
B.1	Carrying out tests for the following gases: a. hydrogen: squeaky pop test b. oxygen: relights a glowing splint c. carbon dioxide: makes limewater turn milky.
B.2	Structure of ionic inorganic compounds: a. cations b. anions.
B.3	Recognition and use of formulae of ions and ionic compounds.
B.4	Flame tests for cations: a. sodium b. potassium c. lithium d. calcium e. barium f. copper.
B.5	Testing for carbonate ions with acid.
B.6	Testing for chloride ions, bromide ions and iodide ions with dilute nitric acid and silver nitrate solution.
B.7	Testing for sulfate ions with dilute hydrochloric acid and barium chloride solution.
B.8	Naming ions and ionic compounds from formulae.
B.9	Testing unknown substances: a. planning how to undertake testing b. naming a substance, once the anion and cation are identified.
B.10	Writing formulae of ionic compounds.
B.11	Writing equations: a. word equations b. balanced symbol equations c. ionic equations.
B.12	Understanding cross-contamination and false positives.

What needs to be learnt	
Learning aim C: Carry out quantitative analysis on substances	
C.1	Calculation of concentration of solutions in g dm^{-3}.
C.2	Evaporation of a solution to dryness to determine the mass of solute in a given mass of solution.
C.3	The amount of a substance can be measured in grams, numbers of particles or number of moles of particles.
C.4	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).
C.5	Conversion of concentrations in g dm^{-3} into mol dm^{-3} and vice versa.
C.6	Soluble salts can be prepared from an acid and an insoluble reactant: a. excess of the reactant can be added to ensure that all the acid is used up b. the excess reactant can be removed by filtration c. the solution remaining is only salt and water d. the salt can be obtained by crystallisation.
C.7	Soluble salts can be prepared from an acid and a soluble reactant: a. titration must be used to determine the exact amount of the soluble reactant that reacts with an acid b. the acid and the soluble reactant can then be mixed in the correct proportions c. the solution remaining after reaction is only salt and water.
C.8	Acid–base titrations are neutralisation reactions where hydrogen ions (H^+) from the acid react with hydroxide ions (OH^-) from the base.
C.9	Carry out simple acid–base titrations using burette, pipette and suitable acid–base indicators.
C.10	Carry out an acid–base titration to prepare a salt from a soluble base
C.11	Carry out simple calculations using the results of titrations to calculate an unknown concentration of a solution or an unknown volume of solution required.

What needs to be learnt	
Learning aim D: Carry out chromatographic separations	
D.1	Carrying out chromatographic separations on mixtures of substances/extracts using non-instrumental techniques.
D.2	Techniques: a. paper chromatography b. thin-layer chromatography c. column chromatography.
D.3	Substances to separate: a. chlorophyll b. inks c. orange and lemon juice d. a mixture of amino acids e. caffeine from coffee.
D.4	Use information from chromatographs to: a. determine if a substance is pure b. identify the components of a mixture.
D.5	Calculation of Rf value.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Classify substances on the basis of pH			
1A.1 Classify solutions of household and laboratory substances as acidic, alkaline or neutral.	2A.P1 Carry out tests on solutions of household and laboratory substances to determine their pH.	2A.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.	2A.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			
1B.2 Describe practical tests to identify common gases.	2B.P2 Carry out practical tests to identify common gases.	2B.M2 Deduce the identity of unknown substances tested.	2B.D2 Write balanced symbol equations for tests used to identify an unknown substance. *
1B.3 State the formula of named ionic compounds.	2B.P3 State the formulae of ions present in named ionic compounds.		
1B.4 Identify the cations present in unknown substances.	2B.P4 Devise and follow a plan to correctly identify the cations in unknown substances.		
1B.5 Identify the anions present in unknown substances by carrying out simple tests.	2B.P5 Devise and follow a plan to correctly identify the anions in unknown substances.		

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim C: Carry out quantitative analysis on substances			
1C.6 Identify the equipment needed to produce a pure salt.	2C.P6 Prepare salts from soluble and insoluble reactants.	2C.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}. *	2C.D3 Determine the concentration of an unknown solution using data from a titration experiment. *
1C.7 Identify the equipment needed to carry out a titration.	2C.P7 Carry out a titration of an acid and an alkali.		
Learning aim D: Carry out chromatographic separations			
1D.8 Identify the equipment needed to carry out a chromatographic separation.	2D.P8 Carry out chromatographic separation using different techniques.	2D.M4 Calculate an Rf value for a chromatographic separation. *	2D.D4 Analyse the outcomes of a chromatographic separation.

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources required for this unit are good laboratory facilities and a range of suitable chemicals and equipment.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson. Please read this guidance in conjunction with *Section 8 Internal assessment*.

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

Level 1 exemplifies partial achievement within a level 2 learning aim.

Learners must observe safe practice when they are carrying out practical work. It is the responsibility of centres to carry out risk assessments for all practical work that they undertake with their learners. Learners should collect their data under full supervision for health and safety reasons.

Observation records should be provided for all practials assessments in this unit.

Learning aim A: Classify substances on the basis of pH

For 1A.1, learners should test the pH of a limited range, including acidic, alkaline and neutral solutions, of substances using indicator paper or solutions (pH values are not required).

For 2A.P1, learners should be given a more extensive list than at level 1 that will allow them to determine the pH value using universal indicator.

For 2A.M1, 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 2A.P1. They should be able to conclude that the difference in pH is due to there being fewer hydrogen ions in the weak acid.

For 2A.D1, learners should be able to assess the accuracy of the procedures used, identify factors which 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.

Learning aim B: Use chemical tests to identify ions and gases

For 1B.2, learners should describe the tests for hydrogen, carbon dioxide and oxygen correctly. Recording can be on a straightforward proforma.

For 2B.P2, learners should carry out the tests to identify hydrogen, carbon dioxide and oxygen.

For 1B.3, learners should state the formula of at least six named ionic compounds.

For 2B.P3, 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.

For 1B.4, learners should identify at least three unknown cations using flame tests and for 1B.5 learners should identify at least three unknown anions. These are the standard tests for anions and cations as listed in the content of learning aim B.

For 2B.P4, 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. The tests carried out as part of the plan should be those identified in 1B.4. The plan should be devised to be carried out in a logical order.

For 2B.P5, learners are required to devise and follow a plan of how to identify the anions in at least three inorganic substances. The plan could be in the form of a flow chart. The tests carried out as part of the plan should be those identified in 1B.5. The plan should be devised to be carried out in a logical order.

For 2B.M2, 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 2B.D2, learners must write balanced symbol equations for the tests they have carried out. This must be linked to the work carried out in 2B.M2.

Learning aim C: Carry out quantitative analysis on substances

For 1C.6, learners need to identify, label and name each piece of equipment needed to produce a pure salt. The teacher could give a case study or demonstrate the use of the equipment to carry out the preparation of a pure salt.

For 2C.P6, 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.

For 1C.7, learners need to identify the equipment required to carry out a titration. The teacher could give a case study or demonstrate the use of the equipment to carry out a titration.

For 2C.P7, learners need to carry out a simple titration using an acid and an alkali. Assessors should use an observation sheet to record their observations and learners could write a brief laboratory report.

For 2C.M3, learners need to use the mole concept to calculate the concentration of a solution correctly. This could be one they have used in 2C.P7.

For 2C.D3, learners could use the results from 2C.P7 to calculate the concentration of the unknown solution.

Learning aim D: Carry out chromatographic separations

The chromatography undertaken will be determined by the available resources.

For 1D.8, learners could carry out the same paper chromatography separation more than once and identify the equipment needed by labelling a diagram.

For 2D.P8, 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.

For 2D.D4, learners could sketch or photograph chromatograms and calculate Rf values.

For 2D.M4, learners need to analyse the outcomes of the separations, including the analysis of unknowns and reasons why spots move different distances.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 2A.P1, 2A.M1, 2A.D1	pH of Household Substances	You work for the council as a scientific safety adviser. You have been asked to produce a report for the public about the chemistry of household substances and give advice about their storage and use. The first part of that report will be about the meaning of pH and the classification of household chemicals with regard to pH. A visiting analytical chemist speaker or a visit to a chemical analysis laboratory would be helpful to motivate learners and gather information towards their evidence.	Practical report/proforma Observation records
1B.2, 2B.P2 1B.2, 1B.3, 1B.4, 1B.5, 2B.P2, 2B.P3, 2B.P4, 2B.P5, 2B.M2, 2B.D2	Testing unknown substances	You work in a forensic science laboratory. You have been asked to analyse samples from a large landfill site that has been in operation for a number of years. Bubbles of gas are often seen on the ponds at the north of the site. You have been asked to analyse samples of the gas from different areas on the site. The police are investigating an abandoned house where there are several bottles of unlabelled chemicals, believed to be inorganic salts. (The eccentric person who lived in the house was believed to have made his own fireworks.) You must identify these substances so that they can be disposed of safely.	Practical work report/log with suitable proforma Observation records Practical work on known substances and reports/recording results Planning, carrying out and reporting on the analysis of unknown substances Observation records

Criteria covered	Assignment	Scenario	Assessment evidence
1C.6, 1C.7, 2C.P6, 2C.P7, 2C.M3, 2C.D3	Production and Quality Control	You are employed as an analytical science assistant by a science company that manufactures salts on a large scale. You are carrying out quality control tests to ensure the salts are pure. In addition you are also checking the quality of the raw materials by carrying out laboratory preparations and testing the products.	Observation reports for carrying out preparations and titration Results and reports from the learners
1D.8, 2D.P8, 2D.M4, 2D.D4	Are Our Drugs Safe to Use?	You work as an analytical technician in a quality control laboratory for a company that manufactures drugs. There has recently been a scare where contaminated drugs were found in the shops of a chain of local chemists. To restore public confidence, you have been asked to explain how chromatography is used by the pharmaceutical industry to identify impurities.	Observation reports of carrying out chromatographic separations Results and reports of practical work

Unit 20: Exploring Our Universe

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **30**

Assessment type: **Internal**

Unit introduction

There is a growing interest in astronomy and the exploration of our Universe. You 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 you 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.

You 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.

Learning aims and unit content

What needs to be learnt	
Learning aim A: Explore the structure of our Solar System and the Universe	
A.1	Names and key data (diameters, numbers of moons, surface features) of: a. the eight planets b. the dwarf planet Pluto c. exoplanets d. the Sun e. the Moon f. asteroids g. meteors h. comets.
A.2	Orbital characteristics of the eight planets and Pluto: a. distance from the Sun b. pull of gravity c. time for one revolution about the Sun.
A.3	Earth–Moon–Sun system: a. how lunar, solar, full and partial eclipses occur b. gravitation and the link with tides c. axis of rotation d. Moon's rotation about the Earth e. Earth's rotation about the Sun.
A.4	Impact of comets and meteors with planets and moons and how the planetary objects themselves are changing as a result.
A.5	Formation of stars: a. information from space telescopes about how stars are created b. the death of stars related to their size c. influence of gravitation on stars d. gas clouds and nebulae.
A.6	Galaxies and galaxy clusters: a. types of galaxies (Hubble classification) b. characteristics of some well-known galaxies and clusters c. galaxies colliding d. gravitational forces in the centre of galaxies (black holes).

What needs to be learnt	
Learning aim B: Study methods used to explore our Universe	
B.1	Optical telescopes a. reflector b. refractor c. principles of both types with ray diagrams d. their use throughout history and in the present day.
B.2	Other electromagnetic spectrum telescopes: a. radio telescopes b. microwaves telescopes c. infrared telescopes d. ultraviolet telescopes e. X-ray and gamma ray telescopes f. principles of the different types with ray diagrams g. their use throughout history and in the present day.
B.3	Unmanned space missions: a. interplanetary probes b. landers and probes to the sun c. intercept craft (landings on asteroid and comet surface).
B.4	Manned space missions: a. Apollo programme b. International Space Station (ISS) c. NASA Space Shuttle programme d. future missions to Mars.
B.5	Search for Extra Terrestrial Life (SETI) project.

What needs to be learnt	
Learning aim C: Explore theories of how the Universe was formed	
C.1	The Big Bang theory and the age of the Universe (estimate of 13.7 billion years).
C.2	Evidence to support the Big Bang theory:* a. evidence for an expanding Universe (redshift showing galaxies moving away from each other) b. cosmic microwave background radiation and the importance of its detection.
C.3	Limitations of the Big Bang theory: a. dark matter b. dark energy.

*This builds on the content in Unit 3

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Explore the structure of our Solar System and the Universe			
1A.1 Identify the planets in the Solar System.	2A.P1 Describe the main features of the Solar System, including its planets.	2A.M1 Explain the relationship between the bodies in the Earth-Moon-Sun system.	2A.D1 Explain the characteristics of galaxies and galaxy clusters.
1A.2 Identify the different types of galaxies.	2A.P2 Describe the main features of the Universe, excluding the Solar System and including different types of galaxies.	2A.M2 Explain the life cycle of stars.	
Learning aim B: Study methods used to explore our Universe			
1B.3 Identify different types of telescopes.	2B.P3 Describe the different methods used to explore the Universe including the use of different types of telescopes.	2B.M3 Explain why different telescopes are used to observe the Universe.	2B.D2 Analyse how the scientific data collected through observation and space missions is being used. *
1B.4 Describe how manned space missions collect scientific data.	2B.P4 Describe how manned and unmanned space missions collect scientific data.	2B.M4 Compare manned and unmanned space missions, in terms of scientific data collected and their limitations. *	

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim C: Explore theories of how the Universe was formed			
1C.5 Identify the main points of the Big Bang theory.	2C.P5 Describe the Big Bang theory and how it is used to obtain the age of the Universe.	2C.M5 Explain how evidence supports the Big Bang theory.	2C.D3 Evaluate evidence to support the Big Bang theory and limitations of the theory.

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

There are no special resources needed for this unit.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson. Please read this guidance in conjunction with *Section 8 Internal assessment*.

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

Level 1 exemplifies partial achievement within a level 2 learning aim.

Learners must observe safe practice when they are carrying out practical work. It is the responsibility of centres to carry out risk assessments for all practical work that they undertake with their learners. Learners should collect their data under full supervision for health and safety reasons.

Observation records should be provided for all practical assessments in this unit.

Learning aim A: Explore the structure of our Solar System and the Universe

For 1A.1 and 2A.P1, 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 simplified list with the planets in the correct order from the Sun will suffice for 1A.1 but such a list or diagram must be annotated to provide a full description for 2A.P1. A description of the impacts of comets and meteors with planets and moons should also be included for 2A.P1, including how the planetary objects are changed as a result of the collisions.

For 2A.M1, learners need to provide an explanation of 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.

For 1A.2, learners should make a list of the different types of galaxies or they could download images and briefly indicate the type of galaxy shown. Learners should use the Hubble classification of galaxies, e.g. spiral, barred spiral, elliptical and irregular.

For 2A.P2, learners will describe the features of the Universe, including nebulae, galaxies and the effects of gravitation. The description can be a series of annotated diagrams or images.

For 2A.M2, learners need to provide an explanation of the life cycle of stars, including characteristics such as the diameters and mass of stars. The learners could use annotated diagrams or images to achieve this criterion.

For 2A.D1, 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 black holes at the centre of galaxies.

Learning aim B: Study methods used to explore our Universe

For 1B.3, a list of different types of telescopes or annotated images or diagrams should be given.

For 2B.P3, learners must provide information on how we use different techniques to explore the Universe. This could be shown as a comprehensive table of different telescopes and techniques used to explore the Universe.

For 2B.M3, learners are required to provide an explanation of why different telescopes are used to observe the Universe. The 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) etc. 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. The learners might also include ray diagrams to help in the explanation of why different telescopes are used in observations.

For 1B.4, learners need to describe how manned space missions collect scientific data. This could be shown as a table of different manned space missions and data collected by them.

For 2B.P4, learners 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.

For 2B.M4, learners need to compare manned and unmanned space missions so a description of each is not sufficient here. The 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 2B.D2, 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.

Learning aim C: Explore theories of how the Universe was formed

For 1C.5, learners are expected to identify the main points of the Big Bang theory.

For 2C.P5, 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 2C.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.

For 2C.M5, learners may complete this as part of 2C.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 2C.P5. The evidence needs to mention the redshift and cosmic microwave background radiation and its significance in the Big Bang theory.

For 2C.D3, learners are required to produce an evaluation of the evidence to support the Big Bang theory. The learners will have to look at the supporting evidence (given in 2C.M5) and other evidence that may not be supportive of the theory. Descriptions will not be sufficient to achieve this criterion. The learners have 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.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1A.2, 2A.P1, 2A.P2, 2A.M1, 2A.M2, 2A.D1	What's in the Universe?	You are working as an assistant with responsibility for science and astronomy resources in the schools liaison team in a science educational centre. Part of your role is to make models and prepare materials for the science education centre about the Solar System and the Universe. A visiting astronomy speaker or a visit to an observatory would be helpful to motivate learners and gather information towards their evidence.	Development of models, scientific diagrams and data tables assessed through presentation; teacher observation record
1B.3, 1B.4, 2B.P3, 2B.P4, 2B.M3, 2B.M4, 2B.D2	The Final Frontier	You are working as an assistant astronomy technician at a professional astronomical observatory. You have been asked to prepare materials for visiting parties about the exploration of space.	Itemised lists, diagrams, research logbooks and reports
1C.5, 2C.P5, 2C.M5, 2C.D5	The Beginning of Time	You are working as a junior science journalist for a national newspaper. You have been asked to prepare an article on the Big Bang and an evaluation of the evidence that supports it.	Diagrams, timeline of events, presentation, informative newspaper article

Unit 21: Electronics in Action

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **30**

Assessment type: **Internal**

Unit introduction

Almost all electrical equipment we use at home and in the workplace contains electronic components. This unit will enable you to identify electronic components and learn about their uses in the electronics industry for safe, effective circuit design and construction. It will also help you gain some understanding of the way in which some domestic devices operate. You will be provided with step-by-step guidance on the function of electronic components and use those to build simple electronic circuits that are used as 'building blocks' for complex electronic systems.

You 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 emphasis on the importance of using equipment with care. This aspect will become routine in practical lessons and you should follow industrial practice and minimise the risk of accidents and damage.

This unit builds on the investigations into electricity in Unit 6.

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.

Learning aims and unit content

What needs to be learnt	
Learning aim A: Identify electronic components and their uses	
A.1	Resistors: a. fixed resistors (E24 values, colour code, tolerance, power ratings) b. variable resistors.
A.2	Capacitors a. fixed capacitors (values) b. voltage–time graphs for charging and discharging a capacitor through a resistor.
A.3	Diodes and LEDs (values and graphs of turn on voltages for silicon and germanium diodes).
A.4	Switches (tilt and reed), lamps and buzzers.
A.5	Transducers (resistive input): a. light dependent resistors (LDRs) b. moisture detector c. photodetector d. thermistors.
A.6	Transistors: a. types (npn and pnp) b. use as a switch c. use as a current amplifier.
A.7	Integrated circuits: a. logic gates (NOT, OR, AND, NOR, NAND) b. 555 timer (monostable and astable configurations) c. operational amplifiers (741) and use as a comparator.
A.8	Physical appearance and symbols for components in this learning aim.

What needs to be learnt	
Learning aim B: Build electronic circuits and systems safely	
B.1	Health and safety considerations: a. risk assessments b. first-aid procedures (shock/electric or acid burns) c. safe handling of equipment and components d. wiring and cable identification e. general safety precautions (earthing).
B.2	Power sources (batteries, low voltage power supply units).
B.3	Ohm's Law ($V=IR$), series and parallel circuits, power equation ($P = VI$).
B.4	Potential divider circuits.
B.5	Transistor circuits (switch and amplifier) using Bipolar Junction Transistors (BJT).
B.6	Transducers: a. input transducers (thermistor, LDR, moisture detector and photodetector) b. output transducers (LED, buzzer).
B.7	Integrated circuits: a. logic gates (NOT, OR, AND, NOR, NAND) b. 555 timers (monostable and astable configurations) c. operational amplifier as a comparator, using sensors and output devices.
B.8	Systems: a. block diagrams showing input/processor/output b. circuit diagrams c. purpose of systems (home, business, hospitals, cars).
Learning aim C: Check, measure and test electronic circuits	
C.1	Circuit checks: a. check circuit diagram matches circuit layout b. importance of checking for good connections.
C.2	Measurements and testing: a. use of Ohm's Law and potential divider equations to calculate circuit values that can be measured b. use of meters to measure voltage and current c. importance of repeating measurements.
C.3	Importance of health and safety when carrying out checks, measurements and tests on circuits and systems.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Identify electronic components and their uses			
1A.1 Identify electronic components from symbols.	2A.P1 Identify electronic components from symbols and their physical appearance.	2A.M1 Describe the function of electronic components.	2A.D1 Evaluate the advantages and disadvantages of using integrated circuits.
Learning aim B: Build electronic circuits and systems safely			
1B.2 Identify components for building electronic circuits.	2B.P2 Safely construct working electronic circuits.	2B.M2 Calculate expected value of voltages and currents for different places in electronic circuits. *	2B.D2 Evaluate an electronic system and suggest improvements. *
1B.3 Identify the circuit building blocks required for building a specific system.	2B.P3 Safely construct a useful working electronic system that meets an identified purpose.	2B.M3 Explain how the electronic system meets its purpose and identify any weaknesses.	
Learning aim C: Check, measure and test electronic circuits			
1C.4 Carry out checks on constructed circuits safely.	2C.P4 Carry out checks and electrical measurements safely to test circuits. *	2C.M4 Discuss the importance of reliability of measurements on circuits. *	2C.D3 Evaluate electrical measurements of voltages and currents against calculated values. *

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources required for this unit are:

- standard electronic equipment – low voltage power supplies and multimeters (or voltmeters and ammeters)
- a wide range of electronic components.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson. Please read this guidance in conjunction with *Section 8 Internal assessment*.

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

Level 1 exemplifies partial achievement within a level 2 learning aim.

Learners must observe safe practice when they are carrying out practical work. It is the responsibility of centres to carry out risk assessments for all practical work that they undertake with their learners. Learners should collect their data under full supervision for health and safety reasons.

Observation records should be provided for all practical assessments in this unit.

Learning aim A: Identify electronic components and their uses

For 1A.1, learners should be able to identify all components in the content from circuit symbols. This could be achieved through a poster, leaflet, or an exercise from matching cards, for example.

For 2A.P1, learners should be able to identify all components in the content from their associated circuit symbols and physical appearance. For examples, 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.

For 2A.M1, 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 a monostable for timing circuits or as an astable, e.g. to make an LED flash or produce sound effects.

For 2A.D1, learners are expected to evaluate the advantages and disadvantages of integrated circuits over discrete components (include cost, size, power consumption, ease of use).

Learning aim B: Build electronic circuits and systems safely

For 1B.2, learners need to identify the components required for building specific electronic circuits. This is best facilitated by providing learners with a range of components from which they must make an appropriate choice.

For 2B.P2, learners must construct a sufficient number of working circuits to cover all components in the content. 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.

For 2B.M2, 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 2B.P2 learners should have previously 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.

For 1B.3, learners must demonstrate that they can identify the building blocks that are needed for a given electronic system by providing a block diagram showing the input, processing and output stages. A typical system may be a temperature indicator that flashes a LED when a set temperature is reached. This system will consist of a sensor, comparator and 555 timer. Another example of a suitable system is a burglar alarm that uses logic circuits to detect the state of several switches and a transistor amplifier to operate a buzzer when the state of a switch is changed.

For 2B.P3, learners must construct a useful working electronic system, from a minimum of two smaller circuits that may have been constructed in 2B.P2. This could be any of the systems mentioned for 1B.3, for a specific purpose. Aspects of safety and correct handling are to be clearly demonstrated and must be evidenced by an observation record.

For 2B.M3, learners must explain how their system meets its purpose and identify any weaknesses. This will relate all input changes to the eventual output.

For 2B.D2, 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 the burglar alarm in 1B2. Sound reasoning and valid suggestions are required to achieve this criterion.

Learning aim C: Check, measure and test electronic circuits

Learners could carry out measurements and tests on the circuits built for learning aim B to achieve the criteria in learning aim C.

For 1C.4, learners must demonstrate that they can check a simple circuit layout against a circuit diagram and check for loose connections. This should be evidenced by a teacher witness statement.

For 2C.P4, learners must use appropriate test equipment to measure voltages and currents at various points in their circuits. Results could be shown on a circuit diagram.

For 2C.M4, learners must discuss the importance of reliability of measurements, for electric circuits, by repeating measurements.

Learners could measure the voltages and currents that were calculated in 2B.M4 for evaluating electrical measurements against calculated values to achieve 2C.D3. Learners should account for any differences, for example by referring to the tolerance of components.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 2A.P1, 2A.M1, 2A.D1	Electronic Building Blocks	You are working as a technical adviser for an electronic supplier. Part of your role is to update the annual catalogue with the new electronic components, their uses, and information on integrated circuits. A visit to a manufacturer would be helpful to motivate learners and gather information towards their evidence.	A catalogue with photos or drawings of components and their circuit symbols and a description Presentation on integrated circuits including slides with accompanying notes
1B.2, 2B.P2, 2B.M2, 2B.D2 1B.3, 2B.P3, 2B.M3, 2B.D2 1C.4, 2C.P4, 2C.M4, 2C.D3 1B.3, 2B.P3, 2B.M3, 2B.D2 1C.4, 2C.P4, 2C.M4, 2C.D3	Putting the Puzzle Together	You are working as an electronics technician in an electronic manufacturing company. You have been asked to build electronic circuits/systems safely and keep a record, showing diagrams and calculations used. Part of your role as an electronics technician is to test the electronic circuits, carrying out checks and measurements.	Scientific report for electronics employer, including expected currents and voltages for a circuit, photograph of circuit, observation record Observation record, scientific report

Unit 22: Biotechnology Procedures and Applications

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **30**

Assessment type: **Internal**

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 you will research the areas mentioned above and their underlying principles. You will research the manipulation of DNA and the host organisms that are used. By the end of the unit, you should be able to describe the uses of biotechnology and how biotechnology is used in a laboratory environment. You 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.

Learning aims and unit content

What needs to be learnt
Learning aim A: Explore how the biotechnology industry has developed
A.1 Definition of the term 'biotechnology' A.2 Principles, explanations and advantages/disadvantages of historical biotechnology processes: a. breeding of plants and animals b. gathering/processing herbs for medicine, bread, cheese and vaccines. A.3 Principles, applications and advantages/disadvantages of using the following contemporary biotechnology processes: a. artificial selection b. genetic manipulation.

What needs to be learnt	
Learning aim B: Explore how biotechnology is used in our everyday lives	
B.1	The characteristics and advantages/disadvantages to society of the following products of biotechnology: a. biodegradable plastics b. biofuels c. genetically modified crops d. detergents e. drugs f. medical treatments for illness/disease g. human enzymes h. functional proteins i. tissue culture (stem cell technology and fertility treatments).
B.2	The applications and advantages/disadvantages of using biotechnology techniques and how they influence our lives: a. drug production b. large-scale laboratory production of materials c. production of fuels and detergents.
B.3	Principles and explanations of issues surrounding the use of biotechnology: a. ethical considerations of biotechnology b. drawbacks of using biotechnology c. risks associated with new technologies d. clinical efficacy and longevity of treatments e. lack of long-term scientific trials for side effects.
B.4	Principles, explanation, applications and advantages/disadvantages of DNA isolation: a. theory of DNA isolation b. procedure used for DNA isolation c. uses of DNA once isolated.

What needs to be learnt	
B.5	The explanation and advantages/disadvantages of organisms used to manipulate genes: a. yeast b. bacteria c. plasmids d. viruses.
B.6	Principles, description and advantages/disadvantages of using the following processes of gene manipulation: a. DNA isolation b. restriction c. ligation d. transformation e. selection and culture f. polymerised chain reaction (PCR) g. tissue culture h. use of specific microbes and vectors in the production of different materials i. principles of aseptic techniques.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Explore how the biotechnology industry has developed			
1A.1 Identify processes used in the past to change biological characteristics in plant and animal systems.	2A.P1 Describe processes used in the past to change biological characteristics in plant and animal systems.	2A.M1 Explain the differences in how genes have been selected in the past and present in plant and animal systems.	2A.D1 Evaluate the use of biotechnology procedures in plant and animal systems over time.
1A.2 Identify the contemporary processes used in the biotechnology industry to change biological characteristics in plant and animal systems.	2A.P2 Describe the contemporary processes used in the biotechnology industry to change biological characteristics in plant and animal systems.		

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim B: Explore how biotechnology is used in our everyday lives			
1B.3 List products that can be made using biotechnology.	2B.P3 Describe areas where biotechnology is used to improve manufacturing and medicine.	2B.M2 Explain how different products can be produced through biotechnology to improve human health and make manufacturing more productive.	2B.D2 Evaluate the use of biotechnological techniques and procedures giving consideration to ethical, environmental and social issues.
1B.4 List techniques used with biotechnology.	2B.P4 Describe a variety of techniques used within biotechnology.	2B.M3 Explain how different techniques allow biotechnology to make improvements to society.	
1B.5 List the advantages and disadvantages of the process used for gene manipulation.	2B.P5 Describe two processes used for gene manipulation and summarise their advantages and disadvantages.	2B.M4 Describe how a biotechnology procedure is used on an industrial scale.	

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

There are no special resources needed for this unit.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson. Please read this guidance in conjunction with *Section 8 Internal assessment*.

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

Level 1 exemplifies partial achievement within a level 2 learning aim.

Learners must observe safe practice when they are carrying out practical work. It is the responsibility of centres to carry out risk assessments for all practical work that they undertake with their learners. Learners should collect their data under full supervision for health and safety reasons.

Observation records should be provided for all practical assessments in this unit.

Learning aim A: Explore how the biotechnology industry has developed

A visit to a biotechnology laboratory is highly recommended to give learners first-hand experience. Where this is not possible, there are excellent web-based resources showing most biotechnology procedures.

For 1A.1, learners must produce a list of the processes, which have led to the plants and animals we see in agriculture today, such as artificial selection and genetic manipulation. Historical details are not required. The assessor should look for the processes being stated rather than 'sheep were bred to be bigger or with more wool'. It is the fact that farmers understood they could cross breed sheep in order to try and get the desirable characteristics they wanted i.e. bigger sheep, certain types of wool etc.

For 2A.P1, learners must describe the contemporary processes identified. They will need to describe, for example, how herbs used in medicine were investigated to extract the active agent, so they could be purified and used more effectively. From this the chemical industry then tried to mimic the chemical structure of the active ingredients, either by manipulating the plants concerned or synthetically producing the ingredient in order to produce larger quantities of a known purity. A number of different examples should be given to meet this criterion.

For 1A.2, the identification of the processes currently used will be sufficient for this criterion. The learners should give examples from both artificial selection and genetic manipulation, of which the best known will be genetically modified (GM) crops.

For 2A.P2, learners must list the biological changes in plants and animals, and this must be backed up by a description of the processes used. For example, in order to get identical plants by the thousands, biotechnology uses cloning. The principle here is that breeding vegetatively guarantees identical plants for an industry supplying food in vast quantities.

For 2A.M1, learners must explain that modern-day selection is based on an understanding of genes and how they work. 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 2A.D1, 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, the learners must provide a coherent and logical argument with both advantages and disadvantages given. Examples should be used to illustrate their arguments. The learners do not have to give a final opinion about whether they support biotechnology or not.

Learning aim B: Explore how biotechnology is used in our everyday lives

For 1B.3, learners should include in this list a range of products made using biotechnology. The assessor needs to check the list to make sure they are the products of biotechnology as opposed to, for instance, the by-products of the oil industry.

For 2B.P3, learners are required to describe areas in the 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. They could also mention brewing and 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.

For 2B.M2, learners must use a range of products to show how biotechnology has been used to improve manufacturing processes and human health. The obvious examples will be the production of drugs and tissue cultures involved in improving human health. For instance, the learner may quote research on the treatment of diabetes with insulin, which originally came from animals but is often synthetic now. Understanding the structure of the insulin molecule and the ability to manufacture a synthetic version has improved treatment for those diabetics unable to use or tolerate animal-based insulin. A range of examples should be quoted for this criterion to be achieved.

For 1B.4, learners must list the biotechnology techniques used, which should include gene manipulation, selective breeding, drug developments etc.

For 2B.P4, learners must describe a variety of techniques rather than the processes involved in manufacturing. The techniques could include cloning, genetic manipulation, etc, and it is the technical side that is required.

For 2B.M3, learners must explain the biotechnology applications for the techniques that have already been given. The learners need to explain a number of biotechnology techniques and their role in making improvements in society. For example, the ability to synthesise insulin in large quantities rather than relying on extracting it from animal sources has meant more effective treatment for diabetics tailored to their needs.

For 1B.5, learners must list both advantages and disadvantages in reference to the processes used in gene manipulation. Although not every process listed in the unit content (B6) needs to be given, a representative example should be listed.

For 2B.P5, 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.

For 2B.M4, 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 procedure must be related to industrial-scale production.

For 2B.D2, learners need to evaluate the techniques they have studied and then put them into the context of ethical, social and environmental issues. The learners will need to show the assessor that they can weigh up the contrasting opinions that may, for instance, be held about genetic manipulation of plants, and then compare those opinions to ones about genetic manipulation for the production of medicines.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1A.2, 2A.P1, 2A.P2, 2A.M1, 2A.D1	The Development of the Biotechnology Industry	You are a biotechnology laboratory technician providing scientific report as information for visitors to your laboratory on an open day. A visiting biotechnology speaker or a visit to the biotechnology laboratory or company would be helpful to motivate learners and gather information towards their evidence.	A scientific report broken into sections or on-screen presentations
1B.3, 1B.4, 2B.P3, 2B.P4, 2B.M2, 2B.M3, 2B.D2 1B.5, 2B.P5 2B.M4, 2B.D2	Biotechnology in Our Lives	You are a biotechnology technician, who works for an industrial biotechnology company, and you are studying on a day-release course at a college. A biotechnology magazine has asked you to write an article about the positive uses of biotechnology and its drawbacks. As part of your course you have to produce a report about gene manipulation and the use of biotechnological techniques.	A newspaper article, series of articles or presentation Written account or presentation

Unit 23: Further Chemistry

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **30**

Assessment type: **Internal**

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.

You 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 that it is used to purify metals such as copper.

You will also develop your understanding of reversible reactions and equilibrium reactions between gases. You 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.

You will extend your 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 your knowledge and understanding of electrolysis, equilibrium and alcohols and build on the chemistry concepts you have learnt in Units 1, 2 and 5.

Learning aims

In this unit you will:

A investigate electrolytic processes

B explore equilibrium reactions between gases

C explore the chemistry of alcohols.

Learning aims and unit content

What needs to be learnt	
Learning aim A: Investigate electrolytic processes	
A.1	Electrolytes are ionic substances that conduct electricity when molten or in solution in water and are decomposed by the passage of the current.
A.2	Electrolysis is the chemical decomposition produced by passing an electric current through a liquid or solution containing ions.
A.3	The movement of ions during electrolysis: a. positively charged cations migrate to the negatively charged cathode b. negatively charged anions migrate to the positively charged anode.
A.4	Oxidation can involve the loss of electrons and reduction can involve the gain of electrons.
A.5	Reduction occurs at the cathode and oxidation occurs at the anode in electrolysis reactions.
A.6	Half equations for reactions occurring at the anode and cathode in electrolysis reactions in this unit.
A.7	The electrolysis of aqueous solutions can give products from ions in water, rather than from ions of the dissolved solid.
A.8	The formation of the products in the electrolysis, using inert electrodes, of the following electrolytes: a. copper chloride solution b. copper sulfate solution c. molten lead bromide d. sodium chloride solution e. sodium sulfate solution.
A.9	The mass changes at the electrodes during the electrolysis of copper sulfate solution, using copper electrodes.
A.10	The purification of copper: a. by electrolysis, using a pure copper cathode and an impure copper anode b. additional production of small amounts of valuable metals from the anode sludge.
A.11	Electroplating can be used to improve the appearance and the resistance to corrosion of metal objects.
A.12	The conditions that need to be used during electroplating in order to get an even coverage of the plating metal.

What needs to be learnt	
Learning aim B: Explore equilibrium reactions between gases	
B.1	The amount of a substance can be measured in grams, numbers of particles or number of moles of particles.
B.2	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).
B.3	One mole of any gas occupies 24 dm^3 at room temperature and atmospheric pressure and that this is known as the molar volume of the gas.
B.4	Explosives work by producing a rapid expansion as a small volume of solid releases gases, which take up a much larger volume.
B.5	Molar volume and balanced equations in calculations involving the masses of solids and volumes of gases.
B.6	Avogadro's law to calculate volumes of gases involved in gaseous reactions, given the relevant equations.
B.7	The concept of reversible reactions.
B.8	The concept of dynamic equilibrium.
B.9	The position of a dynamic equilibrium is affected by changes in: a. temperature b. pressure.
B.10	The consequential effects of temperature and pressure changes on the rate of attainment of equilibrium and the need to use a catalyst.
B.11	The Haber process uses a reversible reaction between nitrogen (extracted from the air) and hydrogen (obtained from natural gas and steam) to form ammonia.
B.12	Industrial reactions, such as the Haber process, use specific temperatures, pressures and catalysts to produce an acceptable yield in an acceptable time.
B.13	Ammonia is oxidised to form nitric acid and the reaction between ammonia and nitric acid is used to make the fertiliser ammonium nitrate.

What needs to be learnt	
Learning aim C: Explore the chemistry of alcohols	
C.1	Production of ethanol during the fermentation of carbohydrates: a. the fermentation mixture is kept warm under anaerobic conditions b. yeast gives an enzyme to catalyse this reaction.
C.2	Concentrated solutions of ethanol can be produced by fractional distillation of the fermentation mixture.
C.3	Ethanol can also be manufactured by reacting ethene (from cracking of crude oil fractions) with steam.
C.4	The factors that are relevant to the choice of method used in the manufacture of ethanol: a. the relative availability of sugar cane or sugar beet and crude oil b. the quality of the final product and whether it needs further processing.
C.5	Homologous series are series of compounds that: a. have the same general formula b. show a gradual variation in physical properties as exemplified by their boiling points c. have similar chemical properties.
C.6	The names, formulae and structures of members of the following homologous series (no treatment of isomers is required in any of these series): a. alkanes, up to four carbons atoms per molecule b. alkenes, up to three carbons atoms per molecule c. alcohols, up to three carbons atoms per molecule d. carboxylic acids, up to three carbon atoms per molecule.
C.7	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.
C.8	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.
C.9	Uses of esters as flavourings and perfumes, as they are pleasant smelling.
C.10	Uses of polyesters as fibres to make fabric and as plastics for making bottles.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Investigate electrolytic processes			
1A.1 Describe the nature of a molten and an aqueous electrolyte.	2A.P1 Predict the products that form when solutions of electrolytes and molten electrolytes are electrolysed.	2A.M1 Explain the redox processes that occur when ions migrate to electrodes during electrolysis.	2A.D1 Construct half equations to represent the electrode reactions taking place during electrolysis. *
1A.2 Identify the purposes of electroplating.	2A.P2 Describe the process of electroplating.	2A.M2 Explain how copper is purified using an electrolytic process.	2A.D2 Account quantitatively for the changes occurring at the electrodes during the electrolytic purification of copper.
Learning aim B: Explore equilibrium reactions between gases			
1B.3 Describe reversible reactions as reactions that may reach equilibrium.	2B.P3 Describe the principles of dynamic equilibrium.	2B.M3 Explain the changes that happen in equilibrium systems when the temperature and pressure of the system is changed.	2B.D3 Explain how conditions are adjusted in industry in order to achieve the maximum yield in the fastest time from equilibrium reactions.
1B.4 Compare the volumes of gases, solids and liquids.	2B.P4 Describe what is meant by the term ‘molar volume’.	2B.M4 Apply Avogadro’s law to calculate volumes of gases involved in gas phase reactions. *	2B.D4 Carry out molar volume calculations. *

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim C: Explore the chemistry of alcohols			
1C.5 Describe the process of fermentation to produce ethanol.	2C.P5 Describe the two different methods used to produce ethanol.	2C.M5 Compare the different reaction conditions used to produce ethanol.	2C.D5 Evaluate the factors influencing the choice of method used to make ethanol.
1C.6 Identify features of the homologous series of alcohols.	2C.P6 Describe the features and reactions of the homologous series of alcohols.	2C.M6 Describe the applications of esterification reactions.	2C.D6 Construct equations for esterification reactions. *

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

There are no special resources needed for this unit.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson. Please read this guidance in conjunction with *Section 8 Internal assessment*.

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

Level 1 exemplifies partial achievement within a level 2 learning aim.

Learners must observe safe practice when they are carrying out practical work. It is the responsibility of centres to carry out risk assessments for all practical work that they undertake with their learners. Learners should collect their data under full supervision for health and safety reasons.

Observation records should be provided for all practical assessments in this unit.

Learning aim A: Investigate electrolytic processes

For 1A.1, learners need to describe the nature of an electrolyte, which should be one molten ionic substance and one ionic substance dissolved in water.

For 2A.P1, 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.

For 2A.M1, learners need to explain the electrolytic process and, when ions migrate to the electrodes, the oxidation and reduction processes that occur for those used in 2A.P1.

For 2A.D1, learners need to construct half equations from two different electrolytic processes where the cations and anions are different.

For 1A.2, learners need to identify the purposes of electroplating. Learners could be given a case study from the teacher about improving the appearance and resistance to corrosion of certain metals for different everyday applications.

For 2A.P2, learners need to describe the process of electroplating. This could be done by annotating a fully labelled diagram.

For 2A.M2, learners could use a diagram to explain the purification of copper.

For 2A.D2, learners need to use the quantity of electrons required at each electrode to discharge an amount of pure copper during the electrolytic purification process.

Learning aim B: Explore equilibrium reactions between gases

For 1B.3, learners need to describe a reversible reaction and state that it has the possibility of reaching equilibrium. This could be achieved using an equation and diagrams to support the description.

For 2B.P3, learners need to describe the principles of a dynamic equilibrium. This again can be done using equations or diagrams to support the description.

For 2B.M3, learners can use a dynamic equilibrium process such as the Haber process to explain what happens when the temperature and pressure are changed. This can be extended to achieve 2B.D3 by explaining how these conditions can be adjusted to achieve the maximum yield in the fastest time.

For 1B.4, learners need to compare the volumes of gases, liquids and solids, for a fixed mass of a particular substance. This could be done using labelled diagrams with a brief description.

For 2B.P4, learners can use a diagram and an equation to help them describe what is meant by a molar volume.

For 2B.M4, learners need to use two examples of gas phase reactions to calculate volumes of gases using Avogadro’s law.

For 2B.D4, learners need to carry out three different molar volume calculations successfully.

Learning aim C: **Explore the chemistry of alcohols**

For 1C.5, learners need to describe the process of fermentation to produce ethanol. Learners can use a labelled diagram to help them describe this process.

For 2C.P5, learners need to describe two different methods of producing ethanol and, for 2C.M5, they need to compare the reaction conditions.

For 2C.D5, learners need to evaluate the factors influencing the choice of manufacture, such as availability of raw materials etc. This criterion could be achieved in the form of diagrams or using a table or a poster with diagrams and conditions.

For 1C.6, learners need to find information about the homologous series of alcohols and identify three features.

For 2C.P6, 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.

For 2C.M6, 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 2C.D6, learners need to construct at least two balanced equations for esterification reactions.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1A.2, 2A.P1, 2A.P2, 2A.M1, 2A.M2, 2A.D1, 2A.D2	Electrolysis and Electroplating	You are a chemist who specialises in electrochemistry and you work for a chemical company that produces products by electrolysis (including pure copper) and carries out electroplating. You have been asked to produce some introductory materials for school and college groups, who are visiting the site and are also looking for work experience places. A visit to a chemical company that carries out electrolysis, manufactures organic compounds, or uses equilibrium reactions to manufacture products would be helpful to motivate learners and assist them in gathering information towards their assignment evidence.	A report containing diagrams, equations and text
1B.3, 1B.4, 2B.P3, 2B.P4, 2B.M3, 2B.M4, 2B.D3, 2B.D4	The Dynamic Equilibrium	You work as a research chemist for a large industrial company producing fertilisers. You are researching how efficient and effective the Haber process is, and need to put together a report for the directors. They are not chemists and therefore require information that will give them the basics in terms of reversible reactions, equilibrium and molar volumes of gases.	A report to include diagrams, equations, descriptions and molar volume calculations

Criteria covered	Assignment	Scenario	Assessment evidence
1C.5, 1C.6, 2C.P5, 2C.P6, 2C.M5, 2C.M6, 2C.D5, 2C.D6	Alcohols and their Applications	You work for a chemical company as a production chemist. The company produces alcohols using different methods and uses the alcohol to manufacture esters. You need to prepare a report for the production director using current data, such as costs of raw materials, to advise which method of manufacture to use to manufacture ethanoic acid and polyesters. This report will be used in discussions with the business director and therefore there needs to be information in the report to help the business director's understanding.	A report to include diagrams, equations and descriptions

Unit 24: Further Physics

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **30**

Assessment type: **Internal**

Unit introduction

There are many important concepts that underpin applications of physics in medicine, for example in medical diagnosis of disease, such as the use of X-rays, Computerised Axial Tomography (CAT) scans, Position Emission Tomography (PET) scans and radioactive isotopes as tracers.

In this unit, you will investigate and explore the theory that underpins several major areas of the application of physics. From this work you 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 you 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 you will look at the use of radioactive isotopes in medicine.

The final topic is on the kinetic theory of gases. You 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.

Your teacher should encourage you 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 Units 1, 3 and 6. 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.

Learning aims and unit content

What needs to be learnt	
Learning aim A: Investigate X-rays	
A.1	The ionisation by X-rays is related to their frequency and energy ($E = hf$ is not required).
A.2	The production of X-rays in an evacuated tube: a. thermionic emission of electrons from a heated filament b. a potential difference applied between the cathode (filament) and the anode (metal target) causes the electrons to accelerate, forming a beam of charged particles c. a beam of charged particles is equivalent to an electric current d. the collision of electrons with the metal target produces X-rays e. why the vacuum is necessary.
A.3	Uses of X-rays in computerised axial tomography (CAT) scans and fluoroscopes.
A.4	The risks and advantages of using X-rays for treatment and diagnosis.
A.5	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.
A.6	Use the equation: $I = Nq$ current (ampere, A) = number of particles per second (1/s) x charge on each particle (coulomb, C)
A.7	Use the equation: $KE = ½mv^2 = eV$ kinetic energy (joule, J) = charge on the electron (coulomb, C) x accelerating potential difference (volt, V)
A.8	The need to control the X-ray beam for diagnostic and therapeutic purposes by adjusting: a. the accelerating potential difference b. the current flowing in the evacuated tube.

What needs to be learnt	
Learning aim B: Investigate the motion of particles	
B.1	For motion in a circle there must be a resultant force, known as a centripetal force that acts towards the centre of the circle.
B.2	Particle accelerators called cyclotrons cause charged particles to move in a circular or spiral path, due to a magnetic field.
B.3	Certain stable elements can be bombarded with proton radiation to change them into radioactive isotopes.
B.4	The use of particle accelerators (cyclotrons) to produce radioactive isotopes for medical purposes.
B.5	For inelastic collisions, momentum is conserved but kinetic energy is not conserved.
B.6	For elastic collisions, both momentum and kinetic energy are conserved.
B.7	Carry out calculations using momentum conservation for a two-body collision (in one dimension only).
B.8	Carry out calculations using conservation of kinetic energy for a two-body elastic collision (in one dimension only).

What needs to be learnt	
Learning aim C: Investigate radioactivity	
C.1	Balance nuclear equations.
C.2	The effects on the atomic (proton) number (Z) and mass (nucleon) number (A) of radioactive decays (alpha (α), beta (β) and gamma (γ) decay).
C.3	The features of the *N*–*Z* curve for stable isotopes: a. the position relative to the stability curve of radioactive isotopes b. nuclei with high values of *Z* (above 82) usually undergo alpha decay c. an isotope above the stability curve has too many neutrons to be stable and will undergo $\beta-$ decay d. an isotope below the stability curve has too many protons to be stable and will undergo $\beta+$ decay.
C.4	Quarks: a. protons and neutrons each contain three particles called quarks b. the arrangement of up and down quarks in protons and neutrons c. the charges and masses of up and down quarks related to the charge and mass of neutrons d. the charges and masses of up and down quarks related to the charge and mass of protons e. $\beta-$ decay as a process that involves a down quark changing into an up quark (a neutron becomes a proton and an electron) f. $\beta+$ decay as a process that involves an up quark changing into a down quark (a proton becomes a neutron and a positron).
C.5	For positron-electron annihilation: a. production of gamma rays b. conservation of momentum and charge c. conservation of mass energy using the equation $E = mc^2$.
C.6	The uses of radioactive substances in medicine: a. in diagnosis of medical conditions (Position Emission Tomography (PET) scanners and tracers) b. in the treatment of tumours (applied internally and externally).
C.7	The precautions taken to reduce the hazards of medical isotopes for medical personnel and patients, including limiting the dose.

What needs to be learnt	
Learning aim D: Investigate kinetic theory and gases	
D.1	Kinetic theory model to describe movement of particles in gases.
D.2	Relationship between the macroscopic and microscopic properties of an ideal gas: a. the pressure of a gas is caused by its particles striking the wall of its container b. increasing/decreasing the temperature of a gas increases/decreases the speed of its particles c. the average kinetic energy of the particles in a gas is directly proportional to the Kelvin temperature of the gas d. at absolute zero, −273°C, the particles of an ideal gas are at rest.
D.3	The relationship between the Kelvin and Celsius scales.
D.4	Use the equation: $V_1 = V_2T_1/T_2$ to calculate volume for gases of fixed mass at constant pressure (rearranging not required).
D.5	Use the equation: $P_1V_1 = P_2V_2$ to calculate volume or pressure for gases of fixed mass at constant temperature.
D.6	Use the equation: $P_1V_1/T_1 = P_2V_2/T_2$ for fixed masses of gas where: initial pressure (pascal, Pa) x initial volume (metre^3, m^3) /initial temperature (kelvin, K) = final pressure (pascal, Pa) x final volume (metre^3, m^3) /final temperature (kelvin, K)
D.7	The application of gas laws to bottled gases.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Investigate X-rays			
1A.1 Identify the main features of a tube used to produce X-rays.	2A.P1 Describe the ionising nature of X-rays and how these are produced in an X-ray tube.	2A.M1 Calculate current and kinetic energy for a beam of charged particles, using appropriate equations. *	2A.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.
1A.2 Identify the equation used to find the current for a beam of charged particles.	2A.P2 Describe the relationship between the variables used to find the current for a beam of charged particles, using words and symbols.		
1A.3 Identify the equation used to find kinetic energy for a beam of charged particles.	2A.P3 Describe the relationship between the variables used to find the kinetic energy for a beam of charged particles, using words and symbols.		
1A.4 Identify the uses of X-rays in medicine.	2A.P4 Describe the uses and advantages of X-rays for treatment and diagnosis in medicine.	2A.M2 Assess the benefits and risks of X-rays in medicine.	
1A.5 Identify the risks of using X-rays in medicine.	2A.P5 Describe how to minimise the risks of using X-rays in medicine.		

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim B: Investigate the motion of particles			
1B.6 Describe centripetal force as a resultant force that causes circular motion.	2B.P6 Describe how cyclotrons can be used to produce fast-moving charged particles.	2B.M3 Explain how proton radiation from a cyclotron may be used to change stable elements into radioactive isotopes for medical purposes.	2B.D2 Calculate momentum and kinetic energy for two-body elastic and inelastic collisions in one dimension only, using appropriate equations. *
Learning aim C: Investigate radioactivity			
1C.7 Draw accurately an *N-Z* graph for the elements. *	2C.P7 Relate the different types of radioactive decay to the position of isotopes on the *N-Z* graph and proton and nucleon numbers. *	2C.M4 Balance equations for radioactive decay and describe the relationship between quarks and beta decay. *	2C.D3 Explain how momentum, charge and mass-energy are conserved in positron-electron annihilation. *
1C.8 Identify the uses of radioactive isotopes in medicine.	2C.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.	2C.M5 Explain the advantages of using radioactive sources in the diagnosis and treatment of medical conditions despite the hazards involved.	

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim D: Investigate kinetic theory and gases			
1D.9 Describe the movement of particles in gases.	2D.P9 Relate qualitatively the macroscopic properties of ideal gases to their microscopic properties.	2D.M6 Calculate the temperature, pressure and volume of fixed masses of gases, converting between Celsius and Kelvin scales, using appropriate equations. *	2D.D4 Explain the application of gas laws to bottled gases. *

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

There are no special resources needed for this unit.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson. Please read this guidance in conjunction with *Section 8 Internal assessment*.

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

Level 1 exemplifies partial achievement within a level 2 learning aim.

Learners must observe safe practice when they are carrying out practical work. It is the responsibility of centres to carry out risk assessments for all practical work that they undertake with their learners. Learners should collect their data under full supervision for health and safety reasons.

Observation records should be provided for all practical assessments in this unit.

Learning aim A: Investigate X-rays

For 1A.1, learners can give a list, which must include details such as the need for a vacuum, emissions from a heated electrode etc. A reasonable list should be given that has three to four features listed. Alternatively, a fully annotated diagram may be drawn.

For 2A.P1, 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 1A.2 and 1A.3, it is sufficient for learners to give the equation in words to meet this criterion.

For 2A.P2 and 2A.P3, the relationship must be described using words and symbols. Appropriate units should be included.

For 1A.4, learners must identify the uses of X-rays in medicine e.g. using X-rays in CAT scans and fluoroscopes. Descriptions of how the machines work is not required, it is the uses that will meet the criterion.

For 2A.P4, a detailed description of the uses and advantages of X-rays in medicine must be given but again 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.

For 1A.5, learners must identify the risks of using X-rays in CAT scans and fluoroscopes. Descriptions of how the machines work is not required, it is the risks that will meet the criterion. The evidence for this criterion could be linked with that of criterion 1A.4.

For 2A.P5, 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. The evidence for this criterion could be linked with that of criterion 2A.P4.

For 2A.M1, learners may well cover this when they do 2A.P2 and 2A.P3. The learners will be expected to substitute correctly into the equation, most probably with figures given to them by the teacher or extracted from simulations.

For 2A.M2 learners must assess the benefits and risks of X-rays in medicine. This will follow on from 2A.P4 and 2A.P5

For 2A.D1, 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 scattering (e.g. photoelectric scattering, Compton scattering) are not expected.

Learning aim B: Investigate the motion of particles

For 1B.6, the best way for the learners to tackle this is to use an annotated diagram to describe centripetal force.

For 2B.P6, learners must describe how cyclotrons accelerate particles in a circular or spiral path to produce fast moving charged particles.

For 2B.M3, the previous assessment criterion 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 2B.D2, 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.

Learning aim C: Investigate the production of ionising radiation from radioactive sources

For 1C.7, learners must draw accurately an N–Z graph of the elements showing stable and unstable isotopes.

For 2C.P7, 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.

For 2C.M4, the nuclear equations can be given to the 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.

For 1C.8 sand 2C.P8, 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.

For 2C.P8, learners must 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.

For 2C.M5, 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 2C.D3, the equation $E = mc^2$ must be used by learners when discussing mass–energy conservation. The equation can be given to the learners with an explanation of the meaning of the symbols. The 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.

Learning aim D: Investigate kinetic theory and gases

For 1D.9, learners at this level may find it easier to draw a diagram to show the random movement of particles in a gas and label it, as opposed to producing a written description. Note this criterion only requires a description.

For 2D.P9, 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.

For 2D.M6, 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 2D.D4, 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.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1A.2, 1A.3, 1A.4, 1A.5, 2A.P1, 2A.P2, 2A.P3, 2A.P4, 2A.P5, 2A.M1, 2A.M2, 2A.D1 1C.7, 1C.8, 2C.P7, 2C.P8, 2C.M4, 2C.M5, 2C.D3	Get Well Soon	You spent your summer break in work experience in a medical unit that uses X-rays and radioactive isotopes for diagnosis and treatment. Your teacher has now asked you to write up the physics involved in order to help other learners prepare for their work experience. A visit to a medical physics department or a visit from a medical physicist would be helpful to motivate learners and assist them in gathering information towards their assignment evidence.	This could be a series of small reports which could include diagrams, descriptions and use of given equations The material presented will be the result of research, observation and carrying out practical work
1B.6, 2B.P6. 2B.M3, 2B.D2	In a Spin!	You work as a technical writer in the publications department of a facility that has a cyclotron for investigating collisions between particles. You have been asked to produce a booklet that discusses the physics involved.	Booklet that covers the cyclotron and the basic physics of elastic and inelastic collisions
1D.9, 2D.P9, 2D.M6, 2D.D4	Something to Gas About	As a junior science technician you work for a large industrial unit that specialises in producing gases in pressurised cylinders for industrial and medical purposes. One of the senior technicians tells you that it is essential to know about kinetic theory and gases for this type of work. You decide to investigate this as it links with some work you are doing at college.	Report on the gas laws including calculations and an application of them

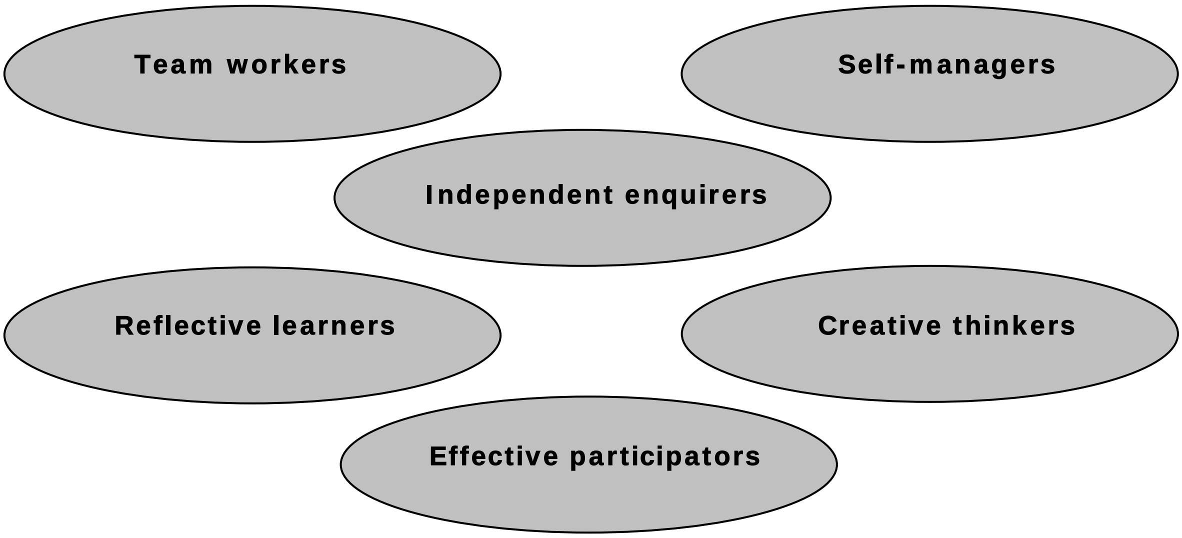
Annexe A

Personal, learning and thinking skills

A FRAMEWORK OF PERSONAL, LEARNING AND THINKING SKILLS 11–19 IN ENGLAND

The framework comprises six groups of skills that are essential to success in learning, life and work. In essence, the framework captures the essential skills of: managing self; managing relationships with others; and managing own learning, performance and work. It is these skills that will enable young people to enter work and adult life confident and capable.

The titles of the six groups of skills are set out below.



For each group, there is a focus statement that sums up the range of skills. This is followed by a set of outcome statements that are indicative of the skills, behaviours and personal qualities associated with each group.

Each group is distinctive and coherent. The groups are also interconnected. Young people are likely to encounter skills from several groups in any one learning experience. For example, an independent enquirer would set goals for their research with clear success criteria (reflective learner) and organise and manage their time and resources effectively to achieve these (self-manager). In order to acquire and develop fundamental concepts such as organising oneself, managing change, taking responsibility and perseverance, learners will need to apply skills from all six groups in a wide range of learning contexts.

The skills

Independent enquirers
Focus: Young people process and evaluate information in their investigations, planning what to do and how to go about it. They take informed and well-reasoned decisions, recognising that others have different beliefs and attitudes.
Young people: ● identify questions to answer and problems to resolve ● plan and carry out research, appreciating the consequences of decisions ● explore issues, events or problems from different perspectives ● analyse and evaluate information, judging its relevance and value ● consider the influence of circumstances, beliefs and feelings on decisions and events ● support conclusions, using reasoned arguments and evidence.

Creative thinkers
Focus: Young people think creatively by generating and exploring ideas, making original connections. They try different ways to tackle a problem, working with others to find imaginative solutions and outcomes that are of value.
Young people: ● generate ideas and explore possibilities ● ask questions to extend their thinking ● connect their own and others' ideas and experiences in inventive ways ● question their own and others' assumptions ● try out alternatives or new solutions and follow ideas through ● adapt ideas as circumstances change.

Reflective learners
Focus: Young people evaluate their strengths and limitations, setting themselves realistic goals with criteria for success. They monitor their own performance and progress, inviting feedback from others and making changes to further their learning.
Young people: ● assess themselves and others, identifying opportunities and achievements ● set goals with success criteria for their development and work ● review progress, acting on the outcomes ● invite feedback and deal positively with praise, setbacks and criticism ● evaluate experiences and learning to inform future progress ● communicate their learning in relevant ways for different audiences.

Team workers
Focus: Young people work confidently with others, adapting to different contexts and taking responsibility for their own part. They listen to and take account of different views. They form collaborative relationships, resolving issues to reach agreed outcomes.
Young people: ● collaborate with others to work towards common goals ● reach agreements, managing discussions to achieve results ● adapt behaviour to suit different roles and situations, including leadership roles ● show fairness and consideration to others ● take responsibility, showing confidence in themselves and their contribution ● provide constructive support and feedback to others.

Self-managers
Focus: Young people organise themselves, showing personal responsibility, initiative, creativity and enterprise with a commitment to learning and self-improvement. They actively embrace change, responding positively to new priorities, coping with challenges and looking for opportunities.
Young people: ● seek out challenges or new responsibilities and show flexibility when priorities change ● work towards goals, showing initiative, commitment and perseverance ● organise time and resources, prioritising actions ● anticipate, take and manage risks ● deal with competing pressures, including personal and work-related demands ● respond positively to change, seeking advice and support when needed.

Effective participators
Focus: Young people actively engage with issues that affect them and those around them. They play a full part in the life of their school, college, workplace or wider community by taking responsible action to bring improvements for others as well as themselves.
Young people: ● discuss issues of concern, seeking resolution where needed ● present a persuasive case for action ● propose practical ways forward, breaking these down into manageable steps ● identify improvements that would benefit others as well as themselves ● try to influence others, negotiating and balancing diverse views to reach workable solutions ● act as an advocate for views and beliefs that may differ from their own.

Summary of the PLTS coverage throughout the programme

This table shows where units support the development of personal, learning and thinking skills.

Key:

✓ indicates opportunities for development

a blank space indicates no opportunities for development

Unit	Personal, learning and thinking skills					
	Independent enquirers	Creative thinkers	Reflective learners	Team workers	Self-managers	Effective participators
1	✓					
2	✓	✓	✓	✓	✓	
3	✓	✓	✓	✓	✓	
4	✓	✓	✓	✓	✓	✓
5	✓	✓		✓	✓	✓
6	✓	✓	✓	✓	✓	
7	✓	✓	✓	✓	✓	✓
8	✓	✓	✓	✓	✓	
9	✓	✓	✓		✓	
10	✓	✓				
11	✓	✓				
12	✓					
13	✓				✓	
14	✓	✓			✓	✓
15	✓	✓			✓	
16	✓					✓
17	✓	✓				
18	✓	✓			✓	
19	✓	✓			✓	
20	✓	✓				
21	✓	✓	✓		✓	
22	✓	✓				
23	✓	✓				✓
24	✓	✓				

Annexe B

English knowledge and skills signposting

This table shows where an assessment criterion in a BTEC First unit can provide an opportunity to practise a subject content area from the GCSE English subject criteria (including functional elements).

Unit number and title	Learning aim	Assessment criterion reference	Subject content area from the GCSE subject criteria (details of the content area can be found below)
Unit 1: Principles of Science (External)	N/A	N/A	N/A
Unit 2: Chemistry and Our Earth	N/A	N/A	N/A
Unit 3: Energy and our Universe	N/A	N/A	N/A
Unit 4: Biology and our Environment	N/A	N/A	N/A
Unit 5: Applications of Chemical Substances	N/A	N/A	N/A
Unit 6: Applications of Physical Science	N/A	N/A	N/A
Unit 7: Health Applications of Life Science	N/A	N/A	N/A
Unit 8: Scientific Skills (External)	C	N/A	2, 5, 15
Unit 9: Practical Scientific Project	C	2C.P6, 2C.M3, 2C.D3, 2C.P7	2, 5, 15
Unit 10: World Energy	C	2C.P4	2, 5, 15
Unit 11: How Scientific Theories are Formulated	N/A	N/A	N/A
Unit 12: The Living Body	N/A	N/A	N/A
Unit 13: Monitoring the Environment	N/A	N/A	N/A
Unit 14: Growing Plants for Food	N/A	N/A	N/A
Unit 15: Investigating a Crime Scene	C	2C.P8, 2C.M5	2, 5, 15
Unit 16: Science in Medicine	N/A	N/A	N/A

Unit number and title	Learning aim	Assessment criterion reference	Subject content area from the GCSE subject criteria (details of the content area can be found below)
Unit 17: Understanding Human Behaviour	N/A	N/A	N/A
Unit 18: Designing and Making Useful Devices in Science	N/A	N/A	N/A
Unit 19: Chemical Analysis and Detection	N/A	N/A	N/A
Unit 20: Exploring Our Universe	N/A	N/A	N/A
Unit 21: Electronics in Action	N/A	N/A	N/A
Unit 22: Biotechnology Procedures and Applications	N/A	N/A	N/A
Unit 23: Further Chemistry	N/A	N/A	N/A
Unit 24: Further Physics	N/A	N/A	N/A

GCSE English subject content area

The topic areas below are drawn from the GCSE English subject criteria.

Learners should:

1 analyse spoken and written language, exploring impact and how it is achieved

2 express ideas and information clearly, precisely, accurately and appropriately in spoken and written communication

3 form independent views and challenge what is heard or read on the grounds of reason, evidence or argument

4 understand and use the conventions of written language, including grammar, spelling and punctuation

5 explore questions, solve problems and develop ideas

6 engage with and make fresh connections between ideas, texts and words

7 experiment with language to create effects to engage the audience

8 reflect and comment critically on their own and others' use of language.

In speaking and listening, learners should:

9 present and listen to information and ideas

10 respond appropriately to the questions and views of others

11 participate in a range of real-life contexts in and beyond the classroom, adapting talk to situation and audience and using standard English where appropriate

12 select and use a range of techniques and creative approaches to explore ideas, texts and issues in scripted and improvised work.

In reading, learners should:

13 understand how meaning is constructed through words, sentences and whole texts, recognising and responding to the effects of language variation

14 evaluate the ways in which texts may be interpreted differently according to the perspective of the reader.

In writing, learners should write accurately and fluently:

15 choosing content and adapting style and language to a wide range of forms, media, contexts, audiences and purposes

16 adapting form to a wide range of styles and genres.

Annexe C

Mathematics knowledge and skills signposting

This table shows where an assessment criterion in a BTEC First unit can provide an opportunity to practise a subject content area from the GCSE Mathematics subject criteria (including functional elements).

Unit number and title	Learning aim	Assessment criterion reference	Subject content area from the GCSE subject criteria (details of the content area can be found below)
Unit 1: Principles of Science (External)	A	N/A	1–7, 17, 21
	C	N/A	1–6, 13, 21, 22, 24
	D, E, F	N/A	1–6, 13, 21, 24
Unit 2: Chemistry and Our Earth	C	2C.P7	1–6, 13, 21, 24
Unit 3: Energy and Our Universe	A	2A.M1, 2A.D1	1–6, 12, 14, 16, 21
		2A.D3	1–6, 12, 14, 16, 21, 22
	B	2B.P6, 2B.M4, 2B.D4	1–6, 12, 14, 16, 21, 24
Unit 4: Biology and Our Environment	C	2C.D4	8, 12, 14–16, 21
Unit 5: Applications of Chemical Substances	A	1A.1	1, 10, 11
		2A.P1, 2A.M1, 2A.D1	1, 3, 10, 11,21
	B	2B.D2	1, 14

Unit number and title	Learning aim	Assessment criterion reference	Subject content area from the GCSE subject criteria (details of the content area can be found below)
Unit 6: Applications of Physical Science	A	1A.1, 2A.P1	9–12, 14
		2A.M1, 2A.D1	9–12, 14, 16
		1A.2	9-11
		2A.P2	1–6, 9–11, 13, 21, 24
		1A.3	1–6, 14
		2A.P3	1–6, 13, 14, 21
		2A.M2	1–6, 13, 14, 21, 24
	B	2B.P4	1–6
		2B.M3	1–6, 13, 21, 24
		2B.P5	1–6, 13, 21, 24
	D	2D.M7	1–6, 13, 21, 24
		2D.M8	1–6, 12–14, 16, 21, 24
Unit 7: Health Applications of Life Science	A	1A.2, 2A.P2, 2A.M1, 2A.D1	1–6, 21
Unit 8: Scientific Skills (External)	B	N/A	1–6, 8 10–15, 21, 25
	C	N/A	14, 16
Unit 9: Practical Scientific Project	B	1B.4, 2B.P4, 2B.M2, 2B.D2	10–16, 21
	C	1C.6, 2C.P6, 2C.P7, 2C.M3, 2C.D3	10–16, 21
Unit 10: World Energy	N/A	N/A	N/A
Unit 11: How Scientific Theories are Formulated	N/A	N/A	N/A

Unit number and title	Learning aim	Assessment criterion reference	Subject content area from the GCSE subject criteria (details of the content area can be found below)
Unit 12: The Living Body	N/A	N/A	N/A
Unit 13: Monitoring the Environment	B	1B.3, 2B.P3, 2B.M2, 2B.D2	1–6, 9–11, 21
Unit 14: Growing Plants for Food	A	1A.2, 2A.P3, 2A.D1	10, 12, 14–16, 21
	B	2B.M2	10, 12, 14–16, 21
	C	2C.D3	10, 12, 14–16, 21
Unit 15: Investigating a Crime Scene	B	2B.P5	15
	C	1C.6	15
		1C.7	14, 16
		2C.P6	12, 14, 16
		2C.P7	16
		2C.M4	14, 16
Unit 16: Science in Medicine	N/A	N/A	N/A
Unit 17: Understanding Human Behaviour	N/A	N/A	N/A
Unit 18: Designing and Making useful Devices in Science	A	1A.1	1–3, 9–11, 18, 19, 21
		2A.P1, 2A.D1	1–6, 9–11, 14, 16, 18, 19, 21
	B	1B.2	1–3, 9–11, 18, 19, 21
		2B.P2, 2B.D2	1–6, 9–11, 14, 16, 18, 19, 21
	C	1C.3	1–3, 9–11, 18, 19, 21
		2C.P3, 2C.D3	1–6, 9–11, 14, 16, 18, 19, 21
	D	1D.4	1–3, 9–11, 18, 19, 21
		2D.P4, 2D.D4	1–6, 9–11, 14, 16, 18, 19, 21

Unit number and title	Learning aim	Assessment criterion reference	Subject content area from the GCSE subject criteria (details of the content area can be found below)
Unit 19: Chemical Analysis and Detection	B	2B.D2	1–6, 13, 24
	C	2C.M3, 2C.D3	1–6, 13, 24
	D	2D.M4	1–6, 13, 24
Unit 20: Exploring Our Universe	B	2B.M4, 2B.D2	14, 16
Unit 21: Electronics in Action	B	2B.M2, 2B.D2	1–6, 13, 21, 24
	C	2C.P4, 2C.M4, 2C.D3	10, 11
Unit 22: Biotechnology Procedures and Applications	N/A	N/A	N/A
Unit 23: Further Chemistry	A	2A.D1	1–6, 13
	B	2B.M4, 2B.D4	1–6, 9, 13
	C	2C.D6	1–6, 13
Unit 24: Further Physics	A	2A.M1	1–6, 13, 24
	B	2B.D2	1–6, 13, 24
	C	1C.7	12, 14
		2C.P7	12, 14, 16
		2C.M4, 2C.D3	1–6, 13, 24
	D	2D.M6, 2D.D4	1–6, 13, 24

GCSE Mathematics subject content area

The topic areas below are drawn from the GCSE Mathematics subject criteria.

Learners should be able to:

1 understand number size and scale and the quantitative relationship between units

2 understand when and how to use estimation

3 carry out calculations involving +, – , ×, ÷, either singly or in combination, decimals, fractions, percentages and positive whole number powers

4 understand and use number operations and the relationships between them, including inverse operations and the hierarchy of operations

5 provide answers to calculations to an appropriate degree of accuracy, including a given power of ten, number of decimal places and significant figures

6 understand and use the symbols =, <, >, ~

7 understand and use direct proportion and simple ratios

8 calculate arithmetic means

9 understand and use common measures and simple compound measures such as speed

10 make sensible estimates of a range of measures in everyday settings and choose appropriate units for estimating or carrying out measurement

11 interpret scales on a range of measuring instruments, work out time intervals and recognise that measurements given to the nearest whole unit may be inaccurate by up to one half in either direction

12 plot and draw graphs (line graphs, bar charts, pie charts, scatter graphs, histograms) selecting appropriate scales for the axes

13 substitute numerical values into simple formulae and equations using appropriate units

14 translate information between graphical and numerical form

15 design and use data-collection sheets, including questionnaires, for grouped, discrete or continuous data, process, represent, interpret and discuss the data

16 extract and interpret information from charts, graphs and tables

17 understand the idea of probability

18 calculate area and perimeters of shapes made from triangles and rectangles

19 calculate volumes of right prisms and of shapes made from cubes and cuboids

20 use Pythagoras' theorem in 2-D

21 use calculators effectively and efficiently

In addition, level 2 learners should be able to:

22 interpret, order and calculate with numbers written in standard form

23 carry out calculations involving negative powers (only -1 for rate of change)

24 change the subject of an equation

25 understand and use inverse proportion

26 understand and use percentiles and deciles

27 use Pythagoras' theorem in 2-D and 3-D

28 use trigonometric ratios to solve 2-D and 3-D problems.

Annexe D

Synoptic assessment

Synoptic assessment in applied science is embedded throughout the assessment criteria across the units of study. The mandatory units provide the essential knowledge, understanding and skills required in applied science and underpin the content of the optional specialist units. Learners studying the Pearson BTEC Level 1/Level 2 First Extended Certificate in Applied Science are able to demonstrate a number of synoptic approaches towards meeting the assessment criteria, this include:

- showing links and holistic understanding/approaches to units of study from the specification
- being able to interrelate overarching concepts and issues, bringing together their applied science knowledge
- drawing together and integrating knowledge, understanding and skills across different units, in order to develop an appreciation of how topics relate to one another, how each may contribute to different contexts/situations and to the world of applied science
- making and applying connections to particular scientific contexts or situations
- demonstrating their ability to use and apply a range of different methods and/or techniques
- being able to put forward different perspectives and/or explanations to support decisions they have made or evidence presented
- being able to suggest or apply different approaches to contexts, situations, or in the effective tackling of specific science-related issues
- synthesising information gained from studying a number of different scientific activities
- applying knowledge, understanding and skills from across different units to a particular science situation, issue or case study
- using specialist terminology where appropriate
- demonstrating use of transferable skills
- developing an appreciation and awareness of the use of different techniques, methods or approaches to investigate and/or address specific client needs, issues or situations
- demonstrating analytical and interpretation skills (of evidence and/or results) and the ability to formulate valid well-argued responses
- evaluating and justifying their decisions, choices and recommendations.

Unit 1: Principles of Science introduces learners to the fundamental areas of biology, chemistry and physics, which they will then study further in Units 2, 3 and 4. Therefore Units 2, 3 and 4 are synoptic in nature, drawing together the knowledge and understanding that the learners developed in Unit 1. These units also develop practical skills and introduce the vocational contexts in biology, chemistry and physics.

Unit 8: Scientific Skills in particular, gives learners the opportunity to draw together and demonstrate the skills developed across the qualification. For example, learners will have carried out a number of planning, processing, analysing and evaluating activities as part of Units 5, 6 and 7, which will all be brought together for Unit 8. For this reason it is advisable for centres to develop the skills from Unit 8 throughout the programme of study.

Annexe E

The periodic table of the elements

The Periodic Table of the Elements

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

1	2											3	4	5	6	7	0
						1 **H** hydrogen 1											4 **He** helium 2
7 **Li** lithium 3	9 **Be** beryllium 4											11 **B** boron 5	12 **C** carbon 6	14 **N** nitrogen 7	16 **O** oxygen 8	19 **F** fluorine 9	20 **Ne** neon 10
23 **Na** sodium 11	24 **Mg** magnesium 12											27 **Al** aluminium 13	28 **Si** silicon 14	31 **P** phosphorus 15	32 **S** sulfur 16	35.5 **Cl** chlorine 17	40 **Ar** argon 18
39 **K** potassium 19	40 **Ca** calcium 20	45 **Sc** scandium 21	48 **Ti** titanium 22	51 **V** vanadium 23	52 **Cr** chromium 24	55 **Mn** manganese 25	56 **Fe** iron 26	59 **Co** cobalt 27	59 **Ni** nickel 28	63.5 **Cu** copper 29	65 **Zn** zinc 30	70 **Ga** gallium 31	73 **Ge** germanium 32	75 **As** arsenic 33	79 **Se** selenium 34	80 **Br** bromine 35	84 **Kr** krypton 36
85 **Rb** rubidium 37	88 **Sr** strontium 38	89 **Y** yttrium 39	91 **Zr** zirconium 40	93 **Nb** niobium 41	96 **Mo** molybdenum 42	[98] **Tc** technetium 43	101 **Ru** ruthenium 44	103 **Rh** rhodium 45	106 **Pd** palladium 46	108 **Ag** silver 47	112 **Cd** cadmium 48	115 **In** indium 49	119 **Sn** tin 50	122 **Sb** antimony 51	128 **Te** tellurium 52	127 **I** iodine 53	131 **Xe** xenon 54
133 **Cs** caesium 55	137 **Ba** barium 56	139 **La*** lanthanum 57	178 **Hf** hafnium 72	181 **Ta** tantalum 73	184 **W** tungsten 74	186 **Re** rhenium 75	190 **Os** osmium 76	192 **Ir** iridium 77	195 **Pt** platinum 78	197 **Au** gold 79	201 **Hg** mercury 80	204 **Tl** thallium 81	207 **Pb** lead 82	209 **Bi** bismuth 83	[209] **Po** polonium 84	[210] **At** astatine 85	[222] **Rn** radon 86
[223] **Fr** francium 87	[226] **Ra** radium 88	[227] **Ac*** actinium 89	[261] **Rf** rutherfordium 104	[262] **Db** dubnium 105	[266] **Sg** seaborgium 106	[264] **Bh** bohrium 107	[277] **Hs** hassium 108	[268] **Mt** meitnerium 109	[271] **Ds** darmstadtium 110	[272] **Rg** roentgenium 111	Elements with atomic numbers 112-116 have been reported but not fully authenticated						

** The lanthanoids (atomic numbers 58-71) and the actinoids (atomic numbers 90-103) have been omitted.*

The relative atomic masses of copper and chlorine have not been rounded to the nearest whole number.

Annexe F

The structure of the Pearson BTEC Level 1/Level 2 First Award in Principles of Applied Science

The Pearson BTEC Level 1/Level 2 First Award in Principles of Applied Science is taught over 120 guided learning hours (GLH). It has four mandatory units.

Learners must complete all mandatory units.

This BTEC First Award has units that your centre assesses (internal) and a unit that Pearson sets and marks (external).

Pearson BTEC Level 1/Level 2 First Award in Principles of Applied Science			
Unit	**Mandatory units**	**Assessment method**	**GLH**
1	Principles of Science	External	30
2	Chemistry and Our Earth	Internal	30
3	Energy and Our Universe	Internal	30
4	Biology and Our Environment	Internal	30

The structure of the Pearson BTEC Level 1/Level 2 First Award in Application of Science

The Pearson BTEC Level 1/Level 2 First Award in Application of Science is taught over 120 guided learning hours (GLH). It has four mandatory units.

Learners must complete all mandatory units.

This BTEC First Award has units that your centre assesses (internal) and a unit that Pearson sets and marks (external).

Pearson BTEC Level 1/Level 2 First Award in Application of Science			
Unit	**Mandatory units**	**Assessment method**	**GLH**
5	Applications of Chemical Substances	Internal	30
6	Applications of Physical Science	Internal	30
7	Health Applications of Life Science	Internal	30
8	Scientific Skills	External	30

Specification

BTEC FIRST APPLIED SCIENCE

Extended Certificate

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