Pearson Level 3 Alternative Academic Qualification

L3

BTEC National in

Applied Science (Certificate)

Specification

First teaching from September 2026

First certification from 2027

Issue 2

Qualification Number: 610/6193/1

Pearson
BTEC

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About Pearson

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

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

VQ000455

Welcome

BTEC Nationals are widely recognised by higher education and industry as the vocational qualification of choice at Level 3. They provide students with meaningful and practical learning experiences across a range of career sectors to prepare them to progress to higher education as a route to graduate-level employment.

Recent data has shown that one in five adults of working age in the UK has a BTEC qualification. What's more, well over 90,000 BTEC students apply to UK universities every year and their BTEC Nationals are accepted by over 150 UK universities and other higher education institutions for relevant degree programmes either on their own or in combination with A Levels.

Why are BTECs so successful?

BTECs embody a fundamentally student-centred approach to the curriculum, with a flexible, unit-based structure and knowledge applied through a balanced combination of assignments and examinations. They enable the holistic development of the practical, interpersonal and thinking skills required to succeed in higher education and employment.

When creating these BTEC Nationals we focused on the skills and personal attributes needed to navigate the future, and have worked with many higher education providers, professional bodies, colleges and schools to ensure that their needs are met. Employers are looking for future employees with a thorough grounding in the latest industry requirements and work-ready skills such as critical thinking and problem solving. Higher education needs students who have experience of research, extended writing and meeting deadlines.

We have addressed these requirements by:

- Facilitating and guiding the development of transferable skills through the design and delivery of the qualifications, using a holistic and practical framework which is based on recent research into the most critical skills needed to navigate the future. This Transferable Skills framework has been used to embed transferable skills in the qualifications where they naturally occur and also to signpost opportunities for delivery and development as a part of the wider BTEC learning experience. See page 7 for further information.
- Supporting the delivery of Sustainability Education and Digital Skills development naturally through the content design of the qualifications. Mapping is provided for each qualification to identify where the opportunities for teaching and learning exist.
- Updating sector-specific content to ensure it is relevant and future-facing.
- Implementing a consistent approach to assessment with a balanced combination of internal and external assessments to better engage students, make the qualifications more accessible for them and more manageable for centres to deliver.

We are providing a wealth of support, both resources and people, to ensure that students and their teachers have the best possible experience during their course. See Section 5 for details of the support we offer.

This specification document should be used in conjunction with the *Pearson Level 3 Alternative Academic Qualification BTEC National Specification Supplementary Information* document which is available on our website.

A word to students

Today's BTEC Nationals will require commitment and hard work, as you would expect of the most respected applied learning qualification in the UK. You will have to complete a range of units, be organised, take some assessments that we will set and mark and undertake practical tasks and assignments. But you can feel proud to achieve a BTEC because, whatever your plans in life – whether you decide to study further, go on to work or an apprenticeship – your BTEC National will be your passport to success in the next stage of your life.

Good luck, and we hope you enjoy your course.

Summary of changes to Pearson Level 3 Alternative Academic Qualification BTEC National in Applied Science (Certificate) specification Issue 2

Summary of changes made between previous issue and this issue	Page number
Grading information updated to remove requirement for students to achieve a Near Pass (N) or above in external units to achieve the qualification	58

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

Contents

1 Introduction

Why choose Pearson Level 3 Alternative Academic Qualification BTEC National in Applied Science (Certificate)?

We've listened to feedback from all parts of the Applied Science subject community, including higher education. We've used this opportunity of curriculum change to redesign qualifications so that they reflect the demands of a truly modern and evolving digital environment – qualifications that enable your students to apply themselves and give them the skills to succeed in their chosen pathway.

The Pearson Level 3 Alternative Academic Qualification BTEC National in Applied Science (Certificate) allows students to study the principles and applications of biology, chemistry, and physics, as well as practical scientific procedures and techniques. Students will also have the opportunity to develop their investigation skills or explore contemporary issues in science.

There are three examined units where students will engage in theoretical concepts in Biology, Chemistry and Physics to develop their scientific knowledge and skills.

The qualification is designed to be taken alongside A levels as part of a study programme and can link to learning in A level Psychology, Sociology and Physical Education. It is intended for students that wish to progress into higher education as a pathway to employment.

Total Qualification Time

For all regulated qualifications, Pearson specifies a total number of hours that it is estimated students will require to complete and show achievement for the qualification: this is the Total Qualification Time (TQT). Within TQT, Pearson identifies the number of Guided Learning Hours (GLH) that we estimate a centre delivering the qualification might provide. Guided learning means activities, such as lessons, tutorials, online instruction, supervised study and giving feedback on performance, that directly involve teachers and assessors in teaching, supervising and invigilating students. Guided learning includes the time required for students to complete external assessment under examination or supervised conditions.

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

BTEC Nationals have been designed around the number of hours of guided learning expected. Each unit in the qualification has a GLH value of 60, 90 or 120. There is then a total GLH value for the qualification.

Each qualification has a TQT value. This may vary within sectors and across the suite depending on the nature of the units in each qualification and the expected time for other required learning.

The following table shows the qualifications in this sector and their GLH and TQT values.

Qualification title	Size and structure	Summary purpose
Pearson Level 3 Alternative Academic Qualification BTEC National in Applied Science (Certificate)	180 GLH (240 TQT) Equivalent in size to one AS Level. 3 units mandatory units, of which 3 are externally assessed. Mandatory content (100%) External assessment (100%).	The Certificate in Applied Science is for students who are interested in learning about the Applied Science sector alongside a broader study programme.
Pearson Level 3 Alternative Academic Qualification BTEC National in Applied Science (Extended Certificate)	360 GLH (500 TQT) Equivalent in size to one A Level. 4 units mandatory units, of which 3 are externally assessed. 2 optional units, of which one must be selected. Mandatory content (75%). External assessment (50%).	The Extended Certificate is for students who are interested in learning about the Applied Science sector alongside other fields of study, with a view to progressing to a wide range of higher education courses, not necessarily in Applied Science-related subjects. It is designed to be taken as part of a programme of study that includes A Levels.

Structures of the qualifications at a glance

This table shows all the units and the qualifications to which they contribute. The full structure for this Pearson Level 3 Alternative Academic Qualification BTEC National in Applied Science (Certificate) is shown in *Section 3 Structure*. **You must refer to the full structure to select units and plan your programme.**

Key

Externally assessed units are shown in bold

M **Mandatory units**

O **Optional units**

Unit (number and title)	Unit size (GLH)	Certificate (180 GLH)	Extended Certificate (360 GLH)
1 Principles and Applications of Biology	**60**	**M**	**M**
2 Principles and Applications of Chemistry	**60**	**M**	**M**
3 Principles and Applications of Physics	**60**	**M**	**M**
4 Practical Scientific Procedures and Techniques	**90**		**M**
5 Science Investigation Skills	**90**		**O**
6 Contemporary Issues in Science	**90**		**O**

Qualification and unit content

Pearson has developed the content of the new BTEC Nationals in collaboration with representatives from higher education and relevant professional bodies. In this way, we have ensured that content is up to date and that it includes the knowledge, understanding, skills and attributes required in the sector.

Centres should ensure that delivery of content is kept up to date. Some of the units within the specification may contain references to legislation, policies, regulations and organisations, which may not be applicable in the country you deliver this qualification in (if teaching outside of England), or which may have gone out-of-date during the lifespan of the specification. In these instances, it is possible to substitute such references with ones that are current and applicable in the country you deliver subject to confirmation by your Standards Verifier.

Assessment

Assessment is specifically designed to fit the purpose and objective of the qualification. It includes a range of assessment types and styles suited to vocational qualifications in the sector. This qualification contains only external assessment.

Externally-assessed units

Each external assessment for a BTEC National is linked to a specific unit. All of the units developed for external assessment are of 60 GLH to allow students to demonstrate breadth and depth of achievement. Each assessment is taken under specified conditions, then marked by Pearson and a grade awarded. Students are permitted to resit the examination twice. This equates to three attempts in total: one inclusive of registration, the remaining two attempts as resits. If students resit an examined unit, the best grade achieved will count towards their overall qualification grade, not necessarily the most recent sitting. External assessments are available twice a year. For detailed information on the external assessments, please see the table in *Section 3.* For further information on preparing for external assessment, see *Pearson Level 3 Alternative Academic Qualification BTEC National Specification Supplementary Information* document, which is available on our website.

Language of assessment

Assessment of the external units for these qualifications will be available in English. All student work must be in English. A student taking the qualifications may be assessed in British or Irish Sign Language where it is permitted for the purpose of reasonable adjustment.

For information on reasonable adjustments see *Pearson Level 3 Alternative Academic Qualification BTEC National Specification Supplementary Information* document, which is available on our website.

Grading for units and qualifications

Achievement in the qualification requires a demonstration of depth of study in each unit, assured acquisition of a range of practical skills required for progression to higher education, and successful development of transferable skills. Students achieving a qualification will have completed all units.

Units are assessed using a grading scale of Distinction (D), Merit (M), Pass (P), Near Pass (N) and Unclassified (U). The grade of Near Pass is used for externally-assessed units only. All mandatory units contribute equally to the overall qualification grade.

BTEC National qualifications are graded using a scale of P to D*, **or** PP to D*D*, **or** PPP to D*D*D* depending on the size of the qualification. Please see *Section 6* for more details. The relationship between qualification grading scales and unit grades will be subject to regular review as part of Pearson's standards monitoring processes on the basis of student performance and in consultation with key users of the qualification.

UCAS tariff points

The BTEC Nationals attract UCAS points. Please go to the UCAS website for full details of the points allocated.

Preparing students for the future

Transferable skills

Recent future skills reports have highlighted the growing importance of transferable skills for students to succeed in their careers and lives in this fast-changing world.

Following research and consultation with FE educators and higher education institutions, Pearson has developed a Transferable Skills Framework to facilitate and guide the development of transferable skills through this qualification. The Framework has four broad skill areas, each with a cluster of skills as shown below:

1. **Managing Yourself**: (1) Taking personal responsibility; (2) Personal strengths and resilience; (3) Career orientation planning; (4) Personal goal setting
2. **Effective Learning**: (1) Managing own learning; (2) Continuous learning; (3) Secondary research skills (4) Primary research skills
3. **Interpersonal Skills**: (1) Written communications; (2) Verbal and non-verbal communications; (3) Teamwork; (4) Cultural and social intelligence
4. **Solving Problems**: (1) Critical thinking (2) Problem solving; (3) Creativity and innovation

Each transferable skill has a set of descriptors that outline what achievement of the skill looks like in practice. Each unit in the qualification will show whether a transferable skill has been:

1. fully embedded through the design of the teaching and learning content and assessment of the unit. Skills that are embedded are 'naturally occurring' in that they are inherent to the unit content and don't require extension activities to deliver.
2. signposted as an opportunity for delivery and development and would require extension activities to deliver.

Units will show a summary of the transferable skills that have been embedded or signposted and *Appendix 1* shows the descriptors for each skill across all the skill clusters.

More information on the framework, its design and relevance for student progression is available in the *BTEC Transferable Skills Guide for Teachers*. Resources and guidance to support teachers in the delivery and development of these skills will be available in the Planning and Teaching Guide for this qualification and through our training offer.

Digital skills

Digital skills are required in every industry as well as in everyday life and, with the acceleration of automation and AI in industry, it is critical for students to understand how digital technologies are relevant and applied in the context of the sector they are studying.

With this in mind, we have used the Digital Skills Framework published by IFATE as a frame of reference to identify opportunities for the delivery and development of digital skills in this qualification.

This Digital Skills framework has five categories with specific digital characteristics that apply in varying extent across sectors:

1. **Problem Solving** – The use of digital tools to analyse and solve problems
2. **Digital Collaboration and Communication** – Using digital tools to communicate and share information with stakeholders
3. **Transacting Digitally** – Using digital tools to set up accounts and pay for goods/services
4. **Digital Security** – Identify threats and keep digital tools safe
5. **Handling Data Safely and Securely** – Follow correct procedures when handling personal and organisational data

Opportunities to develop these digital skills are identified where they are relevant and appropriate to a sector, meaning that:

- where they naturally occur
- where embedding adds no assessment burden
- where embedding will enhance a student's skills and knowledge in the sector.

Appendix 2 shows a mapping of the teaching and learning content to the five categories of the framework to show where opportunities to develop these digital skills exist in this qualification.

Sustainability skills

To help students develop sustainability skills, practices and mindset, we have designed content in this qualification aligned to the UNESCO Sustainable Development Goals (17 SDGs), that are relevant and appropriate to the sector. The SDGs are the most common point of reference for content that addresses sustainability and provides a useful and pragmatic way of organising this content.

Sustainability knowledge and understanding may be included in the teaching and learning content but not directly assessed. Alternatively, it could be assessed – the approach chosen for each unit is based on the relevance of the sustainability skills, knowledge or understanding to the purpose and scope and scope of the unit.

Appendix 3 shows a mapping of the teaching and learning content to the relevant SDGs to show where sustainability has been included in this qualification.

2 Qualification purpose

Pearson Level 3 Alternative Academic Qualification BTEC National in Applied Science (Certificate)

In this section you will find information on the purpose of this qualification and how its design meets that purpose through the qualification objective and structure. We publish a full 'Statement of Purpose' for each qualification on our website. These statements are designed to guide you and potential students to make the most appropriate choice of qualification at recruitment.

Who is this qualification for?

Pearson Level 3 Alternative Academic Qualification BTEC National in Applied Science (Certificate) is designed for post-16 students with an interest in science and aiming to progress to higher education as a route to graduate level employment.

Equivalent to half an A level in size, to be studied over a one- or two-year period, it is suitable for students looking to develop their scientific knowledge alongside a broad range of level 3 qualifications such as A levels or Technical Occupational Entry Qualifications.

What will the student study as part of this qualification?

The qualification has been developed in consultation with higher education representatives and sector experts from associated professional bodies to ensure students have the knowledge, understanding and skills they need to progress to, and thrive, in higher education.

The qualification has three mandatory units covering the following topics:

- **Principles and Applications of Biology** – Structure and function of cells and tissues, biological molecules, enzymes and their role in organisms
- **Principles and Applications of Chemistry** – Structure of the Periodic Table and its implications on physical and chemical properties of substances, through analysis of different bonding methods
- **Principles and Applications of Physics** – Waves and their applications; force principles and their application in transportation and construction of electrical circuits

What knowledge and skills will the student develop as part of this qualification and how might these be of use and value in further studies?

Students will develop the following knowledge and skills:

- Fundamental biological principles and their applications
- Fundamental chemical science principles and their applications
- Fundamental physics principles and their applications

- Problem solving
- Critical thinking.

Students can also develop other transferable skills such as personal responsibility and independent learning.

Students develop an understanding of scientific principles; the associated terminology and how scientific theories can interlink. Students will be given opportunities to develop critical thinking and problem-solving skills which can support progression in a broad range of degree programmes.

Which subjects will complement this qualification?

The following subjects would be suitable to combine with this qualification:

- Information Technology
- Maths
- Sociology
- Psychology
- Sport or Physical Education
- Technical Occupational Entry Qualification in Fitness.

What further learning will this qualification lead to?

This qualification can lead to progression to the following degrees:

- BSc (Hons) Computer Science
- BSc (Hons) Science with Foundation Year
- BSc (Hons) Health and Social Care
- BA (Hons) Education and Primary Studies.

This qualification is part of a larger suite. This qualification provides students with the opportunity to develop a basic understanding of scientific principles, which may facilitate progression into the science sector through foundation degree pathways. Additionally, it also provides the fundamental scientific knowledge required for wider STEM progression, such as degrees in computer sciences, social sciences or science education pathways.

Pearson Level 3 Alternative Academic Qualification BTEC National in Applied Science (Extended Certificate) is for those students with science at the core of their degree progression route, who require additional knowledge and skills specific to the science industry.

3 Structure

Qualification structure

Pearson Level 3 Alternative Academic Qualification BTEC National in Applied Science (Certificate)

Students must complete three mandatory units.

See *Section 6* for rules on qualification awarding.

Mandatory units – students complete all units

Unit number	Unit title	GLH	Type	How assessed
1	Principles and Applications of Biology	**60**	**Mandatory**	External
2	Principles and Applications of Chemistry	**60**	**Mandatory**	External
3	Principles and Applications of Physics	**60**	**Mandatory**	External

External assessment

100% of the total qualification GLH is made up of external assessment. A summary is given below. See the unit content and sample assessment materials for more information.

Unit	Type	Availability
Unit 1: Principles and Applications of Biology	• An external examination set and marked by Pearson • 50 marks	**January and May/June** **First assessment January 2027**
Unit 2: Principles and Applications of Chemistry	• An external examination set and marked by Pearson • 50 marks	**January and May/June** **First assessment January 2027**
Unit 3: Principles and Applications of Physics	• An external examination set and marked by Pearson • 50 marks	**January and May/June** **First assessment January 2027**

4 Units

Understanding your units

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

For this qualification there is only external assessment.

This section explains how the assessment's work. It is important that all teachers, and other staff responsible for the programme review this section.

Externally assessed units

Section	Explanation
Unit number	The number is in a sequence in the sector. Numbers may not be sequential for an individual qualification.
Unit title	This is the formal title that we always use and it appears on certificates.
Unit level	All units are Level 3 on the national framework.
Unit type	This confirms that the unit is externally assessed. See structure information in *Section 3* for full details.
GLH	Units have a Guided Learning Hours (GLH) value of 60. This indicates the numbers of hours of teaching, directed activity and assessment expected. It also shows the weighting of the unit in the final qualification grade.
Unit in brief	A brief formal statement on the content of the unit that is helpful in understanding its role in the qualification. You can use this in summary documents, brochures etc.
Unit introduction	This is designed with students in mind. It indicates why the unit is important, how learning is structured and how learning might be applied when progressing to employment or higher education.
Summary of assessment	This sets out the type of external assessment used and the way in which it is used to assess achievement.
Assessment outcomes	These show the hierarchy of knowledge, understanding, skills and behaviours that are assessed. Includes information on how this hierarchy relates to command terms in sample assessment materials (SAMs).

Section	Explanation
Content	For external units all content is obligatory. The depth of content is indicated in the assessment outcomes and sample assessment materials (SAMs). The content will be sampled through the external assessment over time, using the variety of questions shown.
Transferable skills	This summarises the transferable skills present within this unit. The key helps to identify whether they are signposted but require additional assessment, embedded and achieved on completion or not present in this unit.
Key terms typically used in assessment	These definitions will help you analyse requirements and prepare students for assessment.
Resources	Any specific resource requirements that you need to be able to teach and assess are listed in this section.

Index of units

Unit 1: Principles and Applications of Biology

Level: 3

Unit type: External

Guided learning hours: 60

Unit in brief

This unit explores the key components of biological science. It will examine cells and tissues, their varied structures and functions and the biological components that interact with their existence.

Unit introduction

Scientists and technicians working in science and science-related organisations must have a good understanding of core science concepts. 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.

The topic areas covered in this unit include:

- animal and plant cells and tissues, including specialised cells
- biological molecules, including water, carbohydrates, proteins and nucleic acid
- cell transport
- enzymes activity

Science professionals need to understand the structure and workings of cells. They build on this knowledge to understand how the body stays healthy as well as the symptoms and causes of some diseases. This allows them to diagnose and treat illnesses. The study of bacterial prokaryotic cells gives an understanding of how some other diseases are caused and can be treated. Scientists and technicians in the food industry also need to understand the structure and function of plant cells to enable them to develop food crops that produce greater yields.

The knowledge and understanding you will learn in this unit will provide a strong basis for you to progress in the science sector and to a variety of science related programmes such as higher nationals and degrees.

Summary of assessment

The unit will be assessed through one examination of 50 marks lasting 1 hour.

The paper will include a range of question types, including multiple choice, calculations, short answer and extended open response. These question types will assess knowledge and understanding of the content in this unit. Students will need to explore and relate to contexts and data presented.

The assessment availability is twice a year in January and May/June. The first assessment availability is May/June 2026.

Sample assessment materials will be available to help centres prepare students for assessment.

Assessment outcomes

AO1 Demonstrate knowledge and understanding of scientific concepts and theories, terminology, definitions and scientific formulae used in Biology.

AO2 Apply knowledge and understanding of scientific concepts and theories, procedures, processes and techniques in Biology.

AO3 Analyse and interpret scientific information in Biology.

[SP-CT]

Content

The essential content is set out under content areas. Students must cover all specified content before the assessment. All topics require students to apply knowledge, analyse and evaluate.

A: Structure and function of cells and tissues

A1 Structure and function of cells and tissues

The essential content topics require students to apply knowledge and understanding to given contexts:

A1.1 Ultrastructure and function of organelles in the following cells:

A1.1.1 prokaryotic cells (bacterial cell):

- nucleoid
- plasmids
- 70S ribosomes
- capsule
- cell wall
- cytoplasm
- plasma membrane
- mesosomes
- flagellae
- pili

A1.1.2 eukaryotic cells:

- plasma membrane
- cytoplasm
- nucleus
- nucleolus
- endoplasmic reticulum (smooth and rough)
- Golgi apparatus
- vesicles
- lysosomes
- 80S ribosomes
- mitochondria
- centrioles
- cilia

- Plant cell specific organelles:
  - cell wall
  - chloroplasts
  - vacuole
  - tonoplast
  - amyloplasts
  - plasmodesmata
  - pits.

A1.2 Recognising organelles from electron micrographs and photomicrographs.

A1.3 Similarities and differences between the structure and function of plant cells and animal cells.

A1.4 Responses of Gram-positive and Gram-negative bacteria when exposed to antibiotics.

A1.5 Calculate magnification and size of cells and organelles from images.

A2 Structure and function of specialised cells in multicellular organisms

A2.1 The structure and function of specialised eukaryotic cells:

- palisade mesophyll cells
- root hair cells
- xylem cells
- phloem cells
- sperm and egg cells in reproduction
- erythrocytes
- leucocytes
- thrombocytes
- neurones.

A3 Structure and function of biological tissues

A3.1 The structure and function of epithelial tissue:

A3.1.1 squamous as illustrated by the role of alveolar epithelium in gas exchange

A3.1.2 columnar as illustrated by goblet cells and ciliated cells in the lungs to include their role in protecting lungs from pathogens.

A3.1.3 the effect of chronic obstructive pulmonary disease (COPD)

A3.2 The structure and function of endothelial tissue, as illustrated by blood vessels in the cardiovascular system:

A3.2.1 risk factors that damage endothelial cells and lead to the development of atherosclerosis.

A3.3 The structure and function of muscular tissue:

A3.3.1 microscopic structure of a skeletal muscle fibre

A3.3.2 structural and physiological differences between fast- and slow-twitch muscle fibres and their relevance to short term and endurance-based activities

A3.4 The structure and function of nervous tissue:

A3.4.1 non-myelinated and myelinated neurones

A3.4.2 the conduction of a nerve impulse along an axon, to include changes in membrane permeability to sodium and potassium ions and the role of the myelination in saltatory conduction

A3.4.3 interpretation of graphical displays of a nerve impulse

A3.4.4 synaptic structure and the role of neurotransmitters

A3.4.5 imbalances of brain chemicals that can contribute to ill health, including dopamine in Parkinson's disease

A3.4.6 effects of drug interaction on synaptic transmission, to include agonists, antagonists and precursors

B: Structure and function of biological molecules

B1 Structure and function of water

B1.1 Structure:

- contains hydrogen (H) and oxygen (O) atoms
- structural and chemical formulae
- within water molecule (covalent bonding)
- polarity
- hydrogen bonds between water molecules

B1.2 Function:

- as a solvent
- medium for chemical reactions and transport
- pH regulation
- electrolyte balance
- temperature regulator
- cohesion-tension in mass flow.

B2 Structure and function of carbohydrates

B2.1 Structure:

- contain carbon (C), hydrogen and oxygen atoms
- monosaccharides:
  - α and β glucose,
  - galactose
  - fructose
  - ribose and deoxyribose.
- disaccharides:
  - lactose
  - maltose
  - sucrose.
- polysaccharides
  - Starch (amylose and amylopectin)
  - cellulose
  - glycogen

B2.2 Function:

- release of energy and the production of ATP
- energy storage
- structural

B2.3 Using iodine and Benedict's solution as tests for presence of carbohydrates.

B3 Structure and function of proteins

B3.1 Structure:

- primary structure, including peptide links to give polypeptides
- secondary structure, including α-helices and β-pleated sheets
- tertiary structure:
  - ionic interaction
  - hydrogen bonding
  - di-sulfide bridges/bonds
  - van der Waal's forces.
- quaternary structure, including haemoglobin
- classification as globular or fibrous

B3.2 Function:

- muscles
- enzymes
- antibodies
- antigens
- carrier proteins
- hormones
- for transport of other components
- body tissue growth and repair
- blood clotting

B3.3 Using Biuret solution as a test for presence of protein

B4 Structure and function of nucleic acids

B4.1 Structure:

- nucleotide structure (deoxyribose or ribose, phosphate and purine or pyrimidine base)
- polynucleotide structure with bonds made through condensation reactions
- formation of the DNA double helix through complementary base pairing
- formation of RNA nucleotides

B4.2 Function:

- DNA in genes
- RNA for protein synthesis and controlling gene expression.

B5 Structure and function of lipids

B5.1 Structure:

- carbon, hydrogen and oxygen in fats, oils and waxes
- saturated and unsaturated fats, and formation of diglycerides and triglycerides via esterification reactions

B5.2 Function:

- energy sources and stores
- insulation and organ protection
- phospholipids in membranes
- steroid hormones

B5.3 Use of emulsion tests to identify presence of lipids

C: Cellular transport and enzyme activity

C1 Cell transport mechanisms

C1.1 Structure of the cell surface membrane with reference to the fluid mosaic model.

C1.2 Methods used to transport molecules:

- through cell membranes:
  - passive transport brought about by diffusion
  - facilitated diffusion
  - osmosis
  - active transport
- bulk transport
  - endocytosis
  - exocytosis

C1.3 Significance of surface area to volume ratio in living organisms.

C2 Enzymes as biological catalysts

C2.1 Structure:

- made of proteins
- active site with specific tertiary structure

C2.2 Function:

- biological catalysts
- collision theory
- lock and key theory
- formation of enzyme-substrate complex
- specificity of enzymes
- importance of measuring initial rates of reaction

C2.3 Factors affecting enzyme activity

- optimum
- denaturing
- temperature
- pH
- substrate and enzyme concentration

C3 Homeostasis

C3.1 The purpose of homeostasis in relation to:

- optimum
- stimulus
- receptors/sensors
- control centres
- effectors
- feedback.

C3.2 Negative feedback loops effecting the body:

- blood pressure
- body fluids (osmoregulation)
- gas concentration
- blood sugar levels.

C3.3 Positive feedback loops effecting the body:

- blood clotting
- labour contractions.

C3.4 Interrelationship between nervous and endocrine system responses.

C3.4.1 role of the autonomic nervous system, breathing, heartbeat

C3.4.2 role of adrenal glands (fight and flight, heart rate)

C3.4.3 hypothalamus, endocrine and nervous system

C3.4.4 peripheral nervous system, autonomic system, relaying information to the brain.

C3.5 Disturbance of homeostasis

C3.5.1 ageing, weakening of feedback loops, heart failure, diabetes

C3.5.2 influence of lifestyle:

- nutrition
- physical activity
- drug/alcohol abuse

Transferable skills

Managing Yourself	Effective Learning	Interpersonal Skills	Solving Problems
MY – TPR	EL – MOL	IS – WC	SP – CT*
MY – PS&R	EL – CL	IS – V&NC	SP – PS
MY – COP	EL – SRS	IS – T	SP – C&I
MY – PGS	EL – PRS	IS – C&SI	

Table key

*	Signposted to indicate opportunities for development as part of wider teaching and learning.
√	Embedded in teaching, learning and assessment
Blank	TS not embedded or signposted in unit

Key terms typically used in assessment

The following table shows the key terms that will be used consistently by Pearson in our assessments to ensure students are rewarded for demonstrating the necessary skills.

Please note: the list below will not necessarily be used in every paper/session and is provided for guidance only.

Command or term	Definition
Add/label	Students label or add to a stimulus material given in the question, for example labelling a diagram, adding units on a table, adding points or line to a graph.
Assess	Students give careful consideration to all the factors or events that apply and identify which are the most important or relevant. Make a judgement on the importance of something and come to a conclusion where needed.
Calculate	Students obtain a numerical answer, showing relevant working and appropriate units where required.
Compare	Students look for the similarities **and** differences of two (or more) things. Should not require the drawing of a conclusion. Answer must relate to both (or all) things mentioned in the question.
Complete	Students complete a table/ diagram.
Deduce	Students draw/reach conclusion(s) from the information provided.
Describe	Students give an account of something. Statements in the response need to be developed as they are often linked but do not need to include a justification or reason.
Determine	Students' answers must have an element that is quantitative from the stimulus provided or must show how the answer can be reached quantitatively
Devise	Students plan or invent a procedure from existing principles/ ideas.
Discuss	Consider the different aspects in detail of an issue, situation, problem or argument and how they interrelate. Does not require a conclusion.
Draw	Create a graphical or visual representation of information.

Command or term	Definition
Evaluate	Students review information then bring it together to form a conclusion, drawing on evidence, strengths, weaknesses, alternative actions, relevant data or information. Come to a supported judgement of a subject's qualities and relation to its context.
Explain	Students identify a point and then give a linked justification/ reasoning of the given point. For a 3-mark question a further linked justification/reasoning is required. For a 4-mark question there could be two separate identification points that would require appropriate expansion, or one identification with three detailed additional points for expansion.
Give/state/name	These generally require recall of one or more pieces of information.
Give a reason	When a statement has been made and the requirement is only to give the reasons why.
Identify	Usually requires some key information to be selected from a given stimulus/resource.
Predict	Students give an expected result.
Sketch	Students produce a freehand drawing showing a trend line. The axes are labelled but not scaled.
State what is meant by	Provide the accepted definition of a term
Suggest	Propose a likely solution or application.
Which	Select one correct answer from a choice of four options.

Unit 2: Principles and Applications of Chemistry

Level: 3

Unit type: External

Guided learning hours: 60

Unit in brief

Students will explore some of the fundamental concepts which underpin the chemistry and chemical reactions of the world around them.

Unit introduction

Chemistry is not just a subject; it influences many aspects of other sciences. Everything you see, everything you do, everywhere you go, you are surrounded by chemistry and the chemical reactions that are needed for it. Chemistry makes up the world we live in today.

In this unit, you will re-examine basic chemistry (the periodic table, atomic and electronic structure, bonding and structure) with more advanced concepts such as ionisation energy, electronegativity, polarity, molecular shape and intermolecular forces. Periodicity will be explored through the study of Period 3 elements and their compounds, focusing on changes in oxidation number, physical and chemical properties, and making predictions for other elements. You will learn about the main branches of physical chemistry (chemical kinetics, energetics and equilibrium), perform mole calculations, and consider the impact of green chemistry in the chemical industry. You will learn the basics of organic chemistry, naming and drawing formulae, understanding isomerism and other properties, the reactions of different types of organic compound, and the benefits or problems that organic chemistry can provide.

The content covered at the beginning, will provide you with the pre-requisite knowledge to explore the subject further in the latter stages of the unit. The content enables you to build on your understanding as you progress towards your final assessment.

This unit will help you progress to higher education and professional qualifications either in chemistry, or other science-based qualifications. It will also help you to progress to employment in the chemical or scientific industry.

Summary of assessment

The unit will be assessed through one examination of 50 marks lasting 1 hour.

The paper will include a range of question types, including multiple choice, calculations, short answer and extended open response. These question types will assess knowledge and understanding of the content in this unit. Students will need to explore and relate to contexts and data presented.

The assessment availability is twice a year in January and May/ June. The first assessment availability is January 2027.

Sample assessment materials will be available to help centres prepare students for assessment.

Assessment outcomes

AO1 Demonstrate knowledge and understanding of scientific concepts and theories, terminology, definitions and scientific formulae used in Chemistry.

AO2 Apply knowledge and understanding of scientific concepts and theories, procedures, processes and techniques in Chemistry.

AO3 Analyse and interpret scientific information in Chemistry

[SP-CT]

Content

The essential content is set out under content areas. Students must cover all specified content before the assessment. All topics require students to apply knowledge, analyse and evaluate.

A: Atomic and electronic structure.

A1.1 Features of the periodic table and their relationship with atomic structure:

A1.1.1 symbols, atomic number, mass number

- use of these concepts to determine numbers of subatomic particles (protons, neutrons and electrons) in atoms, isotopes and ions

A1.1.2 relative atomic mass

- use of relative atomic mass to determine relative abundance of isotopes (and use of relative abundance of isotopes to determine relative atomic mass)
- use of relative atomic mass to determine relative formula masses

A1.1.3 group, period, blocks

- use of these concepts to determine the number and arrangement of electrons in atoms and ions

A1.2 Electronic structure

A1.2.1 energy levels (shells), subshells and electronic orbitals

A1.2.2 rules to determine the electronic structure of atoms

A1.2.3 represent electronic configuration for atoms and ions of elements with atomic numbers 1-36 in terms of:

- s, p and d notation
- electron-in-boxes diagrams.

A1.3 Ionisation energy

A1.3.1 definition and equations for first and successive ionisation energies

A1.3.2 evidence from successive ionisation energies for the electronic structure of an atom

A1.3.3 factors affecting ionisation energy trends down a group and across a period

- nuclear charge
- number of shells
- shielding
- subshells

B: Bonding and structure

Students will need to be able to describe and represent different types of bonding and structure listed in **B1.1**, **B1.2** and **B1.3** as dot-and-cross diagrams and/or lattice arrangements for atoms, ions and molecules.

B1.1 Metallic bonding and giant metallic structures

B1.2 Ionic bonding and giant ionic structures

B1.3 Covalent bonding and molecules:

- electrostatic attraction between two nuclei and the shared pair of electrons between them
- single, double, triple and dative covalent (coordinate) bonds
- sigma and pi molecular orbitals
- relationship between bond lengths and bond strength
- simple molecular structures and giant covalent structures

B1.4 Typical physical properties of substances with different types of bonding and structure in **B1.1**, **B1.2** and **B1.3**, to include melting point and electrical conductivity.

B1.5 Molecular shape – the use of electron pair repulsion theory to determine shapes of molecules (up to 6 electron pairs around the central atom):

- linear
- non-linear
- trigonal planar
- pyramidal
- tetrahedral
- trigonal bipyramidal
- octahedral and their associated bond angles.

B1.6 Electronegativity and polarity

- definition of electronegativity, trends across a period and down a group
- use of electronegativity to determine bond polarity
- use of electronegativity and molecular shape to identify molecules as polar or non-polar.

B1.7 Intermolecular forces

- London dispersion forces/temporary dipole – induced dipole forces
- permanent dipole – permanent dipole forces
- hydrogen bonding (and effects on physical properties).

B1.8 Effect of hydrogen bonding on the properties of water (melting and boiling point, densities of ice and liquid water, surface tension of water)

C: Periodicity

Students will need to be able to use the principles covered in section A (atomic and electronic structure) and section B (structure and bonding) to describe and explain the properties and reactions covered in this section.

C1.1 Changes in physical properties for the elements across Period 3 (Na to Ar):

- atomic radius and ionic radius (positively and negatively charged ions)
- melting point
- electrical conductivity.

C1.2 Oxidation number concept, oxidation and reduction

C1.2.1 determination of the oxidation number of an element in compounds and ions using the oxidation number concept

C1.2.2 application of the oxidation number concept to determine the formula of common oxides, hydroxides/acids and chlorides of Period 3 elements

C1.2.3 oxidation and reduction in terms of loss and gain of electrons

C1.2.4 construct half equations and redox equations

C1.3 Trends and observations for the reactions of the Period 3 elements with

C1.3.1 oxygen (formation of the products Na_2O, MgO, Al_2O_3, P_4O_{10} and SO_2 only)

C1.3.2 water (formation of the products $NaOH$, $Mg(OH)_2$ and $Al(OH)_3$ only)

C1.3.3 chlorine (formation of the products $NaCl$, $MgCl_2$, Al_2Cl_6, $SiCl_4$, and PCl_5 only)

C1.4 Differences in physical properties (melting point and electrical conductivity only) for the Period 3 oxides and chlorides listed in **C1.3**

C1.5 Acid-base behaviour of Period 3 oxides and hydroxides listed in **C1.3.1**, and of the compounds SiO_2, H_3PO_4, H_2SO_4, HCl, $HClO$ and $HClO_4$

C1.6 The action of water with Period 3 chlorides listed in **C1.3.3** and the pH of the solutions produced

C1.7 Write balanced equations for reactions in **C1.3, C1.5** and **C1.6.**

C1.8 Predict the physical and chemical properties of elements in other periods based upon knowledge of the Period 3 elements

C1.9 Uses of Period 3 elements and compounds, based upon their physical and chemical properties

D: Physical chemistry

D1.1 Concept of the mole and use in calculations involving:

- mass and molar mass (relative atomic mass or relative formula mass)
  - 1 mole of any substance contains the same number of particles as there are atoms in 12.00g of carbon-12
  - the number of particles in 1 mole is 6.02×10^{23} (known as the Avogadro constant)
  - convert moles into number of particles using the Avogadro constant (and the reverse)
  - the molar mass of a substance is the mass in grams of 1 mole of the substance (and is the same as the relative atomic mass or relative formula mass expressed in g mol^{-1})
  - perform calculations involving the mass of a substance, the number of moles and the molar mass
- empirical formula and stochiometric ratios in equations
  - determine whether a reactant is a limiting reagent or in excess
  - calculate quantities of masses for substances reacting or produced, using balanced chemical equations, moles and molar mass
- gas volume and molar volume ($24dm^3$ at room temperature and pressure)
  - one mole of any gas occupies 24.0 dm^3 at room temperature and pressure.
  - at any given temperature and pressure one mole of any gas occupies the same volume.
  - the molarity is the number of moles of a substance dissolved in water to produce a volume of 1 dm^3 of a solution and has units of mol dm^{-3}
  - perform calculations involving the concentration (molarity) of a solution, the number of moles and volume of the solution
  - perform calculations involving the concentration of a solution in g dm^{-3}, the mass of the substance dissolved and volume of solution
- percentage yield, actual yield and theoretical yield.

D1.2 Chemical kinetics

D1.2.1 factors affecting rate of reaction to include concentration, pressure, temperature, surface area and catalysis

- a catalyst is a substance that speeds up the rate of a reaction without altering the products of the reaction, being itself unchanged chemically and in mass at the end of the reaction.

D1.2.2 collision theory and activation energy

- effects on rates of reaction of changes in temperature, concentration, surface area to volume ratio of a solid and pressure (on reactions involving gases) in terms of frequency and/or energy of collisions between particles.

- the addition of a catalyst increases the rate of a reaction in terms of activation energy

D1.2.3 interpretation of concentration vs time graphs

D1.2.4 Maxwell-Boltzmann distribution curves – effect of changes in concentration, temperature and catalysis

D1.2.5 determination of rate equations, to include finding orders of reaction and the value of a rate constant (and its units), when given appropriate data

- using generalised rate equation is $r = k[A]^m[B]^n$
- rate order is determined experimentally
- k is rate constant.

D1.3 Chemical energetics

D1.3.1 enthalpy change – definition, endothermic and exothermic processes

D1.3.2 energy level diagrams and reaction profile diagrams for exothermic and endothermic reactions

- understand the effect of a catalyst upon the shape of an enthalpy reaction profile

D1.3.3 standard enthalpy changes –standard conditions and definitions of standard enthalpy change of formation, of combustion and of reaction

- the general symbol ΔH^θ will be used to represent the standard enthalpy change for a given reaction
- standard symbol indicates that standard conditions have been used
- importance of stating the conditions used in enthalpy change data
- define the standard enthalpy change of formation as the enthalpy change that occurs when one mole of a substance is formed from its elements in their standard states under standard conditions
- know the symbol for the standard enthalpy change of formation ($\Delta_f H^\theta$)
- recognise formation from a supplied equation
- know and understand why $\Delta_f H^\theta = 0$ kJ mol^{-1} for elements in their standard states
- define the standard enthalpy change of combustion as the enthalpy change that occurs when one mole of a substance is burnt completely in oxygen under standard conditions
- know the symbol for the standard enthalpy change of combustion ($\Delta_c H^\theta$)
- recognise combustion from a supplied equation.

D1.3.4 Hess's Law and energy cycles

D1.3.5 calculations involving energy cycles and standard enthalpy changes

- use equations to calculate enthalpy changes from supplied data, to include:
  - $\Delta H = \Delta U + p\Delta V$
  - $\Delta H^{\theta} = \Sigma \Delta_f H^{\theta}$ (products) – $\Sigma \Delta_f H^{\theta}$ (reactants)
  - $\Delta H^{\theta} = \Sigma \Delta_c H^{\theta}$ (reactants) – $\Sigma \Delta_c H^{\theta}$ (products)
  - $Q = mc\Delta T$

D1.4 Chemical equilibrium

D1.4.1 dynamic equilibrium – definition and characteristics

- many reactions are readily reversible and that they can reach a state of dynamic equilibrium in which:
  - the rate of the forward reaction is equal to the rate of the backward reaction
  - the concentrations of reactants and products remain constant.

D1.4.2 Le Chatelier's principle and predicting the effect on equilibrium of changes in concentration, pressure and temperature, and the presence of a catalyst

D1.4.3 equilibrium constant expressions (K_c or K_p) and units

D1.4.4 calculations involving equilibrium constants and concentrations or partial pressures

- deduce an expression for K_c, for homogeneous and heterogeneous systems, in terms of equilibrium concentrations
- deduce an expression for K_p, for homogeneous and heterogeneous systems, in terms of equilibrium partial pressures in atm
- calculate a value, with units where appropriate, for the equilibrium constant (K_c and K_p) for homogeneous and heterogeneous reactions, from experimental data

D1.4.5 interpretation of yield vs pressure or temperature graphs

D1.5 Application of chemical kinetics, energetics and equilibrium to the chemical industry

(Students are not required to have knowledge of specific chemical industries)

- control of temperature, pressure and catalyst used produce an acceptable yield in an acceptable time
- evaluate data to explain the necessity, for many industrial processes, to reach a compromise between the yield and the rate of reaction

D1.6 Application of green chemistry in the chemical industry

- atom economy and uses of waste products
  - calculate the atom economy of a reaction
- renewable and recycled resources
- energy efficiency and catalysis
  - understand how catalyst efficiency can be improved and inhibited
- hazards of reactants and products
  - understand risks and hazards in practical procedures and suggest appropriate precautions where necessary
- recycling of unused reactants
- end-of-life for products (recycling and degradation)

E: Organic chemistry

E1.1 Knowledge and understanding of key terms used in organic chemistry:

- saturated hydrocarbon and unsaturated hydrocarbon
- straight-chain, branched chain and cyclic organic compounds
- homologous series and functional group
- general formulae for alkanes, alkenes, halogenoalkanes and alcohols

E1.2 Structure representations of organic compounds, using

- full (displayed) structural formula (fully displayed and condensed formulae)
- skeletal formulae
- 3D representations using wedge/dashed line diagrams

E1.3 Naming alkanes, alkenes, halogenoalkanes and alcohols, using International Union of Pure and Applied Chemistry (IUPAC) nomenclature rules (up to 6 carbon atoms)

E1.3 Isomerism – predicting and explanation of occurrence of:

- structural isomerism
- stereoisomerism (E/Z and cis-trans stereoisomers only)

E1.5 Sigma and pi molecular orbitals in alkanes and alkenes

E1.6 Changes in boiling point within due to changes in chain length or branching

E1.7 Types of reactions of organic compounds

(Students are required to predict products of the reactions and know reaction conditions. Students are not required to know reaction mechanisms or practical techniques).

E1.7.1 addition reactions of alkenes with H_2, halogens, hydrogen halides and steam

- write equations, name and draw products from:
  - hydrogenation of alkenes
  - alkenes (to include symmetric and asymmetric alkenes)
  - hydration of alkenes
- the conditions for these reactions

E1.7.2 substitution reactions of alkanes with halogens using UV radiation

- write equations, name and draw products from substitution reactions of alkanes with halogens
- limitations of the use of radical substitution reactions in the synthesis of organic molecules, in terms of further substitution reactions and the formation of a mixture of products
- conditions for these reactions.

E1.7.3 substitution reactions of halogenolkanes with aqueous sodium hydroxide

- write equations, name and draw products from substitution reactions of halogenolkanes with aqueous sodium hydroxide
- conditions for these reactions.

E1.7.4 substitution reactions of alcohols with PCl_5 and with HBr

- write equations, name and draw products from substitution reactions of alcohols with PCl_5 and with HBr
- the conditions for these reactions.

E1.7.5 elimination reactions of halogenoalkanes using ethanolic sodium hydroxide

- write equations, name and draw products from elimination reactions of halogenoalkanes using ethanolic sodium hydroxide
- the conditions for these reactions.

E1.7.6 oxidation of primary alcohols to carboxylic acids using acidified $K_2Cr_2O_7$

- write equations, name and draw products from oxidation of primary alcohols to carboxylic acids using acidified $K_2Cr_2O_7$
- the conditions for these reactions.

E1.7.7 condensation reactions of alcohols with carboxylic acids to form esters

- write equations, name and draw products from condensation reactions of alcohols with carboxylic acids to form esters
- the conditions for these reactions.

E1.8 Reactions of commercial importance

(Students are required to write equations and predict products for these reactions)

E1.8.1 combustion (complete and incomplete) of hydrocarbons and alcohols

- predict products of complete and incomplete combustion of alkanes
- understand the importance of combustion.

E1.8.2 cracking of large chain alkanes (into smaller alkanes and alkenes)

- the conditions required to crack hydrocarbons
- smaller chain alkanes and alkenes are produced
- the purpose of cracking and the uses of the products.

E1.8.3 addition polymerisation

- recognise and draw polymers to include poly(ethene), poly(propene), poly(styrene), poly(chloroethene) (PVC), poly(tetrafluoroethene) (PTFE)
- understand the properties and uses of poly(ethene), poly(propene), poly(styrene), PVC, PTFE
- how ethene molecules can combine together in a polymerisation reaction.

E1.8.4 condensation polymerisation (dicarboxylic acids with diols or diamines)

- why polyesters are condensation polymers
- how a polyester is formed when a monomer molecule containing two carboxylic acid groups is reacted with a monomer molecule containing two alcohol groups
- how a molecule of water is formed each time an ester link is formed.

E1.9 Benefits and problems arising from combustion, halogenoalkanes (CFCs), polymers (plastics) and alcohol (ethanol)

E1.10 Solutions to environmental problems caused by organic compounds and their usage in **E1.8** and **E1.9**

Transferable skills

Managing Yourself	Effective Learning	Interpersonal Skills	Solving Problems
MY – TPR	EL – MOL	IS – WC	SP – CT *
MY – PS&R	EL – CL	IS – V&NC	SP – PS
MY – COP	EL – SRS	IS – T	SP – C&I
MY – PGS	EL-PRS	IS – C&SI	

Table key

*	Signposted to indicate opportunities for development as part of wider teaching and learning.
√	Embedded in teaching, learning and assessment
Blank	TS not embedded or signposted in unit

Key terms typically used in assessment

The following table shows the key terms that will be used consistently by Pearson in our assessments to ensure students are rewarded for demonstrating the necessary skills.

Please note: the list below will not necessarily be used in every paper/session and is provided for guidance only.

Command or term	Definition
Add/label	Students label or add to a stimulus material given in the question, for example labelling a diagram, adding units on a table, adding points or line to a graph.
Balance	Provide an appropriate number/formula to complete an equation.
Calculate	Students obtain a numerical answer, showing relevant working and appropriate units where required
Compare	Students look for the similarities and differences of two (or more) things. Should not require the drawing of a conclusion. Answer must relate to both (or all) things mentioned in the question.
Complete	Students complete a table/diagram
Deduce	Students draw/reach conclusion(s) from the information provided.
Describe	Students give an account of something. Statements in the response need to be developed as they are often linked but do not need to include a justification or reason
Determine	Students' answers must have an element that is quantitative from the stimulus provided or must show how the answer can be reached quantitatively.
Devise	Students plan or invent a procedure from existing principles/ ideas.
Discuss	Consider the different aspects in detail of an issue, situation, problem or argument and how they interrelate. Does not require a conclusion.
Draw	Create a graphical or visual representation of information
Evaluate	Students review information then bring it together to form a conclusion, drawing on evidence, strengths, weaknesses, alternative actions, relevant data or information. Come to a supported judgement of a subject's qualities and relation to its context

Command or term	Definition
Explain	Students identify a point and then give a linked justification/ reasoning of the given point. For a 3-mark question a further linked justification/reasoning is required. For a 4-mark question there could be two separate identification points that would require appropriate expansion, or one identification with three detailed additional points for expansion.
Give/state/name	These generally require recall of one or more pieces of information.
Give a reason	When a statement has been made and the requirement is only to give the reasons why
Identify	Usually requires some key information to be selected from a given stimulus/resource.
Plot	Students produce a graph by marking points accurately on a grid from data that is provided and then drawing a suitable line. A suitable scale and appropriately labelled axes must be included if these are not provided in the question.
Predict	Students give an expected result.
Sketch	Students produce a freehand drawing showing a trend line. The axes are labelled but not scaled
State what is meant by	Provide the accepted definition of a term
Suggest	Propose a likely solution or application.
Which	Select one correct answer from a choice of four options.
Write	Provide the correct equation or formula

Unit 3: Principles and Applications of Physics

Level: 3

Unit type: External

Guided learning hours: 60

Unit in brief

Students will explore the use of practical and mathematical skills in the study of waves, motion and electricity.

Unit introduction

If you've ever considered how the mechanics of a car, your mobile phone or how circuitry work, you shouldn't be surprised that physics plays a huge part in their action. This unit will explore the role physics has on our everyday tasks and activities, communication networks and our work with electrical circuits.

In this unit, you will learn about waves and how electromagnetic waves are the basis for our modern communication systems. Mobile phones, Wii-FI and Bluetooth© will no doubt be concepts you're already familiar with. This unit will enable you to develop an insight into how these systems work and the activities they perform. The study of motion and laws of motion are also important when developing safety products for our everyday lives. Seat belts, air bags and crumple zones are just three innovations that came about through the study of motion. Electricity, electrical circuits and their relationship to energy usage, are also very important as our use of electrical devices continues to rise. By using physics, it is possible to understand how we can create energy alternatives that can help us develop greater more sustainability in our future environment.

Understanding the physical principles, practical investigations and mathematical skills developed in this unit will allow for progression to higher education and professional qualifications such as health and social care, technicians in medicine, dentistry and laboratory quality control.

Summary of assessment

The unit will be assessed through one examination of 50 marks lasting 1 hour.

The paper will include a range of question types, including multiple choice, calculations, short answer and extended open response. These question types will assess knowledge and understanding of the content in this unit. Students will need to explore and relate to contexts and data presented.

The assessment availability is twice a year in January and May/ June. The first assessment availability is January 2027.

Sample assessment materials will be available to help centres prepare students for assessment.

Assessment outcomes

AO1 Demonstrate knowledge and understanding of scientific concepts and theories, terminology, definitions and scientific formulae used in Physics.

AO2 Apply knowledge and understanding of scientific concepts and theories, procedures, processes and techniques in Physics.

AO3 Analyse and interpret scientific information in Physics.

[SP-PS]

Content

The essential content is set out under content areas. Students must cover all specified content before the assessment. All topics require students to apply knowledge, analyse and evaluate.

A: Understanding waves and optical fibres

A1 Working with waves

A1.1 Features common to waves

A1.1.1 understand terminology:

- periodic time
- wave speed
- wavelength
- frequency
- amplitude
- oscillation

A1.1.2 graphical and diagrammatic representation of wave features.

A1.2 Similarities and differences between transverse and longitudinal waves

A1.3 Concepts of; displacement, coherence, path difference, phase difference and superposition of waves as applied to diffraction gratings.

A1.3.1 emission of different light frequencies due to electron energy level changes within the atom.

A1.3.2 using diffraction gratings to form line emission spectra

A1.3.3 using the lines of emission spectra to identify elements in gases.

A1.4 Using the wave equation: $v = f\lambda$

A1.5 Concepts and applications of stationary waves and resonance in strings and pipes.

A1.5.1 concepts and applications of stationary waves and resonance to musical instruments.

A1.5.2 using the equation: speed of a transverse wave on a string, $v = \sqrt{(T/\mu)}$ where T is the tension in the string and μ is the mass per unit length of the string

A2 Principles of optical fibres

A2.1 Concept of refraction and total internal reflection (TIR)

A2.1.1 use equations for refractive index $n = \frac{C}{V} = \frac{Sin\ i}{Sin\ r}$

A2.1.2 know that total internal reflection only occurs when the angle of incidence in the more optically dense medium is greater than the critical angle

A2.1.3 calculate the critical angle at a glass–air interface given the refractive index of glass using:

$$sin\ c = \frac{l}{n}$$

A2.1.4 know how cladding of optical fibres effects the critical angle in the fibre

A2.2 Applications of optical fibres in engineering, communication, and medicine.

A2.3 Differences between analogue and digital signals

A3 Uses of electromagnetic waves in communication

A3.1 All electromagnetic waves travel at the speed of light in a vacuum.

A3.2 Use the inverse square law in relation to the intensity of a wave: $I = \frac{k}{r^2}$

A3.3 Regions of electromagnetic spectrum overlap and have different frequencies and wavelengths

A3.3.1 using electromagnetic waves and frequencies in communication applications, to include:

- satellite communication and GPS positioning
- mobile phones
- Bluetooth©
- infrared
- Wi-Fi

B: Forces in transportation and Newtons Laws of Motion

B1 Measurement and representation of motion

B1.1 Standard SI units

B1.1.1 standard SI units and symbols for initial velocity (u), final velocity (v), distance and displacement (s), time (t), and acceleration (a).

B1.1.2 units of speed: kilometres per second (kms^{-1}), kilometres per hour (kmh^{-1}).

B1.2 Calculating speed and average speed

B1.2.1 speed = distance ÷ time

B1.2.2 average speed = total distance ÷ total time.

B1.3 Using vector and scalar quantities to describe motion:

B1.3.1 using velocity as a vector quantity that has magnitude and direction

B1.3.2 using distance as a scalar quantity that has magnitude only

B1.3.3 using displacement/time graphs to find velocity

B1.3.4 using velocity time graphs to describe the motion of an object

B1.3.5 using velocity/time graphs to find the distance travelled from the area beneath the graph

B1.3.6 using velocity/time graphs to find acceleration as rate of change of velocity from the gradient of the graph, $a = \frac{(v-u)}{t}$

B1.3.7 find the acceleration of a trolley moving down a gradient

B1.3.8 use equations for the calculation of motion:

$$s = \frac{(u + v)t}{2}$$

$$v = u + at$$

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

B1.4 Understand the applications of accelerometers, to include: 'fitbits', mobile phones and blood pressure monitors

B2 Laws of motion

B2.1 Newton's First Law of Motion – the application of a resultant force to make an object move or stop

B2.2 Definitions of inertia, mass and weight.

B2.2.1 inertia as a resistance to change in motion

B2.2.2 gravitational field strength (g) and weight

B2.2.3 calculations for weight, equation $W = mg$

B2.3 Calculation of the coefficient of friction (μ) using the equation: force $F = \mu N$ where N is the normal reaction force, the weight of object on a horizontal surface.

B2.3.1 measuring coefficient of static friction, where *F* is the force applied just as the object is about to move

B2.3.2 measuring coefficient of dynamic (kinetic) friction, where *F* is the force applied to keep the object moving at a constant velocity.

B2.4 Calculating the momentum (p) of objects using the equation $p = mv$

B2.5 Using Newton's Second Law of Motion, force is proportional to rate of change of momentum, to include:

$F = \frac{(mv-mu)}{t}$ and $F = ma$

force is proportional to acceleration for a constant mass

B2.5.1 calculations using Newtons Second Law

B2.5.2 implications for transportation when travelling at high speed with low mass and low speed with high mass

B2.5.3 use of impact force controls:

- air bags
- seat belts
- helmets for motor bike users
- passenger 'cells'
- crumple zones.

B2.6 Newton's third law of motion action and reaction are equal and opposite

B2.7 Know that if *F* is the resultant force on an object, the object accelerates, if the forces are balanced *F* is zero and the object is moving at a constant velocity or stationary

B2.7.1 effect of air resistance, drag and terminal velocity in different applications, to include:

- vehicles on roads
- falling parachutes
- objects falling in liquids

C: Electrical circuits and the transfer of energy

C1 Use of electrical components

C1.1 Identifying circuit symbols

C1.2 Defining terminology – current, potential difference, energy and power

C1.2.1 identifying the electrical units of measurement:

- current in amps (A)
- potential difference in volts (V)
- power in watts (W)
- energy in joules (J)
- resistance in ohms (**Ω**)

C1.3 Connecting circuits with cells, batteries, power supplies, lamps, resistors, variable resistors, switches, ammeters and voltmeters.

C1.3.1 using electrical meters in series and parallel to measure current and potential difference

C1.3.2 using an ohmmeter to measure the resistance of a component

C1.4 Using electrical components in circuits:

- filament lamps
- diodes
- thermistors
- light dependent resistors (LDR)
- photodiodes and light emitting diodes (LED)

C2 Equations

C2.1 Using equations for electrical calculations:

C2.1.1 power = potential difference × current **($P = IV$)**

C2.1.2 voltage = current × resistance **($V = IR$)**

C2.1.3 power = work done/ time **($P = \frac{E}{t}$)**

C2.1.4 energy = potential difference × current × time **($E = VIt$)**

C3 Electrical energy usage

C3.1 Relating to different domestic appliances to calculate energy usage.

C3.2 Relating fuse size to current.

C3.3 Calculating transferred energy using the equation:
Energy transferred = power in kilowatts × time in hours (kWh = kW × h)

C4 Energy transfer

C4.1 Defining units – joules (J), kilojoules (kJ), mega joules (MJ)

C4.2 Converting temperatures between Celsius (°C) and Kelvin (K)

C4.3 The transfer of energy to give a change of temperature and change of state

C4.4 Temperature change

C4.4.1 measuring specific heat capacity of liquids and solids

C4.4.2 using equation:
Thermal energy = mass × specific heat capacity × temperature change
$\Delta Q = m\ c\ \Delta T$

C4.4.3 unit of measurement of specific heat capacity J $kg^{-1}K^{-1}$

C5 Change of state

C5.1 Measuring specific latent heat fusion and vapourisation for a liquid

C5.2 Using the equation:
Thermal energy = mass x specific latent heat. $\Delta Q = m\ L$

Transferable skills

Managing Yourself	Effective Learning	Interpersonal Skills	Solving Problems
MY – TPR	EL – MOL	IS – WC	SP – CT
MY – PS&R	EL – CL	IS – VC	SP – PS *
MY – COP	EL – SRS	IS – T	SP-C&I
MY – PGS	EL-PRS	IS– C&SI	

Table key

*	Signposted to indicate opportunities for development as part of wider teaching and learning.
√	Embedded in teaching, learning and assessment
blank	TS not embedded or signposted in unit

Key terms typically used in assessment

The following table shows the key terms that will be used consistently by Pearson in our assessments to ensure students are rewarded for demonstrating the necessary skills.

Please note: the list below will not necessarily be used in every paper/session and is provided for guidance only.

Command or term	Definition
Add/label	Students label or add to a stimulus material given in the question, for example labelling a diagram, adding units on a table, adding points or line to a graph.
Assess	Students give careful consideration to all the factors or events that apply and identify which are the most important or relevant. Make a judgement on the importance of something and come to a conclusion where needed.
Calculate	Students obtain a numerical answer, showing relevant working and appropriate units where required
Compare	Students look for the similarities **and** differences of two (or more) things. Should not require the drawing of a conclusion. Answer must relate to both (or all) things mentioned in the question
Complete	Students complete a table/diagram
Describe	Students give an account of something. Statements in the response need to be developed as they are often linked but do not need to include a justification or reason
Determine	Students' answers must have an element that is quantitative from the stimulus provided or must show how the answer can be reached quantitatively.
Devise	Students plan or invent a procedure from existing principles/ ideas.
Discuss	Consider the different aspects in detail of an issue, situation, problem or argument and how they interrelate. Does not require a conclusion.
Draw	Create a graphical or visual representation of information
Evaluate	Students review information then bring it together to form a conclusion, drawing on evidence, strengths, weaknesses, alternative actions, relevant data or information. Come to a supported judgement of a subject's qualities and relation to its context

Command or term	Definition
Explain	Students identify a point and then give a linked justification/ reasoning of the given point. For a 3-mark question a further linked justification/reasoning is required. For a 4-mark question there could be two separate identification points that would require appropriate expansion, or one identification with three detailed additional points for expansion.
Give/state/name	These generally require recall of one or more pieces of information.
Give a reason	When a statement has been made and the requirement is only to give the reasons why
Identify	Usually requires some key information to be selected from a given stimulus/resource.
Predict	Students give an expected result
Show that	Students prove that a numerical figure is given to one more decimal place than stated in the question.
Sketch	Students produce a freehand drawing showing a trend line. The axes are labelled but not scaled
State what is meant by	Provide the accepted definition of a term
Suggest	Propose a likely solution or application.
Which	Select one correct answer from a choice of four options.

5 Planning your programme

Supporting you in planning and implementing your programme

There will be lots of free teaching and learning support to help you deliver the new qualifications, including:

- Our Planning and Teaching Guide will help you to plan how to deliver the content and assessments that make up the Pearson Level 3 Alternative Academic Qualification BTEC National in Applied Science (Certificate). It also highlights opportunities to develop the transferable skills identified within the units in this specification.
- Sample Assessment materials are available for each external unit to help you to plan and prepare for assessments.
- Our mapping document highlights key differences between the new qualification and Pearson BTEC Level 3 National Certificate in Applied Science, which this qualification replaces.

Is there a student entry requirement?

As a centre it is your responsibility to ensure that students who are recruited have a reasonable expectation of success on the programme. There are no formal entry requirements but we expect students to have qualifications at or equivalent to Level 2.

Students are most likely to succeed if they have:

- five GCSEs at good grades, and/or
- BTEC qualification(s) at Level 2
- achievement in English and mathematics through GCSE or Functional Skills.

Students may demonstrate ability to succeed in various ways. For example, students may have relevant work experience or specific aptitude shown through diagnostic tests or non-educational experience.

6 Understanding the qualification grade

Awarding and reporting for the qualification

This section explains the rules that we apply in awarding a qualification and in providing an overall qualification grade for each student. It shows how all the qualifications in this sector are graded.

The awarding and certification of these qualifications will comply with regulatory requirements.

Eligibility for an award

In order to be awarded a qualification, a student must:

- complete and **have an outcome** (D, M, P, N or U) for all units within a valid combination
- achieve the **minimum number of points** at a grade threshold.

Awarding the qualification grade

The final grade awarded for a qualification represents an aggregation of a student's performance across the qualification. As the qualification grade is an aggregate of the total performance, there is some element of compensation in that a higher performance in some units may be balanced by a lower outcome in others.

BTEC Nationals are Level 3 qualifications and are awarded at the grade ranges shown in the table below.

Qualification	Available grade range
Certificate	P to D*

The *Awarding the qualification grade* table, shown further on in this section, shows the minimum thresholds for calculating these 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.

Students who do not meet the minimum requirements for a qualification grade to be awarded will be recorded as Unclassified (U) and will not be certificated. They may receive a Notification of Performance for individual units. The *Information Manual* gives full information.

Points available for external units

Raw marks from the external units will be awarded **points** based on performance in the assessment. The table below shows the **minimum number of points** available for each grade in the external units.

Grade	Unit size (60 GLH)
U	0
Near Pass	4
Pass	6
Merit	10
Distinction	16

Pearson will automatically calculate the points for each external unit once the external assessment has been marked and grade boundaries have been set. For more details about how we set grade boundaries in the external assessment please go to our website.

Claiming the qualification grade

Subject to eligibility, Pearson will automatically calculate the qualification grade for your students when the internal unit grades are submitted and the qualification claim is made. Students will be awarded qualification grades for achieving the sufficient number of points (with valid combinations) within the ranges shown in the relevant *Award of qualification grade* table for the cohort.

Awarding the qualification grade

Applicable for registration from 1 August 2026.

Certificate (180 GLH)

Grade	Points threshold
U	0
Pass	18
Merit	26
Distinction	37
Distinction *	45

The table is subject to review over the lifetime of the qualification. The most up-to-date version will be issued on our website.

Example grading table for Pearson Level 3 Alternative Academic Qualification BTEC National in Applied Science (Certificate)

Unit number	GLH	Type (Int/Ext)	Grade	Unit points
1	60	Ext	Distinction	16
2	60	Ext	U	2
3	60	Ext	Pass	6
TOTAL	**180**		**Pass**	**24**

Appendix 1 Transferable Skills framework

Code = transferable skill initials-skill cluster initials

Managing yourself

Code	Skill cluster	Performance Descriptor
MY-TPR	Taking personal responsibility	• Demonstrates understanding of their role and responsibilities and the expected standards of behaviour. • Demonstrates compliance with codes of conduct and ways of working. • Makes use of available resources to complete tasks. • Manages their time to meet deadlines and the required standards. • Demonstrates accountability for their decisions or actions.
MY-PS&R	Personal strengths and resilience	• Identifies own personal strengths and demonstrates the ability to utilise/ these in relevant areas. • Demonstrates the ability to adapt own mindset and actions to changing situations or factors. • Uses challenges as learning opportunities.

Code	Skill cluster	Performance Descriptor
MY-COP	Career orientation planning	• Undertakes research to understand the types of roles in the sector in which they could work. • Reviews own career plans against personal strengths and identifies areas for development to support progression into selected careers. • Takes part in sector-related experiences to support career planning.
MY-PGS	Personal goal setting	• Sets SMART goals using relevant evidence and information. • Reviews progress against goals and identifies realistic areas for improvement. • Seeks feedback from others to improve own performance.

Effective learning

Code	Skill cluster	Performance Descriptor
EL-MOL	Managing own learning	• Maintains a focus on own learning objectives when completing a task. • Demonstrates the ability to work independently to complete tasks. • Reviews and applies learning from successful and unsuccessful outcomes to be effective in subsequent tasks.
EL-CL	Continuous learning	• Engages with others to obtain feedback about own learning progress. • Responds positively to feedback on learning progress from others. • Monitors own learning and performance over the short and medium term.
EL-SRS	Secondary research skills	• Define the research topic or question • Uses valid and reliable sources to collate secondary data. • Interprets secondary data and draws valid conclusions. • Produces a reference list and cites sources appropriately.
EL-PRS	Primary research skills	• Define the research topic or question • Carries out primary data collection using appropriate and ethical research methodology. • Interprets primary data to draw valid conclusions

Interpersonal skills

Code	Skill cluster	Performance Descriptor
IS-WC	Written communication	• Produces clear formal written communication using appropriate language and tone to suit purpose.
IS-V&NC	Verbal and non-verbal communications	• Uses verbal communication skills effectively to suit audience and purpose. • Uses body language and non-verbal cues effectively • Uses active listening skills and checks understanding when interacting with others.
IS-T	Teamwork	• Engages positively with team members to understand shared goals and own roles and responsibilities. • Respectfully consider the views of team members and consistently shows courtesy and fairness. • Completes activities in line with agreed role and responsibilities. • Provide support to team members to achieve shared goals.
IS-C&SI	Cultural and social intelligence	• Demonstrates awareness of own cultural and social biases • Demonstrates diversity, tolerance and inclusivity values in their approach to working with others.

Solving problems

Code	Skill cluster	Performance Descriptor
SP-CT	Critical thinking	• Demonstrates understanding of the problem or issue to be addressed • Make use of relevant information to build ideas and arguments • Assesses the importance, relevance and/or credibility of information and ideas • Analyses, interprets and evaluates information to present reasoned conclusions
SP-PS	Problem solving	• Presents a clear definition of the problem • Gathers relevant information to formulate proposed solutions • Selects relevant and significant information to formulate proposed solutions. • Identifies negative and positive implications of proposed solutions. • Presents and justifies selected solutions to problems.
SP-C&I	Creativity and innovation	• Identifies new and relevant ideas to help solve a problem. • Refines ideas into workable solutions based on test results and/or feedback.

Appendix 2 Digital Skills framework

Problem solving

Using digital tools to analyse and solve problems:

Performance descriptor	Unit mapping
Use digital tools and techniques for research, collaboration and resolution of problems.	Unit 3, A3 Uses of electromagnetic waves in communication Unit 3, B1 Measurement and representation of motion Unit 3, C1 Use of electrical components
Have up-to-date knowledge of ways that technology is used within a sector.	N/A
Present ideas and finding using digital tools.	N/A
Use digital tools to manipulate data.	N/A

Digital collaboration and communication

Using digital tools to communicate and share information with stakeholders:

Performance descriptor	Unit mapping
Understand and use digital collaboration and communication platforms.	N/A
Use collaboration tools to meet with, share and collaborate with customers and colleagues.	N/A

Transacting digitally

Using digital tools to set up accounts and pay for goods/services:

Performance descriptor	Unit mapping
Use online systems to access and update digital records.	N/A
Set-up accounts to complete transactions.	N/A

Digital security

Identify threats and keep digital tools safe:

Performance descriptor	Unit mapping
Understand the types of malware.	N/A
Understand the threats involved in carrying out online activities.	N/A
Protect personal and organisation information and data.	N/A
Keeping systems secure.	N/A

Handling data safely and securely

Follow correct procedures when handling personal and organisational data:

Performance descriptor	Unit mapping
Manage passwords and keep them secure.	N/A
Identify website and services that are secure and insecure.	N/A
Understand the digital policy for a sector.	N/A
Understand the impact of online data.	N/A
Understand copyright and intellectual property.	N/A

Appendix 3 Sustainability framework

Sustainable development goal	Unit mapping
SDG 1: No poverty	N/A
SDG 2: Zero hunger	N/A
SDG 3: Good health and wellbeing	N/A
SDG 4: Quality education	N/A
SDG 5: Gender equality	N/A
SDG 6: Clean water and sanitation	N/A
SDG 7: Affordable and clean energy	Unit 2, D1 Green chemistry Unit 2 E1 Reactions of commercial importance Unit 2 E1 Solutions to environmental problems caused by organic compounds
SDG 8: Decent work and economic growth	N/A
SDG 9: Industry, innovation and infrastructure	N/A
SDG 10: Reduced inequalities	N/A
SDG 11: Sustainable cities and communities	N/A
SDG 12: Responsible consumption and production	Unit 2 D1 Yield and Equilibrium Unit 2 D1 Green Chemistry Unit 2 E1 Reactions of commercial importance Unit 3 C3 Electrical energy usage
SDG 13: Climate action	N/A
SDG 14: Life below water	N/A
SDG15: Life on land	N/A
SDG 16: Peace, justice and strong institutions	N/A
SDG 17: Partnerships for the goals	N/A

Appendix 4 Formulae Sheet

Summary formulae sheet for Unit 3 Principles and Applications of Physics:

Wave speed	$v = f\,\lambda$
Speed of a transverse wave on a spring	$v = \sqrt{\frac{T}{\mu}}$
Refractive index	$n = \frac{c}{v} = \frac{\sin i}{\sin \mathrm{r}}$
Critical angle	$\sin c = \frac{1}{n}$
Inverse square law in relation to the intensity of the wave	$I = \frac{k}{r^2}$
Distance travelled = average speed x time	
Acceleration = change in Velocity ÷ time	$a = \frac{(\mathrm{v} - \mathrm{u})}{t}$
Force = mass x acceleration	$F = m \times a$
Weight = mass x gravitational field strength	$W = m \times g$ $g = 9.81\ N/m^2$
Momentum = mass x velocity	$p = m \times v$
Force as rate of change of momentum	$F = \frac{(\mathrm{mv} - \mathrm{mu})}{t}$
Force due to friction	$F = \mu N$

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