New for 2016

LEVEL 3 CERTIFICATE IN APPLIED SCIENCE

180 GLH (1776)

LEVEL 3 EXTENDED CERTIFICATE IN APPLIED SCIENCE

360 GLH (1777)

Specifications
First registration September 2016 onwards

Version 4.6 July 2020

Applied General qualifications from AQA

Contents

1 About these qualifications

These qualifications meet Department for Education (DfE) design requirements for Applied Generals and are Advanced (Level 3) Applied qualifications, on a par with A-levels. They have been developed in close collaboration with higher education and professional bodies to ensure that they have both recognition and value.

They are for learners of 16 and over who wish to progress to higher education or to employment in an applied science area.

They fulfil entry requirements for a range of higher education courses, either by meeting the entry requirements in their own right or by being accepted alongside and adding value to other qualifications at the same level. These qualifications could also support learners in progressing to a related apprenticeship or into employment.

The Statements of purpose give more detail on the likely progression for learners with these qualifications.

2 Qualifications at a glance – overview

2.1 Level 3 Certificate in Applied Science

Ofqual qualification number	601/7104/2	**AQA qualification number**	1776
First registration date	1 September 2016	**Age range**	16–18, 19+
Total qualification time (TQT)	180 hours (180 Guided Learning Hours)	**UCAS points**	Information on UCAS points can be obtained from ucas.com
Unit weighting **Externally assessed** **Internally assessed**	33.3% per unit 66.6% externally assessed 33.3% internally assessed	**Performance table points**	Information on performance measures can be found at education.gov.uk
Eligibility for funding	Yes	**Entry requirements**	There are no formal entry requirements for this qualification set by AQA.

Mandatory units	All units in this qualification are mandatory.
Resits, resubmissions and retakes	Resits and retakes are permitted where a learner has either failed the requirements of the unit, or where they wish to improve on a grade awarded. For certification purposes, AQA will recognise the best achievement by the learner and not the most recent. **Resitting an exam or external assessment** The learner is permitted **three** attempts (one initial and two resits) in relation to each examined/externally assessed unit of the specification. Learners who have been awarded the Certificate qualification and have progressed to the Extended Certificate are allowed to use the resit opportunities to go back and improve the grade achieved in the external assessment. Any improvement cannot be used to upgrade and reclaim the previously awarded Certificate. **Resubmitting internal assessments** The learner is permitted **one** resubmission in relation to each internally assessed unit of the qualification, but only when the tutor believes the learner can achieve the outstanding criteria without further guidance. Any resubmission of work must be undertaken prior to external moderation. **Retaking internal assessments** The learner is permitted **one** retake in relation to each internally assessed unit of the qualification. This could mean the learner doing the entire unit work again, or simply correcting a task/assignment before the unit is again submitted for external moderation by AQA. With a retake, learners are not allowed a resubmission opportunity. Any retake and/or resubmission of work must be completed within a defined and reasonable period of time following learner feedback of the initial assessment. Any work provided as evidence must be authenticated by the learner as their own.

Assessment model	This qualification contains externally assessed and internally assessed units. Externally assessed units are assessed by written examination. Internally assessed units are externally moderated by AQA.	**Examination sessions**	January and June each year.

Grading	The units are graded Pass, Merit or Distinction following the application of compensation rules for the internally assessed units. The overall qualification is graded as P, M, D and D*. (Learners must pass each unit in order to pass the qualification subject to the 'near pass rule' see specification section 16.5).
Synoptic learning and assessment	This qualification is structured to support the mandatory requirement of synoptic learning and synoptic assessment.

2.2 Level 3 Extended Certificate in Applied Science

Ofqual qualification number	601/7105/4	AQA qualification number	1777
First registration date	1 September 2016	Age range	16–18, 19+
Total qualification time (TQT)	360 hours (360 Guided Learning Hours)	UCAS points	Information on UCAS points can be obtained from ucas.com
Unit weighting Externally assessed Internally assessed	16.6% per unit 50% externally assessed 50% internally assessed	Performance table points	Information on performance measures can be found at education.gov.uk
Eligibility for funding	Yes	Entry requirements	There are no formal entry requirements for this qualification set by AQA.

Mandatory units	This qualification has five mandatory units.
Optional units	Learners are required to achieve one optional unit from a choice of three.
Resits, resubmissions and retakes	Resits and retakes are permitted where a learner has either failed the requirements of the unit, or where they wish to improve on a grade awarded. For certification purposes, AQA will recognise the best achievement by the learner and not the most recent. **Resitting an exam or external assessment** The learner is permitted **three** attempts (one initial and two resits) in relation to each examined/externally assessed unit of the specification. Learners who have been awarded the Certificate qualification and have progressed to the Extended Certificate are allowed to use the resit opportunities to go back and improve the grade achieved in the external assessment. Any improvement cannot be used to upgrade and reclaim the previously awarded Certificate. **Resubmitting internal assessments** The learner is permitted **one** resubmission in relation to each internally assessed unit of the qualification, but only when the tutor believes the learner can achieve the outstanding criteria without further guidance. Any resubmission of work must be undertaken prior to external moderation. **Retaking internal assessments** The learner is permitted **one** retake in relation to each internally assessed unit of the qualification. This could mean the learner doing the entire unit work again, or simply correcting a task/assignment before the unit is again submitted for external moderation by AQA. With a retake, learners are not allowed a resubmission opportunity. Any retake and/or resubmission of work must be completed within a defined and reasonable period of time following learner feedback of the initial assessment. Any work provided as evidence must be authenticated by the learner as their own.

Assessment model	This qualification contains externally assessed and internally assessed units. Externally assessed units are assessed by written examination. Internally assessed units are externally moderated by AQA.	**Examination sessions**	January and June each year.

Grading	The units are graded Pass, Merit or Distinction following the application of compensation rules for the internally assessed units. The overall qualification is graded as P, M, D and D*. (Learners must pass each unit in order to pass the qualification subject to the 'near pass rule' see specification section 16.5).
Synoptic learning and assessment	This qualification is structured to support the mandatory requirement of synoptic learning and synoptic assessment.

3 Level 3 Certificate in Applied Science: Statement of purpose

3.1 Qualification objectives

The objectives of this qualification are to:

- prepare learners to progress to a qualification in the same subject area but at a higher level or requiring more specific knowledge, skills and understanding
- meet relevant programmes of learning
- prepare learners for employment
- give learners personal growth and engagement in learning.

3.2 Who is this qualification for?

This qualification is aimed at 16 to 18 year old learners who are in full-time Level 3 education and who wish to progress to higher education and/or pursue a career in the applied science sector. There are no formal entry requirements for this qualification, but to optimise their chances of success, learners will typically have four GCSEs at grade C or above, including science, maths and English.

This qualification will provide learners with a broad understanding of vocationally-related sciences to support progress to higher education. It is suitable for studying alongside substantial academic science qualifications, such as A-level sciences or other Level 3 vocational qualifications. This qualification can also prepare learners to take up employment in the applied science sector, either directly after achieving the qualification or via higher education.

Studying this qualification will enable learners to develop their knowledge and understanding of scientific principles, as well as those scientific practical skills recognised by higher education institutions and employers to be most important. The qualification also offers learners an opportunity to develop transferable skills such as problem-solving, research and communication as part of their applied learning.

3.3 What does this qualification cover?

All three of the units in this qualification are mandatory and AQA has worked with stakeholders in developing the design and content of this qualification to ensure that it covers the fundamental scientific knowledge, understanding and practical skills associated with applied science learning.

Learners will cover topics such as:

- scientific principles associated with the application of biology, chemistry and physics
- experimental and practical techniques associated with applied science
- the roles and skills of scientists, and the public and media perception of science.

3.4 What could this qualification lead to?

This qualification is supported by a range of universities, and taken alongside other qualifications it can fulfil the entry requirements for a number of science-related higher education courses, including biomedical, forensic and sports science, as well as nursing. In addition, the qualification is eligible for UCAS points ucas.com

3.5 Who supports this qualification?

This qualification has been developed in collaboration with higher education and other stakeholders in the science education sector. Therefore, the knowledge and skills gained will provide the best possible opportunity for progress to higher education or employment.

The qualification is supported by the following higher education institutions:

- Aberystwyth University
- Birmingham City University
- University of Bolton
- Edge Hill University
- Staffordshire University
- University of South Wales
- Southampton University
- University of Sunderland
- Teesside University
- University of Wolverhampton
- York St John University.

The qualification has also been supported by:

- Women in Science, Engineering and Technology (WiSET) wiset.org.uk
- University of York Science Education Group uyseg.org
- The Association for Science Education ase.org.uk

3.6 What are the benefits of this qualification?

To learners

The AQA Level 3 Certificate in Applied Science will allow learners the opportunity to learn and understand the core principles and practical applications that underpin applied science. The qualification's synoptic focus will ensure that learning is coherent across all three units. The learner will undertake a programme of assessment designed to measure their knowledge and understanding of applied science as well as its practical application.

Each unit within the qualification has an applied purpose which acts as a focus for the learning in the unit. The applied purpose demands authentic work-related learning in each of the units. It also requires learners to consider how the use and application of their learning affects themselves, other individuals, employers, society and the environment. The applied purpose will also enable learners to learn in such a way that they develop:

- skills required for independent learning and development
- a range of generic and transferable skills
- the ability to solve problems
- the skills of project-based research, development and presentation
- the ability to apply mathematical and ICT skills
- the ability to apply learning in vocational contexts.

To higher education institutions

The AQA Level 3 Certificate in Applied Science has been developed with a wide range of higher education institutions to ensure that the best possible progression opportunities are available to courses at Foundation and/or BSc degree level.

As this qualification contains both examined and assignment-based assessment (both externally and internally assessed), the learner should be better prepared to adjust to the learner-centred ethos of higher educational study.

4 Level 3 Certificate in Applied Science: Unit summary

The acknowledged number of guided learning hours for this qualification is 180.

It consists of three mandatory units.

	Unit title	Assessment type	Ofqual unit reference
1	Key concepts in science	Written exam	J/507/6497
2	Applied experimental techniques	Portfolio	L/507/6498
3	Science in the modern world	Written exam with pre-release material	R/507/6499

Links with other qualifications

The following units:

J/507/6497 1 Key concepts in science
L/507/6498 2 Applied experimental techniques
R/507/6499 3 Science in the modern world

also appear in:

AQA Level 3 Extended Certificate in Applied Science.

5 Level 3 Extended Certificate in Applied Science: Statement of purpose

5.1 Qualification objectives

The objectives of this qualification are to:

- prepare learners to progress to a qualification in the same subject area but at a higher level or requiring more specific knowledge, skills and understanding
- meet relevant programmes of learning
- prepare learners for employment
- give learners personal growth and engagement in learning.

5.2 Who is this qualification for?

This qualification is aimed at 16 to 18 year old learners who are in full-time Level 3 education and who wish to progress to higher education and/or pursue a career in the applied science sector. There are no formal entry requirements for this qualification, but to optimise their chances of success, learners will typically have four GCSEs at grade C or above, including science, maths and English. Learners should also have completed the AQA Level 3 Certificate in Applied Science before beginning this Extended Certificate.

As a substantial vocational qualification it provides a broad understanding of applied science to support progress to higher education. It is suitable for studying alongside academic science qualifications, such as A-level sciences or other Level 3 vocational qualifications. This qualification can also prepare learners to take up employment in the applied science sector, either directly after achieving the qualification or via higher education.

Studying this qualification will enable learners to develop their knowledge and understanding of scientific principles, as well as those scientific practical skills recognised by higher education institutions and employers to be most important. The qualification also offers learners an opportunity to develop transferrable skills such as problem-solving, research and communication as part of their applied learning.

5.3 What does this qualification cover?

Five of the eight units available in this qualification are mandatory. This qualification builds on the knowledge and skills that learners have gained in the Certificate with a continuation of synoptic teaching, learning and assessment. AQA has worked with stakeholders in developing the design and content of this qualification to ensure that it covers the fundamental knowledge, understanding and scientific practical skills associated with applied science learning.

Learners will cover topics such as:

- scientific principles associated with biology, chemistry and physics
- experimental and practical techniques associated with applied science
- the roles and skills of scientists, and the public and media perception of science
- how the human body works
- scientific investigations.

This qualification provides learners with a choice of three optional units (Unit 6a Microbiology,

Unit 6b Medical physics and Unit 6c Organic chemistry), from which they must choose one.

This opportunity to explore a wider range of applied learning will enable learners to follow a particular applied pathway (for example, biological, physical or chemical).

5.4 What could this qualification lead to?

This qualification is supported by a range of universities, and taken alongside other qualifications it can fulfil the entry requirements for a number of science-related higher education courses, including biomedical, forensic and sports science, as well as nursing. In addition, the qualification is eligible for UCAS points ucas.com

5.5 Who supports this qualification?

This qualification has been developed in collaboration with higher education and other stakeholders in the science education sector. Therefore, the knowledge and skills gained will provide the best possible opportunity for progress to higher education or employment.

The qualification is supported by the following higher education institutions:

- Aberystwyth University
- Birmingham City University
- University of Bolton
- Edge Hill University
- Staffordshire University
- University of South Wales
- Southampton University
- University of Sunderland
- Teesside University
- University of Wolverhampton
- York St John University.

The qualification has also been supported by:

- Women in Science Engineering and Technology (WiSET) wiset.org.uk
- University of York Science Education Group uyseg.org
- The Association for Science Education ase.org.uk

5.6 What are the benefits of this qualification?

To learners

The AQA Level 3 Extended Certificate in Applied Science will allow learners the opportunity to learn and understand the core principles and practical applications that underpin applied science. It will allow learners to build on the knowledge and skills acquired in the Certificate and focus on a particular applied pathway depending on the optional unit chosen. The qualification's synoptic focus will ensure that learning is coherent across all units. The learner will undertake a programme of assessment designed to measure their knowledge and understanding of applied science as well as its practical application.

Each unit within the qualification has an applied purpose which acts as a focus for the learning in the unit. The applied purpose demands authentic work-related learning in each of the units. It also requires learners to consider how the use and application of their learning affects themselves, other individuals, employers, society and the environment. The applied purpose will also enable learners to learn in such a way that they develop:

- skills required for independent learning and development
- a range of generic and transferable skills
- the ability to solve problems
- the skills of project-based research, development and presentation
- the ability to apply mathematical and ICT skills
- the ability to apply learning in vocational contexts.

To higher education institutions

The AQA Level 3 Extended Certificate in Applied Science has been developed with a wide range of higher education institutions to ensure that the best possible progression opportunities are available to courses at Foundation and/or BSc degree level.

As this qualification contains both examined and assignment-based assessment (both externally and internally assessed), the learner should be better prepared to adjust to the learner-centred ethos of higher educational study.

6 Level 3 Extended Certificate in Applied Science: Unit summary

The acknowledged number of guided learning hours for this qualification is 360.

It is made up of five mandatory units, plus one optional unit from a choice of three.

	Unit title	Assessment type	Ofqual unit reference
Mandatory			
1	Key concepts in science	Written exam	J/507/6497
2	Applied experimental techniques	Portfolio	L/507/6498
3	Science in the modern world	Written exam with pre-release material	R/507/6499
4	The human body	Written exam	A/507/6500
5	Investigating science	Portfolio	F/507/6501
Optional			
6a	Microbiology	Portfolio	J/507/6502
6b	Medical physics	Portfolio	L/507/6503
6c	Organic chemistry	Portfolio	R/507/6504

7 Synoptic delivery and assessment

The definition of synoptic assessment used by AQA is:

‘A form of assessment which requires a learner to demonstrate that they can identify and use effectively, in an integrated way, an appropriate selection of skills, techniques, concepts, theories and knowledge from across the whole qualification or unit, which are relevant to a key task’.

The design of this qualification allows learners to develop knowledge, understanding and skills from particular units and then provide evidence of this learning in the performance outcomes contained within other units.

The significant amount of synoptic content within the Certificate and the Extended Certificate supports synoptic learning and assessment by:

- showing teaching and learning links between the units across the specification
- giving guidance or amplification relating to the grading criteria for the internally assessed units, about
- where learners could apply the knowledge and understanding from other units
- providing a coherent learning programme of related units
- allowing holistic delivery and the application of prior or concurrent learning
- providing opportunities for the learning and assessment of multiple units combined together to promote holistic delivery.

It is important for centres to be aware of the links between units so that teaching, learning and assessment can be planned accordingly. The units for each qualification should be delivered concurrently as identified below. This is important to create logically cumulative learning and synoptic assessment. This means that when learners are being assessed, they can apply their learning in ways which show they are able to make connections across the qualification. Within each unit we provide references to where the unit content maps from or to other units within the qualification. This will help the learner understand where there are explicit opportunities for synoptic learning as well as synoptic assessment.

It is therefore a requirement that all learners undertake meaningful synoptic learning and assessment during their study. Plans for how this will be undertaken will be scrutinised as part of our centre-approval process and its implementation monitored during our ongoing quality assurance activities with centres.

In the Certificate qualification, Unit 2 will drive practical synoptic assessment in relation to the examined Units 1 and 3. Centres will deliver Units 1, 2 and 3 concurrently, and identify opportunities within Unit 2 to synoptically assess across the full range of the Certificate content. An example of how this could work is as follows: whilst undertaking volumetric and colorimetric analysis in PO2 (demonstrate applied experimental techniques in chemistry) of Unit 2, tutors could also assess the knowledge from Unit 1 on atomic structures and amount of substances. References could also be made to AO4 (Understand the roles and responsibilities that science personnel carry out in the science industry) of Unit 3 Science in the modern world).

In the Extended Certificate, Unit 5 and the learner's chosen optional unit will drive practical synoptic assessment across the full range of the Certificate and Extended Certificate units. In Unit 5 and the learner's chosen optional unit, centres will identify opportunities from across all other units which synoptically assess across the full range of the Certificate and Extended Certificate content. So, for example, whilst undertaking PO2 (carry out investigation and record results) of Unit 5, tutors could also assess PO3 (use practical techniques to investigate factors that affect the growth of microorganisms) of Unit 6a Microbiology.

The following grids demonstrate the overall synoptic coverage in each unit of the qualification:

Unit	Pass criteria	Synoptic links to other units	% of synoptic assessment
Key concepts in science	n/a	Unit 2 Applied experimental techniques Unit 3 Science in the modern world Unit 4 The human body Unit 6a Microbiology Unit 6c Organic chemistry	Implicit as part of the external examination
Applied experimental techniques	P1, P4, P7 P2, P3, P5, P6 P8, P9 P10	Unit 3 Science in the modern world Unit 1 Key concepts in science Unit 6a Microbiology Unit 5 Investigating science Unit 6c Organic chemistry Unit 5 Investigating science	10/10 (100 %) Pass criteria
Science in the modern world	n/a	Unit 1 Key concepts in science Unit 2 Applied experimental techniques Unit 5 Investigating science Unit 6a Microbiology Unit 6b Medical physics Unit 6c Organic chemistry	Implicit as part of the external examination
The human body	n/a	Unit 1 Key concepts in science Unit 2 Applied experimental techniques	Implicit as part of the external examination
Investigating science	P1, P2, P3, P4, P5, P6, P7, P8, P9	Unit 2 Applied experimental techniques Unit 6a Microbiology Unit 6b Medical physics Unit 6c Organic chemistry	9/10 (90 %) Pass criteria
Microbiology	P1, P3, P4, P5, P7, P8	Unit 1 Key concepts in science Unit 2 Applied experimental techniques Unit 5 Investigating science	6/10 (60 %) Pass criteria
Medical physics	P4, P5, P7, P8	Unit 1 Key concepts in science Unit 2 Applied experimental techniques Unit 5 Investigating science	4/10 (40 %) Pass criteria
Organic chemistry	P1, P2, P3, P4, P5, P6, P8, P10	Unit 1 Key concepts in science Unit 2 Applied experimental techniques Unit 5 Investigating science	8/10 (80 %) Pass criteria

8 Transferable skills

Transferable skills, sometimes known as soft skills, are highly valued by higher education institutions and employers. AQA Applied General qualifications will provide opportunities for learners to develop these skills through the Level 3 Certificate and Extended Certificate qualifications. Whilst not a mandatory part of the qualification, subject units will clearly identify the opportunities available to develop transferable skills, including:

- research
- teamwork
- problem-solving
- written and oral communication.

AQA has created a set of standards as well as teaching and learning resources for transferable skills which centres may wish to use in developing these skills with learners.

Visit aqa.org.uk/tech-levels/transferable-skills

9 Total qualification time

For any qualification which it makes available, Ofqual requires an awarding organisation to:

a assign a number of hours for total qualification time to that qualification, and

b assign a number of hours for guided learning to that qualification.

Total qualification time is the number of notional hours which represents an estimate of the total amount of time that could reasonably be expected to be required in order for a learner to achieve and demonstrate the achievement of the level of attainment necessary for the award of a qualification.

Total qualification time is comprised of the following two elements:

a the number of hours which an awarding organisation has assigned to a qualification for guided learning (GLH)

   AQA has assigned GLH to the overall qualification and the individual units.

b an estimate of the number of hours a learner will reasonably be likely to spend in preparation, study or any other form of participation in education or training, including assessment, which takes place as directed by – but, unlike guided learning, not under the immediate guidance or supervision of – a lecturer, supervisor, tutor or other appropriate provider of education or training.

AQA has assigned the following GLH and TQT values to its qualifications:

Qualification	Guided learning hours (GLH)	Total qualification time (TQT)
Certificate in Applied Science (1776)	180	180
Extended certificate in Applied Science (1777)	360	360

10 Support materials and guidance

The following delivery resources and support materials are available from AQA:

- schemes of work for units 1, 2, 4, 6a, 6b and 6c
- sample lesson plans for units 1, 2, 4, 6a, 6b and 6c
- sample assignment briefs for units 2, 5, 6a, 6b and 6c
- sample assessment materials (sample question papers and mark schemes) for examined units
- curriculum planner.

These are available from the Applied Science pages of the AQA website:
aqa.org.uk/subjects/science/applied-general/science

Other relevant resources for teaching purposes can be found in the section entitled ‘Useful links and publications’ within each unit in this specification.

All links to websites were correct at the time of publication of this specification. AQA can take no responsibility for the content of external websites.

11 Qualification units

11.1 Unit 1: Key concepts in science

Title	Key concepts in science
Unit type	Mandatory
Unit assessment type	Externally assessed
Assessment method	Written examination, 1 hour 30 minutes
Guided learning hours	60 guided learning hours
Opportunities for developing transferable skill(s)	• Research • Communication • Problem-solving
Applied context	This is predominantly a theoretical unit in which learners develop their knowledge and understanding of key concepts in science and how they are applied in the medical, healthcare, food, environmental, chemical, pharmaceutical, material and automotive industries.
Synoptic assessment and learning	Learners should be taught this unit alongside Unit 2 and 3, and it is expected that they will learn through appropriate practical work, thereby reinforcing their knowledge and developing practical skills suitable for use in the real world.

Aim and purpose

The aim of this unit is that learners develop an understanding of key concepts in science and its applications, building on their knowledge and understanding of the National Curriculum KS4 Science subject content gained in previous studies. As a result of studying this unit, learners will be able to apply these key concepts to vocational situations and contexts.

Unit introduction

Scientists, and people who work in a variety of industries, use science in many different ways. In order for them to appreciate the day-to-day applications of science in the real world, they need to understand the theory that underpins them.

The key concepts of biology, chemistry and physics, and examples of their applications, are identified in the content of this unit. In the delivery of this content, tutors should find opportunities to provide learners with examples of the types of industries and workplaces in which these key concepts are relevant, the scientists or other professionals who might apply them, and the importance of these applications to society. In their delivery of this unit, tutors should use the knowledge and understanding gained by learners to support the delivery of Unit 2.

In the assessment of this unit, questions will be set in applied contexts.

It is the tutor's responsibility to ensure safe working at all times, and learners' risk assessments must be checked, or a full and correct risk assessment issued, before practical work commences.

Assessment outcomes

Learners will:

Assessment outcome 1:	Understand key concepts in the application of biology.
Assessment outcome 2:	Understand key concepts in the application of chemistry.
Assessment outcome 3:	Understand key concepts in the application of physics.

Unit content

Key concepts in the application of biology

1(a) Cell structure

Cell biologists explore the development and functions of cells and their related systems and interactions. Their work may include developing and testing new pharmaceuticals, diagnosing and screening diseases, testing foods and cosmetics to ensure their safety, developing fertility treatments, and carrying out cancer research, neurological research, genetic engineering, or embryology.

Learners will develop their knowledge and understanding of the following key concepts and their applications:

- the ultrastructure of eukaryotic and prokaryotic cells on electron micrographs, to include nuclei, smooth endoplasmic reticulum (SER), rough endoplasmic reticulum (RER), mitochondria, vesicles, lysosomes, Golgi apparatus, chloroplasts, vacuoles, cell walls, ribosomes (70S and 80S), flagella, nucleoid, plasmids, mesosomes, pili, slime capsules
- the differences between eukaryotic and prokaryotic cell structure
- the functions of nuclei, SER, RER, mitochondria, vesicles, lysosomes, Golgi apparatus, chloroplasts, vacuoles, cell walls, ribosomes, flagella, nucleoid, plasmids, mesosomes, pili, slime capsules
- nucleic acid structure (DNA/RNA)
- calculating magnification or object size using:

$$\text{magnification} = \frac{\text{observed size}}{\text{actual size}}$$

1(b) Transport mechanisms

Those working in the pharmaceutical industry need to understand how substances are absorbed and transported in cells. Knowledge of these mechanisms has applications in the development of drug therapies to treat cancer, dementia, diabetes and HIV, and in the production of amino acids for food products.

Learners will develop their knowledge and understanding of the following key concepts and their applications:

- the structure of cell membranes as a phospholipid bilayer with proteins interspersed
- the function of intrinsic proteins, including their role in facilitated diffusion and active transport
- the function of extrinsic proteins.

Key concepts in the application of biology

1(c) The heart

Those working in cardiac sciences diagnose and monitor diseases that affect the structure and function of the heart, carry out exercise stress testing to determine whether the blood vessels supplying the heart are working properly, and programme pacemaker devices to ensure that they function correctly.

Learners will develop their knowledge and understanding of the following key concepts and their applications:

- key structures of the heart, including bicuspid valve, tricuspid valve, semi-lunar valves, sinoatrial node (SAN), atrioventricular node (AVN), Purkinje fibres, bundle of His
- myogenic stimulation of the heart
- the role of the SAN, AVN, Purkinje fibres and bundle of His in cardiac stimulation
- the role of carbon dioxide chemoreceptors and baroreceptors in controlling heart rate
- artificial pacemakers as treatment for arrhythmia (abnormal heart rate), and how they work to re-establish normal heart rate
- the advantages and disadvantages of different types of artificial pacemakers.

Key concepts in the application of biology

1(d) Homeostasis

Health professionals need to be able to relate the principles of homeostasis to health and illness, and maintaining a patient's homeostasis is one of the most important roles of a nurse. Many of the tests that a nurse performs on a patient, such as measuring temperature or blood pressure, determine whether the patient's body is in homeostasis or in distress. Nurses need to know about the importance of maintaining insulin levels in people suffering from diabetes, in order to prevent severe consequences of blood sugar imbalance.

Learners will develop their knowledge and understanding of the following key concepts and their applications:

- how homeostasis involves physiological control systems that maintain the internal environment within restricted limits:
  - body temperature range (35.8–37.5 °C)
  - blood glucose range (82–110 mg/dL)
  - blood pH range (7.35–7.45)
- negative feedback as a homeostatic mechanism, eg controlling water retention using anti-diuretic hormone (ADH, also known as vasopressin) produced by the pituitary gland
- the role of different hormones in body function, including:
  - insulin
  - glucagon
  - ADH
  - aldosterone
- the roles of the pancreas and liver in regulating blood glucose concentration
- the body's normal system for regulating blood glucose concentration:
  - the action of insulin in activating enzymes to convert glucose to glycogen
  - the action of glucagon in activating enzymes to convert glycogen to glucose
  - the action of adrenaline in activating enzymes to convert glycogen to glucose
- the causes of Types I and II diabetes
- the control of Types I and II diabetes
- how health professionals and patients with diabetes use physiological measurements to inform diagnosis and treatment of diabetes, including the use of:
  - fasting glucose levels
  - urine dipsticks
  - blood glucose 'pinprick' tests
- the roles of the hypothalamus, pituitary and ADH in osmoregulation
- the different parts of the nephron and their roles, including:
  - Bowman's capsule as an ultrafiltration unit
  - convoluted tubules in selective reabsorption of glucose, sodium ions and water
- the roles of the adrenal cortex, convoluted tubules and aldosterone in the reabsorption of sodium ions
- the consequences of sodium chloride (salt) deficiency in the short term, and the long-term effects on health
- the circumstances in which certain people may be at risk of losing too much salt
- why excess salt in the diet might create health problems
- the consequences of excess/deficiency of ions and hormones on health.

Key concepts in the application of biology

1(e) Breathing and cellular respiration

An understanding of respiration is vital to many scientists and healthcare professionals. Biochemists can analyse the rates of cellular respiration in samples of tissues. Sport physiologists can determine whether an individual is respiring aerobically or anaerobically using non-invasive methods. Engineers use their understanding of cellular respiration to clean up contamination in the environment, using cells which convert contaminants into energy.

Learners will develop their knowledge and understanding of the following key concepts and their applications:

- the distinction between breathing and cellular respiration:
  - breathing as a physical, external process
  - cellular respiration as a chemical, internal process
- methods of monitoring the respiratory system (breathing rate and volumes)
- how, during cellular respiration, adenosine triphosphate (ATP) is produced by phosphorylation, in which a phosphate group is added to a molecule of adenosine diphosphate (ADP)
- how ATP is used to release energy for cell activity
- the stages in respiration of glucose that result in the production of ATP, and the site of each process:
  - glycolysis (in the cell cytoplasm)
  - Krebs cycle (in the mitochondria)
  - electron transfer chain (in the mitochondria)
- the process of glycolysis, to include:
  - phosphorylation of glucose to glucose phosphate, using ATP
  - production of triose phosphate (TP)
  - oxidation of TP to pyruvate with a net gain of ATP and reduced nicotinamide adenine dinucleotide NAD (NADH)
- the process of the Krebs cycle, to include:
  - pyruvate is converted to acetyl coenzyme A (acetyl-CoA) which enters the Krebs cycle
  - acetyl-CoA reacts with a four-carbon molecule, to form a six-carbon molecule
  - a series of oxidation-reduction reactions generates reduced coenzymes and ATP, and carbon dioxide is lost
- the process of the electron transfer chain, to include:
  - reduced NAD (NADH) or reduced flavine adenine dinucleotide FAD (FADH2) release hydrogen atoms which provide electrons to transfer down the electron transfer chain
  - as electrons are passed down the chain, energy is released which is used to phosphorylate ADP to ATP
  - the final acceptor of the electrons is oxygen, which forms water
- the amount of ATP that can be produced from aerobic and anaerobic pathways
- what is meant by basal metabolic rate (BMR) and how it can be determined by direct or indirect methods
- the differences in BMR for males and females, and for different age groups of both genders, using secondary data.

Key concepts in the application of biology

1(f) Photosynthesis and food chain productivity

Many scientists try to understand and control the photosynthetic process in order to increase crop yields and health, producing plants that are tolerant to insects, drought and disease. Knowledge of photosynthesis in plants can also be adapted to man-made systems to provide efficient ways to collect and use solar energy.

Learners will develop their knowledge and understanding of the following key concepts and their applications:

- photosynthesis as a process of organic carbon capture, to include:
  - essential raw materials and their sources
  - two stages in photosynthesis: light-dependent (water hydrolysed into oxygen and hydrogen) and light-independent (hydrogen combines with carbon dioxide to produce carbohydrate)
  - initial conversion to carbohydrates and subsequent conversions to lipids and proteins
- green plants (producers) as the initiators of food chains
- efficiency of food chains, to include:
  - constraints
    - solar, temperature, water, nutrient and space availability for plants
    - energy transfer out of the food chain through respiration, excretion and movement
  - gross primary production (GPP)
  - net primary production (NPP)
  - biomass/energy pyramids to demonstrate productivity
  - advantages/disadvantages of following a meat-free/reduced meat diet.

Key concepts in the application of chemistry

2(a) Atomic structure

Scientists working in any area of chemical industry or research require a firm understanding of atomic structure and electron configurations and their use in providing the fundamental basis for chemical structures and reactions. Radiographers, environmental chemists and archaeologists all make use of specific isotopes in their work. Analytical chemists use UV/visible spectra and flame emission spectra to help characterise substances and colorimetry as a quantitative analytical technique. The origin of colour in compounds is of great importance in the dye-, pigment-, and paint-based industries and to development chemists researching new products.

Learners will develop their knowledge and understanding of the following key concepts and their applications:

- atomic structure in terms of protons, neutrons and electrons, and their relative charges and relative masses
- the terms atomic (proton) number (Z), mass number (A), isotope, isotopic abundance
- electron configurations for atoms and ions up to $Z = 36$ in terms of sub shells
- the origin of coloured flame emission spectra and of colour in transition metal compounds in terms of electron transitions
- calculating relative atomic mass, relative molecular mass and relative formula mass in terms of ^{12}C.

2(b) The Periodic Table

The patterns evident in the Periodic Table enable industrial and research and development chemists to predict properties and potential new applications of elements, from the inert nature of the noble gases to semiconductor properties of Group 4 (14), to the many applications and uses of the transition metals.

Learners will develop their knowledge and understanding of the following key concepts and their applications:

- that the Periodic Table lists elements in increasing order of proton number
- how each row is equivalent to the filling of an electron shell up to two (in row 1) or eight electrons
- how each column or group contains elements with the same number of outer shell electrons and thus
- similar chemical properties
- how each row begins with a highly reactive alkali metal (Group I) and ends with a noble gas (Group 0 (18))
- how, across a period (row), properties of elements change from metallic to non-metallic
- the properties (including radii, ionisation energy and electronegativity) of:
  - the s-block elements
  - the d-block metals (including the transition metals and their coloured compounds in solution)
  - Group VII (17), the halogens
  - Group 0 (18), the noble gases.

Key concepts in the application of chemistry

2(c) Amount of substance

Chemical engineers and synthetic chemists rely on their knowledge of mole and reaction stoichiometries to determine reacting masses and yields for large-scale industrial production of chemicals. Analytical chemists also apply similar concepts in quantitative analysis, together with the selection of correct reagents to ensure accuracy of outcomes.

Learners will develop their knowledge and understanding of the following key concepts and their applications:

- the mole as the amount of a substance that always contains the same number of entities (eg atoms, molecules, ions, electrons)
- the relationship between mass of substance and amount in moles, $\text{moles} = \frac{\text{mass}}{M_r}$
- the relationship between volume of gas at RTP and STP and amount in moles, PV = nRT
- concentrations of solutions in terms of mol dm^{-3} and g dm^{-3}
- molecular formulas
- empirical formulas
- calculating empirical formulas
- writing balanced equations for typical reactions including:
  - acid–base neutralisation
  - thermal decomposition
  - acid/metal
  - acid/carbonate
  - precipitation
  - combustion reactions
- calculating reacting masses based on correct stoichiometries
- equivalence point of an acid–base titration
- how the choice of indicator for an acid–base titration depends on the types (strengths) of acid and base used and the resulting pH titration curve
- calculating unknown concentrations and volumes from results involving volumetric analysis (limited to acid–base titrations); moles = vol (dm^3) x concentration (mol dm^{-3})
- plotting and interpreting pH curves.

Key concepts in the application of chemistry

2(d) Bonding and structure

Materials scientists are involved in the applications of existing materials to new contexts, and the developments of new materials such as graphene-based nanomaterials. They need a knowledge and an understanding of the structures of those materials and the type and strength of forces present.

Learners will develop their knowledge and understanding of the following key concepts and their applications:

- formulas for common cations
- formulas for common anions (sulfate, carbonate, nitrate, hydroxide)
- deducing formulas for ionic compounds
- ionic bonding and ionic crystal lattices in terms of strong electrostatic forces of attraction
- a covalent bond as a shared pair of electrons
- multiple bonds, neutral molecules, non-conductors and weak intermolecular forces of attraction
- metallic bonding
- structures of:
  - ionic crystal lattices typified by sodium chloride, magnesium oxide
  - metallic lattices typified by magnesium
  - covalent structures typified by iodine, methane, carbon dioxide
  - giant covalent structures (macromolecular), eg diamond, graphite, graphene, fullerene
- predicting types of bonding for compounds given their typical properties and vice versa
- typical properties based on the type of bonding, particles present and forces between particles
- common physical properties of materials related to their structure and bonding, to include:
  - electrical conductivity
  - melting point and boiling point
  - volatility
  - solubility in water
  - non-polar solvents
- drawing diagrams to represent:
  - a named ionic lattice
  - a generalised metallic lattice
  - an alloy
  - giant covalent structures, including silicon, graphite, graphene.

2(e) Enthalpy changes

The knowledge of enthalpy changes and the applications of Hess's Law are important in many areas of scientific research and industry. Biotechnologists develop new fuels such as biodiesel and must compare their energy values with other types of fuel. Development scientists working in the food industry analyse new products for their calorific value and these will also be checked by chemical analysts working for Trading Standards. Chemical engineers in industry will apply Hess's Law to enable the calculation of enthalpies of reaction in order to determine and better understand the likely effect of reaction conditions on yields.

Learners will develop their knowledge and understanding of the following key concepts and their applications:

- energy profiles for exothermic and endothermic reactions
- activation energy using an energy profile
- types of enthalpy changes from equations (limited to combustion, neutralisation, formation and mean bond enthalpies)
- units for molar enthalpy change ($kJ\ mol^{-1}$)
- enthalpy changes as the heat energy change (at constant pressure)
- enthalpy of formation, enthalpy of combustion and enthalpy of reaction, as represented by $\Delta_f H$, $\Delta_c H$ and $\Delta_{rx} H$
- the term 'mean bond enthalpy'
- calculating enthalpy changes based on Hess's Law cycles
- calculating enthalpy changes based on mean bond enthalpies and why these values are only approximate
- determining practically the molar enthalpy of combustion of a liquid fuel (eg ethanol)
- determining practically the molar enthalpy of neutralisation for a simple acid–base reaction, $Q=mc\Delta T$

Key concepts in the application of physics

3(a) Useful energy and efficiency

It is useful for energy consultants to be able to compare the efficiency of different devices in our homes and workplaces. Energy is transferred by different devices, and the rate at which energy is transferred is called 'power'. Architects and energy consultants use U values to measure how effective different materials used in buildings are as insulators. That is, how effective they are at preventing heat energy from transmitting between the inside and the outside of a building.

Many people are concerned about the environmental problems caused by traditional methods of producing electricity and by the potential dangers of nuclear fuels. These concerns have given rise to the use of alternative methods for the generation of useful energy.

Learners will develop their knowledge and understanding of the following key concepts and their applications:

- the meaning of 'efficiency'
- why efficiency is important and why a device can never be 100 % efficient
- methods of improving the efficiency of a system or device
- the formula:

$$\text{efficiency} = \frac{\text{useful energy (or power) output}}{\text{total energy (or power) input}}$$

- the importance of efficiency in making the best use of available energy
- ways in which efficiency can be increased in mechanical and thermal systems
- examples of situations where thermal transfer needs to be maximised and situations where it needs to be minimised
- the meaning of U values
- the formula:

$$U = \frac{Q}{At\Delta T}$$

- the generation of useful energy through the use of a range of different sources, such as:
  - fossil fuels
  - nuclear fuels
  - renewable fuels such as:
    - solar power (both heat and light)
    - wind power
    - wave power
    - tidal power
    - traditional hydroelectric power
    - geothermal sources
    - biomass
- the advantages and disadvantages of these sources and their suitability for use in a range of contexts
- experiments related to measurement of efficiency.

Key concepts in the application of physics

3(b) Electricity and circuits

Electric circuits are found in a huge number of devices. Electrical and electronic engineers are able to alter the properties of an electrical circuit by adding different components.

Learners will develop their knowledge and understanding of the following key concepts and their applications:

- calculating current, voltage, power and resistance in a range of electrical circuits
- calculating the heating effect of a current
- the formulas:
  $I = Q/t$
  $P = IV$
  $I = V/R$
  rate of heat loss = I^2R
- the behaviour of electric current, voltage and resistance in series and parallel circuits
- calculating the total resistance of a circuit which contains resistors in series, resistors in parallel and a combination of both
- the formulas:
  $R_{total} = R_1 + R_2 + R_3$
  $1/R_{total} = 1/R_1 + 1/R_2 + 1/R_3$
- uses of potential divider circuits
- free electrons and the electrical behaviour of conductors and semiconductors
- the effect of temperature on the resistance of conductors and semiconductors
- the behaviour of thermistors and light-dependent resistors (LDRs)
- graphs of V against I to find resistance
- graphs of voltage against current for a range of components including standard resistors, thermistors and lamps.

Key concepts in the application of physics

3(c) Dynamics

Many types of scientists and engineers use Newton's laws of motion to predict the motion and interaction of objects. For instance, automotive engineers when designing crumple zones in cars and sports scientists in suggesting improvements in athletic abilities.

Learners will develop their knowledge and understanding of the following key concepts and their applications:

- application of Newton's First Law of Motion to both stationary and moving objects
- inertia
- Newton's Second Law of Motion
- the formula:
  $F = ma$
- weight = mg as an example of Newton's Second Law of Motion
- Newton's Third Law of Motion including its relationship to the Law of Conservation of Momentum
- the meaning of 'momentum'
- the formulas:
  $p = mv$
  $F = \Delta p/t$
- applying the Law of Conservation of Momentum to a range of situations including collisions and/or the motion of objects
- the formulas:
  (average) $v = s/t$
  $v = u + at$
  $v^2 = u^2 + 2as$
  $s = ut + \frac{1}{2}at^2$
- representing motion through the use of graphs of displacement against time and velocity against time
- calculating the gravitational potential energy of an object
- the formula:
  $GPE = mgh$
- calculating the kinetic energy of a moving object
- the formula:
  $KE = \frac{1}{2}mv^2$
- calculating the power of a mechanical system
- the formula:
  $P = E/t$

Assessment

This unit will be assessed through an external examination, set and marked by AQA. The examination will take place under controlled examination conditions and the date will be published at the start of each academic year.

Learners will be allowed to use a non-programmable scientific calculator in the examination. The examination will consist of a written paper with three sections:

- Section A – Applications of biology
- Section B – Applications of chemistry
- Section C – Applications of physics.

Each section will be allocated 20 marks and will consist of short-answer questions based on the specification.

Assessment outcome	Marks	Weighting
AO1 Understand key concepts in the application of biology	20	33.3 %
AO2 Understand key concepts in the application of chemistry	20	33.3 %
AO3 Understand key concepts in the application of physics	20	33.3 %

There are no optional questions in any section and learners will be required to answer all of the questions in each section.

The examination will last 1 hour and 30 minutes and the total number of marks available in the examination will be 60.

AQA will ensure that the full content is covered equally over the life of the specification.

Learners will not be expected to memorise mathematical formulas. **Any mathematical formulas will be provided in the examination paper on a separate data sheet**.

Learners will **not** be expected to memorise the content of the Periodic Table. Copies of the Periodic Table will be provided to learners in the examination.

Guided learning hours breakdown

	AO1	AO2	AO3	Total
Delivery time (hours)	20	20	20	60

Delivery guidance

Wherever possible, theory should be supported by experimental work. It is also important that learners consider everyday applications of the theory studied.

AO1 Understand key concepts in the application of biology

Cell structure

In order to appreciate the molecular size of cell organelles, learners should examine plant and animal cells under a student microscope and then compare them to electron micrographs which show the ultrastructure of animal and plant cells. The basic cell structure of animal and plant cells can be viewed under a light microscope. These cells can either be prepared by the learner (cheek or onion cells) or viewed as prepared slides.

Transport mechanisms

Every cell is surrounded by a cell membrane, which allows the correct amount of nutrients and water into and out of the cell, and keeps out chemicals not required by the cell. There are different mechanisms that the cell uses to achieve this. These transport mechanisms can be demonstrated using Visking tubing.

The heart

The heart is a pump that sends oxygenated and deoxygenated blood around the body and lungs. Its anatomy and physiology is complex and includes different types of muscle fibres, valves and specialised electrical fibres. An overview of the structure can be understood by dissection of a pig's heart. Blood pressure and heart rate can be measured using a sphygmomanometer.

Homeostasis

Homeostasis and feedback mechanisms will mainly be studied theoretically. Blood glucose levels can be measured using either Clinistix, which is non-invasive, or a blood glucose monitor. These monitors analyse a drop of blood to indicate the glucose concentration, and are used by the nursing profession to identify whether a person is diabetic.

Breathing and cellular respiration

Cellular respiration is biochemical and therefore will be taught mainly through theory, but learners can carry out experiments on breathing or mechanical respiration. Tidal volume (TV), expiratory reserve volume (ERV) and inspiratory reserve volume (IRV) can be measured using a spirometer.

Basal metabolic rate can be assessed by measuring the height and weight of an individual. It must be stressed that this measurement is not very accurate but does give an indication of BMR.

Photosynthesis and food chain productivity

Learners should build on their knowledge of photosynthesis from KS4. Photosynthesis should be considered as a two-stage process and an overview of the light-dependent and light-independent stages should be undertaken.

The importance of photosynthesis to plant/animal interrelationships should be fully considered, particularly in terms of energy transfer and nutrition. Photosynthesis and environmental constraints (limiting factors) can be investigated practically. Aspects of productivity should be considered in terms of these constraints and the associated energy losses at each stage in the food chain. The evaluation of meat-free/reduced meat diets should take into account the energy, nutrition and environmental costs involved, as well as the moral costs, particularly animal welfare, and the economic costs to the agricultural industry.

Conversion of carbohydrates to lipids and proteins involves complex biochemistry and needs to be taught theoretically. This could be drawn as a flow chart.

Food chains can be shown as an animation which could initiate a class discussion. Learners could research food chains and show them as a diagram, including information on constraints. Constraints can be very specific for different regions and learners could carry out research into a particular area for discussion.

Gross primary product (GPP) and net primary product (NPP) can be shown as calculations and include information on climate change and ecosystems. This can include information on biomass and productivity. Biomass and energy pyramids can be drawn for a wide range of examples.

The advantages and disadvantages of a meat-free diet can be a class discussion after individual research.

AO2 Understand key concepts in the application of chemistry

Enthalpy changes

For the determination of the molar enthalpy of combustion of a liquid fuel, learners should use a simple calorimetric approach and calculations based on $q = mc\Delta T$ and masses/moles. Learners should be able to evaluate their experimental results, including accuracy in comparison with the (researched) literature value and a theoretical value based on mean bond enthalpy calculations.

Learners should evaluate their practical methodology and consider heat losses. They should also understand that there are other, more accurate methods (eg Thiemann calorimeter and bomb calorimeter) which prevent heat losses to a greater extent, but detailed knowledge of these is not expected.

For the determination of molar enthalpy of neutralisation for a simple acid–base reaction, learners would be expected to be able to complete a graphical analysis of results, including cooling curve correction by extrapolation, and to calculate the molar enthalpy of neutralisation based on $q = mc\Delta T$ and molarities and volumes used.

Other areas where practical work (either demonstrations or class practicals as appropriate) will reinforce the theory include:

- flame tests
- reactivity of Group I metals, trends across a period, properties of s-block elements, d-block, Group VII
- types of reaction
- pH titration curves, use of indicators, titrations
- physical properties of different types of materials.

AO3 Understand key concepts in the application of physics

Emphasis must be placed on the use of correct units when using quantities. Practice in using and manipulating formulas, as well as drawing and interpreting graphs, is essential.

Key practical work would include:

- measurement of current, voltage, resistance and power in series circuits and parallel circuits, as well as more complex circuits which contain both series and parallel elements
- investigation of the characteristic voltage–current curves for a thermistor and a lamp
- finding resistance graphically from voltage and current measurements for a circuit component
- investigation of conservation of momentum in a collision.

The work on sources of useful energy could be completed through individual or group research into a range of different energy sources.

Learners should report the outcomes of calculations to appropriate numbers of significant figures and using correct units.

Synoptic assessment

Assessment outcome	Links to other units
AO1 Understand key concepts in the application of biology	**Unit 2 Applied experimental techniques** PO1(a) and (b) Demonstrate experimental techniques in biology. **Unit 4 The human body** AO2 Understand the musculoskeletal system and movement. AO3 Understand how oxygen is transported in the blood and how physiological measurements can be applied. **Unit 5 Investigating science** PO2 Carry out the investigation and record results. PO3 Analyse results, draw conclusions and evaluate the investigation. **Unit 6a Microbiology** PO1 Identify the main groups of microorganisms in terms of their structure. PO2 Use aseptic techniques to safely cultivate microorganisms.
AO2 Understand key concepts in the application of chemistry	**Unit 2 Applied experimental techniques** PO2(a) and (b) Demonstrate experimental techniques in chemistry. **Unit 5 Investigating science** PO2 Carry out the investigation and record results. PO3 Analyse results, draw conclusions and evaluate the investigation. **Unit 6c Organic chemistry** PO3 Prepare organic compounds.
AO3 Understand key concepts in the application of physics	**Unit 2 Applied experimental techniques** PO3(a) and (b) Demonstrate experimental techniques in physics. **Unit 5 Investigating science** PO2 Carry out the investigation and record results. PO3 Analyse results, draw conclusions and evaluate the investigation.

This is an externally assessed unit and there are opportunities for learners to use elements of other units to support the development of knowledge and learning for this unit. There are also synoptic teaching and learning opportunities and links with Unit 3: Science in the modern world (the science underpinning the topical scientific issues chosen in this unit) and Unit 5: Investigating science (depending on the investigation chosen).

The amplification below identifies synoptic assessment and where learning from other units can be assessed within this unit.

AO1 Understand key concepts in the application of biology

When considering AO1 in its applied context, consideration should be given to the experiments in Unit 2 for the Certificate and both Unit 2 and Unit 5 for the Extended Certificate. The assessments to be undertaken in Unit 2, Unit 4, Unit 5 and Unit 6a for the Extended Certificate build on the knowledge and understanding in Unit 1.

AO2 Understand key concepts in the application of chemistry

When considering AO2 in its applied context, consideration should be given to the experiments in Unit 2 for the Certificate and both Unit 2 and Unit 5 for the Extended Certificate. The assessments to be undertaken in Unit 2, Unit 5 and Unit 6c for the Extended Certificate build on the knowledge and understanding in Unit 1.

AO3 Understand key concepts in the application of physics

When considering AO3 in its applied context, consideration should be given to the experiments in Unit 2 for the Certificate and both Unit 2 and Unit 5 for the Extended Certificate. The assessments to be undertaken in Unit 2 and Unit 5 in the Extended Certificate build on the knowledge and understanding in Unit 1.

Resources

AO1 Understand key concepts in the application of biology

- Basic laboratory chemicals and glassware
- Light microscope, plain and cavity slides, stains, cover slips
- Prepared slides and electron micrographs
- Visking tubing and relevant chemicals
- Pigs' hearts, dissection kits, gloves, disinfectant
- Model of a human heart
- Blood glucose monitor (obtainable from Philip Harris, Boots etc.)
- Clinistix
- Sphygmomanometers
- Spirometer and stop clocks
- Stadiometer scales
- Plants, sodium hydrogen carbonate flasks
- Pond weed, DCPIP, immobilised algae
- Starch test – source of heat, ethanol, iodine

AO2 Understand key concepts in the application of chemistry

For enthalpy of combustion (of, for instance, an alcohol):

- spirit lamps, copper calorimeters, thermometers (preferably accurate to 0.1 °C or 0.2 °C)
- balance (to 2 or 3 dp).

For enthalpy of neutralisation:

- polystyrene cups, thermometers (accurate to 0.1 °C or 0.2 °C)
- balance (to 2 or 3 dp)
- stop clocks.

For pH titration curves:

- standard glassware for volumetric analysis
- pH meter and pH probe, suitable buffers for calibration
- pH probe, data logger, computer and printer.

For titrations:
- standard glassware for volumetric analysis
- range of suitable indicators.

In addition:
- standard laboratory apparatus and equipment for calorimetry experiments, flame and reactivity tests
- Periodic Table and data books.

AO3 Understand key concepts in the application of physics

- Standard electrical circuit components for use in low voltage circuits: 12 V 24 W lamps, ammeters, voltmeters, resistors, thermistors
- Thermistors and 12 V 24 W lamps for the voltage–current characteristics experiments
- Accurate timing devices such as light gates or other suitable data logging equipment for dynamics experiments
- Force meters, masses, stopwatches, metre rulers, and dynamics trolleys or other vehicles for experiments related to momentum, force and motion
- A linear air track would enhance investigation of many aspects of dynamics
- Standard equipment for investigating heat and thermal transfer: radiant heaters, thermometers, conduction rods, bimetallic strip (Boyle's Law apparatus would be useful but not essential)
- Standard equipment to investigate transverse and longitudinal waves: slinky spring, Polaroid filters.

Useful links and publications

A01 Understand key concepts in the application of biology

- Science and Plants for Schools: saps.org.uk
- Chemistry for Biologists: Photosynthesis: rsc.org/Education/Teachers/Resources/cfb/Photosynthesis.htm
- Educational resource on the chronology of agricultural systems and the relationship between food and farming: ukagriculture.com
- BMR calculator: myfitnesspal.com/tools/bmr-calculator
- Information and activities based on cells, microbes and the immune system: cellsalive.com
- Information and resources based on cells, genetics and human biology: biologymad.com/frontpage.htm
- Revision notes on a range of biological topics: biology-innovation.co.uk
- Resources for teachers and learners, from the Association of the British Pharmaceutical Industry (ABPI):
  abpischools.org.uk/page/index.cfm
  abpischools.org.uk/page/usefullinks.cfm
- Kimball's Biology Pages, an online biology textbook: biology-pages.info
- Lesson on using Visking tubing: nuffieldfoundation.org/practical-biology/evaluating-visking-tubing-model-gut
- Instructions on carrying out a heart dissection:
  biologycorner.com/anatomy/circulatory/heart/heart_dissection.html
  biologyjunction.com/heart_dissection.htm
- Information on homeostasis and negative and positive feedback mechanisms: anatomyandphysiologyi.com/homeostasis-positivenegative-feedback-mechanisms
- Testing for diabetes:
  diabetes.org.uk/Guide-to-diabetes/Monitoring/Testing
  nlm.nih.gov/medlineplus/ency/article/003482.htm
- Organisation offering comprehensive blood screen tests: medichecks.com/find-a-test/test/Essential-Blood-Screen_01MC/?gclid=CJbmh8iqy8cCFUFmGwodcSoKCA
- Using a spirometer: nuffieldfoundation.org/practical-biology/using-spirometer-investigate-human-lung-function
- Lung capacity test: tes.com/teaching-resource/lung-capacity-test-6293219
- Lung function tests: webmd.boots.com/asthma/guide/lung-function-tests-asthma
- Measuring metabolic rate:
  dummies.com/how-to/content/how-to-measure-your-metabolic-rate.html
  acefitness.org/certifiednewsarticle/2882/resting-metabolic-rate-best-ways-to-measure-it-and
- Experiments to show the factors required in photosynthesis: biotopics.co.uk/plants/psfac2.html
- Various experiments relating to photosynthesis: nuffieldfoundation.org/practical-biology/photosynthesis
- Video on photosynthesis: youtube.com/watch?v=joZ1EsA5_NY
- Video on photosynthesis electron transport and ATP synthesis: highered.mheducation.com/olcweb/cgi/pluginpop.cgi?it=swf::535::535::/sites/dl/free/0072437316/120072/bio13.swf::Photosynthetic+Electron+Transport+and+ATP+Synthesis

- Meat-free diets:
  vegetarian.lovetoknow.com/Disadvantages_of_Being_a_Vegetarian
  vegetarian.lovetoknow.com/Advantages_of_Vegetarianism
  getfit.jillianmichaels.com/advantages-disadvantages-vegetarian-diet-1555.html
- British Nutrition Foundation: nutrition.org.uk
- Food chains: users.rcn.com/jkimball.ma.ultranet/BiologyPages/F/FoodChains.html
- Video showing flow of energy in a food chain: youtube.com/watch?v=G-opFAlCFaE
- The Flow of Energy: Primary Production to Higher Trophic Levels:
  globalchange.umich.edu/globalchange1/current/lectures/kling/energyflow/energyflow.html
- Information on biomass and energy pyramids:
  bbc.co.uk/schools/gcsebitesize/science/ocr_gateway/understanding_environment/energyflowrev1.shtml

AO2 Understand key concepts in the application of chemistry

- Information on a wide range of pigments: webexhibits.org/pigments
- A range of resources for theoretical and practical chemistry: alevelchem.com
- A range of resources for theoretical and practical chemistry: avogadro.co.uk/chemist.htm
- Modules based on organic, inorganic, physical, analytical and theoretical chemistry:
  chemwiki.ucdavis.edu/Core
- Interactive Periodic Table: chemicalelements.com
- The story of graphene, from the University of Manchester: graphene.manchester.ac.uk
- Cambridge University Research Centre on graphene: graphene.cam.ac.uk
- Extensive information about graphene: explainthatstuff.com/graphene.html
- Interactive Periodic Table, videos, teaching and learning resources from the Royal Society of Chemistry: rsc.org/resources-tools/education-resources
- RSC ChemNet registration and free membership:
  members.rsc.org/Applogin.asp?AppliedGrade=CHN
- AQA teaching resources for A-level Chemistry:
  aqa.org.uk/subjects/science/as-and-a-level/chemistry-7404-7405/teaching-resources
- AQA textbooks for AS and A-level Chemistry:
  aqa.org.uk/resources/science/as-and-a-level/chemistry-7404-7405/teach/textbooks

AO3 Understand key concepts in the application of physics

- Energy resources from the Institute of Physics: supportingphysicsteaching.net/EnHome.html
- Energy and Electricity resources from the Institute of Physics:
  supportingphysicsteaching.net/EeHome.html
- An introduction to energy resources from the Open University:
  open.edu/openlearn/science-maths-technology/science/environmental-science/energy-resources-introduction-energy-resources/content-section-0
- Information and activities on energy resources: cyberphysics.co.uk/topics/energy/sources.htm
- Teaching resource from the Times Educational Supplement:
  tes.co.uk/teaching-resource/a-level-forces-work-energy-power-6320296

11.2 Unit 2: Applied experimental techniques

Title	Applied experimental techniques
Unit type	Mandatory
Unit assessment type	Internally assessed
Assessment method	Practical assignment
Guided learning hours	60 guided learning hours
Opportunities for developing transferable skill(s)	• Communication • Research • Problem-solving
Resources required for this unit	Apparatus and equipment of an appropriate standard for Level 3 practical work, to include: • laboratory equipment for taking physiological measurements (including peak flow, lung volume, heart rate) • respirometers to measure rate of respiration • laboratory equipment for photosynthesis • centrifuge, blender/food mixer, freezer, refrigerator • laboratory equipment for volumetric analysis and colorimetry • laboratory equipment for measuring resistivity (including Vernier calipers/ micrometer/travelling microscope) and for measuring specific heat capacity.
Applied context	All experimental techniques should relate to their application in research and development for new pharmaceutical products, the quality control of existing products and the investigation of new materials, ecological investigations, consideration of the most suitable material to use for a specific application, or in a forensic or pathology laboratory. It is important that learners are able to describe the usefulness of each technique in a setting outside the school or college laboratory.
Synoptic assessment and learning	Learners should be taught this unit alongside Unit 1 and 3 and it is expected that they will gain knowledge and understanding that will help support the completion of this unit.
Endorsement	The practical work required to be undertaken by learners has been safety checked by, but not trialled by, CLEAPPS. CLEAPSS

Aim and purpose

This unit is designed to introduce learners to new experimental techniques, to reinforce methods met previously and to enable learners to apply these methods to new situations. Experimental work should be set in an applied and vocational context.

Unit introduction

Scientists and technicians working in science industries need to be able to carry out practical techniques.

In this unit, learners will research the background to a number of analytical and experimental techniques. The practice and undertaking of these techniques will be set in an applied context.

In this unit, learners will research the background to a number of analytical and experimental techniques, learn and practise these techniques, and then use them in specific applied or vocational settings.

In this unit, learners will demonstrate their knowledge and understanding of:

- the scientific basis of a range of analytical and experimental techniques
- the use of standard procedures to ensure that the results of analysis can be replicated
- the production and application of risk assessments
- how to analyse errors quantitatively and use this analysis to determine whether experimental results are within tolerance of theoretical or expected values
- correct recording of observations made and data obtained
- how to analyse results and complete relevant calculations
- how to apply graphical skills correctly and accurately
- how to draw conclusions, complete error analyses and evaluations.

Learners will produce **one** scientific report for each experimental technique (see Assessment amplification).

It is important that experimental work is carried out accurately and reproducibly and that results are recorded to suitable levels of precision. Experimental work may identify properties of materials or organisms and analytical work can be either qualitative or quantitative in nature and outcomes.

Contextual setting

For internal assessment, AQA has produced model assignments for each unit. However, centres are permitted to modify the assignment within specified parameters. This will allow centres to tailor the assessment to local needs. The model assignments have been written to ensure that the following controls are in place:

- each unit is assessed through one or more assignments
- each assignment must have a brief that sets out an applied purpose. An applied purpose is a reason for completing the tasks that would benefit society, a community, organisation or company. Further details are in the Statement of purpose in Section 3.6
- the assignments should show how the assessment requirements all contribute to the achievement of the applied purpose of the assignment
- the assignments must provide each learner with the opportunity to address all grading criteria requirements
- the assignments must indicate the acceptable forms of evidence. These must conform to those forms set out in the model assignments
- where a centre has adapted the model assignments, there must be evidence of quality assuring its fitness for purpose and this must be provided in writing to AQA.

Performance outcomes

Learners will:

Performance outcome 1:	Demonstrate applied experimental techniques in biology.
Performance outcome 2:	Demonstrate applied experimental techniques in chemistry.
Performance outcome 3:	Demonstrate applied experimental techniques in physics.
Performance outcome 4:	Understand safety procedure and risk assessment when undertaking scientific practical work.

Unit content

Applied experimental techniques in biology

1(a) Rate of respiration:

Biologists and those working in the healthcare professions need to understand the process of respiration. They need to be able to monitor respiration and interpret their observations as well as being able to suggest appropriate actions that can be taken to change undesirable observations.

Whilst completing investigations, learners will develop their knowledge and understanding of the following concepts and ideas:

Physiological measurements used in relation to rate of respiration in all organisms:

- production of carbon dioxide
- uptake of oxygen.

Factors that affect the rate of respiration in all organisms:

- temperature
- concentration of glucose
- pH levels
- ethical treatment of organisms.

Physiological measurement and monitoring of cardiovascular, circulatory and respiratory systems in humans:

- peak flow
- lung capacity
- blood pressure (breathing rate and heart rate), including in the diagnosis of disease, improvement of performance in sport, or recovery from illness or injury.

Factors that affect rate of respiration measurements in humans as used by sport physiologists to determine metabolic rate whilst at rest and whilst exercising to ensure that energy expenditure meets energy inputs:

- metabolic rate, at rest and whilst exercising
- effects of given factors, such as temperature and exercise, on rate of respiration in a living organism
- ethical treatment of organisms.

Commercial and/or medical uses of physiological measurements.

Applied experimental techniques in biology

1(b) Light-dependent reaction in photosynthesis (the Hill reaction):

Scientists working in agriculture and horticulture need to understand how to obtain and then maintain optimum conditions for plant growth. Photosynthesis is one of the processes these scientists need to consider.

Whilst completing investigations, learners will develop their knowledge and understanding of the following concepts and ideas:

- definition and equations for the overall process of photosynthesis
- light-dependent and light-independent reactions in photosynthesis
- measurement, calculations and graphical presentations of photosynthesis
- factors affecting photosynthesis:
  - light intensity
  - light wavelength
  - carbon dioxide
  - temperature
  - chlorophyll availability
  - herbicide inhibitors
  - plant species
- the value of manipulating factors to increase productivity
- suitable specimens.

Applied experimental techniques in chemistry

2(a) Volumetric analysis:

Volumetric analysis is used in many industries. It is a quick, convenient and accurate method of determining the amount of substance in a sample and can be applied to any scientific area, such as quality control, forensic analysis, ecological and environmental analysis, and trading standards. Analytical laboratories provide some of the most common examples of the application of scientific concepts in the real world, and are found in the food and beverage, water supply, brewing, and pharmaceutical industries.

In completing investigations, learners will develop their knowledge and understanding of the following concepts:

- titration techniques as used in industry, with reference to their convenience and accuracy in determining
- amount of substance present in a sample
- types of titration, including those where an acid and a soluble base or alkali are titrated together in the presence of a suitable indicator:
  - determination of acid in rainwater
  - ethanoic acid in vinegar
  - lactic acid in milk
  - acid in descalers
  - bases (eg used in drain or oven cleaners)
- titrations involving other types of reaction such as precipitation, reduction/oxidation (redox) or the
- formation of metal complex ions. These allow a wider range of substances to be analysed; for example, chloride ions in foodstuffs or polluted water, vitamin C in foodstuffs, and particular types of metal ions in polluted river water
- how volumetric analysis is used in analytical laboratories
- carrying out titrations:
  - scientific principles of the technique
  - use of primary standards
  - preparation and use of standard solution
  - standard procedures
  - risk assessments
  - reactions taking place in titrations
  - use of indicators
  - end points
- recording measurements:
  - precision
  - accuracy
  - reproducibility
  - concordant titres
  - relevant calculations
  - use of correct units
- analysis and interpretation of results
- forming conclusions
- evaluating methodology
- industrial use of volumetric analysis.

Applied experimental techniques in chemistry

2(b) Colorimetric analysis

Analytical chemists apply colorimetric techniques to the determination of the concentration of coloured solutions or, by adding a suitable complexing agent, of some colourless solutions. Colorimetric analysis is used in many industries including, for instance, those associated with dyes, pigments and paints, medicines, food and beverages, and environmental pollution, as well as a wide range of quantitative trace metal determinations such as nickel and iron. Biomedical uses include the analysis of haemoglobin in blood and protein in serum.

In completing investigations, learners will develop their knowledge and understanding of the following concepts:

- scientific principles of colorimetry:
  - colorimetry relying on coloured solutions absorbing light of a particular wavelength
  - the Beer-Lambert Law
- use of colorimetric techniques to measure the concentrations of coloured solutions:
  - analysis of metal ion concentrations in ecological samples
  - quality control of products containing metals such as copper and iron
  - in the dye/pigment/ink and food/beverage industries
- use of colorimetry to analyse colourless substances using suitable complexing agents
- standard procedure in colorimetry:
  - plotting an absorption curve for the substance investigated
  - identifying the wavelength of light for maximum absorption (λmax) or the most appropriate filter to use
  - preparation and use of standard solutions to calibrate the colorimeter
  - use of standard procedure to determine the concentration of a solution
  - risk assessments
  - equipment used
- recording measurements:
  - appropriate levels of precision
  - use of correct units
  - process and interpret results to determine concentration of a solution
  - evaluate methodology.

Applied experimental techniques in physics

3(a) Resistivity

Materials scientists need to be able to recommend appropriate materials for electrical components in a huge range of products.

In completing investigations, learners will develop their knowledge and understanding of the following concepts:

- the meaning of resistivity
- how the resistance of an electrical component relates to the resistivity of the material it is made from
- importance of knowing the resistivity of a material
- uses of materials with both high and low values of resistivity, including, for example, new semiconductors used in electronic circuits
- use of standard procedure to measure the resistivity of a piece of wire
- accuracy and reliability of data, recorded with appropriate precision
- methods used in industry
- recording appropriate measurements:
  - calculate a value for the wire's resistivity
  - calculate the theoretical percentage error
- calculated value compared with researched value for resistivity of the wire's material
- reasons for differences between theoretical and calculated values
- evaluation of methodology.

3(b) Specific heat capacity

Materials scientists use this information when choosing materials for various applications, eg cooking utensils and radiators. The specific heat capacity of a material provides a measure of the rate of heating and cooling of the material and allows engineers and material scientists to compare different materials.

In completing investigations, learners will develop their knowledge and understanding of the following concepts:

- the meaning of specific heat capacity (SHC)
- why different materials have different values
- the importance of knowing SHC values for materials
- behaviour of and possible uses for materials with high and low values of SHC (including water)
- standard procedure to determine the SHC of a material
- ensuring data are accurate and reliable and recorded with appropriate levels of precision
- methods used in industry
- recording appropriate measurements
- calculating theoretical percentage error
- reference to error bars
- graphs showing the change in temperature of the chosen material against time
- reasons for the shape of the graph
- calculating the SHC of the material
- measuring SHC of a material in a different phase
- calculated value compared with data book value
- reasons for differences between theoretical and calculated values.

Grading criteria

Performance outcomes	Pass	Merit	Distinction
	To achieve a pass the learner must evidence that they can:	**In addition to the pass criteria, to achieve a merit the learner must evidence that they can:**	**In addition to fulfilling the pass and merit criteria, to achieve a distinction the learner must evidence that they can:**
PO1 **Demonstrate experimental techniques in biology**	**P1** Outline the uses of physiological measurements of respiration and photosynthesis.	**M1** Explain the scientific principles of physiological measurements.	**D1** Explain how these physiological measurements can be applied in a medical or commercial context.
PO1(a) Rate of respiration	**P2** Follow a standard procedure to measure the effect of varying **one** given factor on the rate of respiration of a living organism.	**M2** Use formulas/ calculations/graphical representations to explain the data.	**D2** Evaluate the results and the method used.
PO1(b) The light-dependent reaction in photosynthesis (the Hill reaction)	**P3** Follow a standard procedure to measure the Hill reaction and record results.	**M3** Explain how this standard procedure could be adapted to investigate **three** limiting factors.	

PO2
Demonstrate applied experimental techniques in chemistry
	P4
	Outline basic principles and uses of volumetric analysis and colorimetry.
		M4
		Explain the scientific principles of:
		• volumetric analysis
		• colorimetry with reference to:
		  ◦ standard solutions
		  ◦ choice of indicators
		  ◦ consideration of Beer—Lambert Law.	

Performance outcomes	Pass	Merit	Distinction
	To achieve a pass the learner must evidence that they can:	**In addition to the pass criteria, to achieve a merit the learner must evidence that they can:**	**In addition to fulfilling the pass and merit criteria, to achieve a distinction the learner must evidence that they can:**
PO2(a) Volumetric analysis	**P5** Follow a standard procedure for volumetric analysis by: • preparing a standard solution • carrying out a titration • recording all • measurements and data.	**M5** Carry out calculations that support: • preparation of the standard solution • the titration.	**D3** Explore how the technique is used in industry, with reference to accuracy and precision and the use of primary standards.
PO2(b) Colorimetric analysis	**P6** Follow a standard procedure for colorimetric analysis, using solution dilutions, by: • recording all data and measurements • producing a calibration curve • determining the unknown concentration.	**M6** Explain the choice of filter/wavelength, describe any inconsistencies in the data recorded making reference to the Beer—Lambert Law.	**D4** Evaluate the outcome of analysis with reference to precision, reliability and accuracy.
PO3 **Demonstrate applied experimental techniques in physics**	**P7** Explain the terms: • resistivity • specific heat capacity (SHC) in relation to material properties.	**M7** Describe how the values of resistivity and SHC determine the uses of materials in industry.	
PO3(a) Resistivity	**P8** Follow a standard procedure to measure the resistivity of **one** material and record results.	**M8** Compare results in resistivity with industry standard data, accounting for anomalous readings.	**D5** Compare the methods used in industry to measure resistivity of materials, including levels of accuracy and precision.

Performance outcomes	Pass	Merit	Distinction
	To achieve a pass the learner must evidence that they can:	**In addition to the pass criteria, to achieve a merit the learner must evidence that they can:**	**In addition to fulfilling the pass and merit criteria, to achieve a distinction the learner must evidence that they can:**
PO3(b) Specific heat capacity	**P9** Follow a standard procedure to measure the SHC of **one** material and record results.	**M9** Calculate percentage error and produce a graph to show change in temperature of **one** material over time and explain the shape of the graph.	**D6** Explain how this standard procedure could be adapted to measure the SHC of a material which is in a different phase.
PO4 **Understand safety procedure and risk assessment when undertaking scientific practical work**	**P10** In using experimental techniques: • safely use a range of practical equipment and materials • identify hazards • produce risk assessments for **one** applied experimental technique from **each** of biology, chemistry and physics.		
Total criteria for each grade	10	15	20

Assessment amplification

The centre is required to complete a Witness confirmation form (see Appendix A) for each learner as evidence that the learner has safely undertaken the applied experimental techniques in biology, chemistry and physics identified in the unit.

Guidance for evidence

In order to meet the grading criteria, each learner's portfolio should contain:

- **six** reports, one for each applied experimental technique
- **three** risk assessments completed by the learner without assistance, **one** for each of biology, chemistry and physics
- **three** additional risk assessments for other techniques, issued by the tutor and used by the learner
- **one** Witness confirmation form completed by the tutor.

PO1 Demonstrate applied experimental techniques in biology

For **P1**, learners are expected to produce portfolio evidence based on research, covering physiological measurements used in relation to respiration and photosynthesis.

For **M1**, the portfolio evidence should concentrate on the science relating to the physiological measurements used in relation to respiration and photosynthesis, and for **D1** the research should highlight the potential uses of each physiological measurement (considered in **M1**) in a commercial or medical context.

Rate of respiration

For **P2**, **M2** and **D2**, the portfolio report should include full tabulated records of all measurements and data obtained when investigating the effect of one factor, such as temperature, on the rate of respiration. Evidence should also include details of how the organisms in the experiment are treated ethically.

For **M2** and **D2**, portfolio evidence should demonstrate learners' ability to:

- use calculations to establish rate of respiration
- construct accurate and appropriate graphs to represent data
- use correct precision for the data used
- analyse data in order to evaluate the results
- evaluate the method used.

Light-dependent reaction in photosynthesis

For **P3**, learners are expected to follow a standard procedure to measure the Hill reaction and produce a report which includes full tabulated records of all measurements and data obtained.

For **M3**, the portfolio report should explain different ways to adapt the methodology to investigate **three** different limiting factors to the ones considered for **P3.** The report should also provide evidence that the learners understand the underpinning science related to the limiting factors of photosynthesis.

PO2 Demonstrate applied experimental techniques in chemistry

In **P4** and **M4**, learners are expected to report on their research, covering the uses, applications and scientific principles of volumetric analysis and colorimetry, including:

Volumetric analysis:

- the reaction, equation and stoichiometry
- the choice of indicator (if required) and colour change at the endpoint
- for acid–base reactions, justification of the choice of indicator based on the reaction and pH curve
- for other reactions, how the colour change at the end point is achieved/occurs
- the importance of using a standard solution or one that has been standardised

Colorimetric analysis:

- the visible spectrum
- the construction of a simple colorimeter to include the light source, the use of filters or a means of selecting wavelength, the cuvette and path length, detection and display
- choice of filter or wavelength of incident light, absorption curves and λmax
- absorbance and the Beer—Lambert Law
- calibration and the nature of the absorbance against concentration calibration graph.

Volumetric analysis

For **P5** and **M5**, in addition to the standard procedure followed, full tabulated records of all measurements and data obtained are expected, including all raw data (such as initial and final burette readings, initial and final masses). This includes all data relating to the preparation of the standard solution, any standardisation titration if relevant, and the main titration. Correct units should be included and normal conventions followed.

Standard accepted levels of precision in recording are very important; for instance, all titres and non-zero burette readings should be recorded to the nearest 0.05 cm^3. Reproducibility is equally important, and mean titres should be calculated from concordant values only (titres within +/- 0.10 cm^3).

For **M5**, portfolios should demonstrate the following:

- correct identification of the standard used and its M_r
- correct equation for the reaction and molar ratio (stoichiometry)
- calculation of the moles of solid used and the concentration of the standard solution
- calculation of the mean titre and its use in calculating the unknown concentration
- correct units
- correct precision evident for the data used, the molarity of the standard solution and the final unknown molarity.

For **D3**, the accuracy of the final outcome should be judged against a literature value (if relevant) or the expected value (based, for instance, on a tutor result). This can then be compared with the techniques used in industry and the increased levels of accuracy and precision employed there. The use of specified primary standards in industry to control the accuracy of concentrations of solutions used should be investigated.

Colorimetric analysis

For **P6** and **M6**, results of all stages should be recorded clearly, with appropriate units where relevant. This includes data relating to the determination of λmax or choice of filter, preparation of the standard solution, serial dilutions, absorbance readings for standard solutions and unknowns.

For **P6**, portfolios should demonstrate the following:

- calculations of molarity of standard solutions with due regard for precision and correct units
- calculations of concentrations produced by serial dilutions
- graphs of absorbance against wavelength (or filter), and absorbance against concentration, which demonstrate correct use of axis scales, plotting of points and lines of best fit
- the use of the calibration graph to determine the unknown concentration.

For **D4**, the accuracy of the final outcome should be judged against a literature value (if relevant) or the expected value (based, for instance, on a tutor result). A full evaluation of the experimental outcomes should follow, with a consideration of the quantitative errors associated with the measurements made, the precision of recording and reliability of measurements, and a qualitative assessment of the practical methodology. This error analysis can then be related to the accuracy of the final outcome.

PO3 Demonstrate applied experimental techniques in physics

For **P8** and **P9**, full tabulated records of all measurements and data obtained are expected.

Resistivity

For **M8** learners should compare their results with industry data, accounting for any anomalies eg the different conditions under which the procedures are undertaken.

For **D5**, comparing methods in relation to accuracy and precision, refer to the glossary of terms.

Specific heat capacity

For **M9**, learners should also calculate the expected percentage error in their results (through considering the percentage precision of each measurement taken) and use this to produce a final figure (+/- X%) for their value of SHC. They should also make reference to minimising energy losses. Error bars should be drawn and used correctly, where relevant. Interpretation of the shape of the graph should be logical and show correct scientific understanding.

For **D6**, portfolios should demonstrate that learners are able to explain how the specific heat capacity of both a solid and a liquid can be determined. If the material they originally used was in a solid state then they would need to explain how the procedure would be adapted to measure the specific heat capacity of a liquid (or vice versa). They would need to consider any additional precautions that would need to be taken to ensure that results were valid and accurate.

PO4 Understand safety procedure and risk assessment when undertaking scientific practical work

For **P10**, learners should undertake their own independent risk assessments for:

- **one** of the two biology techniques and
- **one** of the two chemistry techniques and
- **one** of the two physics techniques.

The remaining **three** risk assessments can be issued by the centre and used by the learner. The portfolio should include **all six** risk assessments.

Guided learning hours breakdown

	PO1	PO2	PO3	PO4	Total
Delivery time (hours)	10	10	10	6	36
Assessment time (hours)	8	8	8	–	24
Total	18	18	18	6	60

Delivery guidance

The practical work should be set in an applied or vocational context and specific objectives set. The context, objectives, and standard procedures should be issued by the centre.

PO1 Demonstrate applied experimental techniques in biology

Formal delivery should concentrate on the underlying principles upon which the investigations are based and the commercial and medical applications.

It is important that learners familiarise themselves with standard procedures prior to undertaking the actual practical investigations, including the correct use of spirometers and respirometers as used by sports scientists or medical professionals, and preparation of chlorophyll pellets as used by biomedical scientists in the agricultural, manufacturing and food industries.

Rate of respiration

Learners may select human volunteers or other suitable organisms for this investigation. Comprehensive risk assessments should be undertaken, and ethical aspects fully considered. Basic equipment can be used but there are several software packages that can be employed.

The light-dependent reaction in photosynthesis

All organisms are ultimately dependent on primary production (the production of biomass by green photosynthesising plants). The rate of photosynthesis is important in food production since it influences crop yield. Environmental factors influencing this rate include light, temperature, carbon dioxide, water and nutrients. Effective crop management requires these factors to be optimised in order to give the best results.

Practical demonstrations of the rate and outcomes of photosynthesis are readily demonstrated by oxygen production and starch formation. In the light-dependent reaction of photosynthesis, carbon dioxide is reduced to carbohydrate using an electron source. At the cellular level, nicotinamide adenine dinucleotide phosphate (NADP) is the electron acceptor which is reduced in the light-dependent reactions and supplies electrons and hydrogen for the light-independent reaction.

Learners should consider how the Hill reaction, as an investigation into photosynthesis, differs from previous levels of study of photosynthesis in terms of what is measured and what limiting factors could be applied to such a procedure.

A number of websites and Level 3 textbooks provide detailed laboratory and health and safety guidance for the Hill reaction. CLEAPSS provide a useful video on YouTube: youtube.com/watch?v=i9_h3TSIJzM

Given the number of individuals involved if learners/volunteers are used instead of other organisms, and the necessity to work quickly when carrying out the Hill reaction, learners should consider working collectively on this investigation.

PO2 Demonstrate applied experimental techniques in chemistry

The two experiments, a volumetric analysis and a colorimetric analysis, provide opportunities for learners to use their practical skills in new and applied contexts such as analysis of water and pollutants as carried out by environmental agencies and the water industry. There are clear links to Unit 1, particularly for the volumetric analysis, but also for colorimetry, where learners developed their knowledge and understanding of a range of relevant areas, including:

- moles, molarities, equations
- pH curves for acid–base titrations, pH at the end point, choice of indicator
- calculations relevant to titration data, moles, molarities
- electron transitions brought about by the absorption of light of a specific wavelength.

In this unit, learners will build on and expand previous knowledge, develop and practise practical skills and then apply them to the determination of unknown concentrations, with the tasks firmly set in applied contexts.

Volumetric analysis

All relevant procedures, including those for the preparation of the standard solution (and its use to standardise another reagent, if relevant) and the main titration, should be evident in reports.

Learners should appreciate that there is a range of possible types of chemical reaction which may be applied to this technique. Examples include:

- acid–base
- redox
- precipitation
- complexiometric.

In terms of the applications and uses of volumetric analysis, these types should be included and suitable examples researched. Further types of titration, such as thermometric and potentiometric, are not expected to be covered.

It is expected that a primary standard is used to prepare a solution that can then be used in the titration to determine an unknown concentration. Alternatively, and more commonly, the titrant may need to be standardised first, and then used in a second titration to determine an unknown concentration.

Centres should ensure that titrations will produce sensible titres (approximately 25 cm^3).

Colorimetric analysis

All relevant procedures, including those for the identification of λmax or the correct filter, preparation of a standard solution and serial dilutions, use of the colorimeter and obtaining absorbance readings, should be evident in reports.

Learners should appreciate that colour arises in some compounds through the absorption of light of specific wavelengths in the visible region of the electromagnetic spectrum, leading to transitions between electron energy levels. Other wavelengths are reflected or transmitted.

A simple colorimeter is designed to measure the level of absorbance of incident light when passed through a solution contained in a cuvette of fixed path length.

Whilst % transmission may also be measured, it is expected that learners will use absorbance throughout this work, both in terms of the underlying principles and in practical work.

Centres should ensure that an appropriate range of concentrations is produced via serial dilution.

A standard solution should be prepared (incorporating any complexing agent if necessary) and serial dilutions performed to produce a series of accurately known concentrations. The range of standards should span the likely concentration of the unknown.

A sample of the solution should be used to determine λmax or the correct filter to use. Absorbance readings are taken for the range of standard solution concentrations and a calibration graph produced. This, if data are accurate, should be a straight line through the origin. Unless learners are able to produce a very high quality graph using a spreadsheet, it is advisable for them to plot the graph in the traditional way.

The absorbance of the unknown is measured and the graph used to determine the unknown concentration.

PO3 Demonstrate applied experimental techniques in physics

Formal delivery should concentrate on the underlying principles upon which the investigations are based, including all relevant mathematics, as well as relevant applications.

Learners will carry out the two experiments to measure the properties of materials. The properties of materials are important for many industries including manufacturing, automotive and medical engineering.

Resistivity

Learners should use a standard procedure to measure the resistivity of a sample of material (conductor or semiconductor). It is expected that suitably precise equipment will be used to measure the relevant dimensions and resistance of the sample used. Learners should repeat their experiment at least three times, recognise anomalies and take suitable averages.

They should compare their value of resistivity with the accepted value and identify whether their result is in agreement with it. They should then consider the reasons for any differences between their results and the accepted value.

Learners should be able to evaluate their methodology in terms of accuracy and precision of results and, where relevant, suggest improvements.

Learners will need to have a sound understanding of what resistivity means in order to be able to discuss the ways in which materials with differing values of resistivity can be used.

Specific heat capacity

Learners should use a standard procedure to measure the SHC of a material which is in either the solid or liquid phase. It is expected that precautions will be taken to reduce heat loss to the surroundings and that suitably precise equipment will be used to measure temperature, mass and energy supplied. Learners should repeat their experiment at least three times, recognise anomalies and take a suitable average. They should be able to explain the shape of the heating/cooling curve obtained and use this when discussing the validity of their results.

They should compare their value for the SHC with the accepted value and identify whether their result is in agreement with it. They should then consider the reasons for any differences between their results and the accepted value.

Learners should be able to evaluate their methodology in terms of accuracy and precision of results and, where relevant, suggest improvements.

Learners will need to have a sound understanding of what SHC means in order to be able to discuss the ways in which materials with high and low values of SHC can be used.

It is likely that schools will have equipment more readily available for measuring the SHC of a solid than for measuring the SHC of a liquid. So it is anticipated that most learners will actually measure the SHC of a solid and then research methods for measuring the SHC of a liquid or gas.

PO4 Understand safety procedure and risk assessment when undertaking scientific practical work

Evidence for hazard identification and the assessment of risks and subsequent control measures will be provided by the inclusion of risk assessments in the portfolio.

The ability to follow written instructions safely and the correct use of safety equipment will be assessed by the tutor, and records kept which will form the basis of a written statement, which should be included in the portfolio evidence.

Risk assessments should consider chemicals and equipment used. Chemicals should be identified correctly, including concentrations used, and the risk assessment should target these concentrations. Hazards must be appropriate to these concentrations, risks assessed accordingly and safety equipment identified. Disposal of chemicals must also be considered, as must action on spillage, etc. Whilst CLEAPSS Hazcards are useful sources of information, they are not themselves risk assessments, as concentrations will vary.

The learner's risk assessment does not replace the requirement for the tutor to do a risk assessment.

Synoptic assessment

Performance outcome	Links to other units
PO1 Demonstrate applied experimental techniques in biology	**Unit 1 Key concepts in science** AO1(a) Cell structure AO1(c) The heart AO1(e) Breathing and cellular respiration AO1(f) Photosynthesis and food chain productivity **Unit 4 The human body** AO3 Understand how oxygen is transported in the blood and how physiological measurements can be applied **Unit 5 Investigating science** PO2 Carry out the investigation and record results PO3 Analyse results, draw conclusions and evaluate the investigation **Unit 6a Microbiology** PO1 Identify the main groups of microorganisms in terms of their structure PO2 Use aseptic techniques to safely cultivate microorganisms
PO2 Demonstrate applied experimental techniques in chemistry	**Unit 1 Key concepts in science** AO2(a) Atomic structure AO2(b) The Periodic Table AO2(c) Amount of substance **Unit 5 Investigating science** PO2 Carry out the investigation and record results PO3 Analyse results, draw conclusions and evaluate the investigation **Unit 6c Organic chemistry** PO1 Identify molecular structure, functional groups and isomerism PO2 Understand reactions of functional groups PO3 Prepare organic compounds

Performance outcome	Links to other units
PO3 Demonstrate applied experimental techniques in physics	**Unit 1 Key concepts in science** AO3(a) Useful energy and efficiency AO3(b) Electricity and circuits **Unit 5 Investigating science** PO2 Carry out the investigation and record results PO3 Analyse results, draw conclusions and evaluate the investigation **Unit 6b Medical physics** PO3 Demonstrate the ability to work with radioisotopes in the laboratory

This unit would logically be taught prior to Unit 5 in the Extended Certificate. There are opportunities for learners to demonstrate synoptic knowledge and learning from Unit 1 in their evidence for this unit.

The amplification below identifies synoptic assessment and where learning from other units can be assessed within this unit.

PO1 Demonstrate applied experimental techniques in biology

Rate of respiration: when conducting this experiment, the knowledge from Unit 1 on breathing and cellular respiration will be consolidated. Learners will also be able to extend their knowledge of homeostasis when studying physiological measurements and oxygen transportation in Unit 4.

Light-dependent reaction in photosynthesis: knowledge of photosynthesis and food chain productivity from Unit 1 is important for learners to understand when carrying out this experiment.

Standard procedures: the skills gained here will be further applied for carrying out investigations and recording results in Unit 5 and Unit 6a when conducting experiments on yeast cells, investigating the use of immobilised cells in bioreactors and cultivating microorganisms.

PO2 Demonstrate applied experimental techniques in chemistry

Volumetric and colorimetric analysis: when conducting these experiments, the knowledge from Unit 1 on atomic structures and amount of substance can enhance learning.

Standard procedures: learners will be able to extend their knowledge gained on substances in Unit 1 when carrying out experiments on titrations and applying standard procedures here. Knowledge and understanding gained here will also be applicable in Unit 5 and Unit 6c, when using investigation techniques and analysing data.

PO3 Demonstrate applied experimental techniques in physics

Resistivity and specific heat capacity: learners will build on their knowledge and understanding of electricity and circuits from Unit 1 when measuring the resistivity of conductors and semiconductors in an applied context.

They will also build on their knowledge and understanding of useful energy and efficiency from Unit 1 when measuring the specific heat capacity of materials in solid or liquid phase in an applied context.

Knowledge and understanding gained here will also be applicable in Unit 5 and Unit 6b, when carrying out investigation techniques, analysing data and recording results working with radioisotopes in the laboratory.

PO4 Understand safe procedure and risk assessment when undertaking scientific practical work

Safe procedure and risk assessment: the skill of carrying out risk assessments is developed further in Unit 5 with a requirement to produce a risk assessment for the chosen science investigation.

Resources

PO1 Demonstrate applied experimental techniques in biology

Rate of respiration

Peak flow meters; lung capacity bags; electronic blood pressure monitor; respirometers (boiling tube, bung, delivery tubing, gauze, soda lime, ruler); water bath; organisms such as maggots or woodlice.

The light-dependent reaction in photosynthesis

Centrifuge and tubes; fresh green spinach, lettuce or cabbage, three leaves (discard the midribs); pestle and mortar; muslin or fine nylon mesh; filter funnel; glass rod; measuring cylinder; beaker; pipettes, 5 cm^3 and 1 cm^3 ; bench lamp; test tubes; boiling tube; pipette for 5 cm^3 and 0.5 cm^3 ; pipette filler; waterproof pen to label tubes; colorimeter and tubes or light sensor and data logger; 0.05 M phosphate buffer solution, pH 7.0; isolation medium (sucrose and KCl in phosphate buffer); potassium chloride; DCPIP solution. A centrifuge is essential for the Hill reaction as you need the spin speed to concentrate the chloroplasts into a pellet and it is also essential to keep everything chilled.

PO2 Demonstrate applied experimental techniques in chemistry

Volumetric analysis

Class sets of apparatus to include volumetric flasks for the preparation of a standard solution and glassware for the subsequent volumetric analysis. Balances to 2 or 3 dp. Suitable primary standards for the standardisation of solutions, and appropriate indicators for use in the titration, relevant to the chosen experiment.

Colorimetric analysis

Sufficient access to colorimeters for individual or small group work. Balances to 2 or 3 dp. Class sets of apparatus to include volumetric flasks and pipettes for serial dilutions. Suitable pure solid samples of standards and complexing agents, if appropriate, relevant to the experimental determination chosen.

PO3 Demonstrate applied experimental techniques in physics

Resistivity

Class sets of meters that will enable learners to measure the resistance of a sample of the material to be tested. The meters could be ammeters and voltmeters or resistance meters which have an appropriate range and degree of precision.

The material tested is likely to be in the form of a wire. Some means of accurately measuring the diameter of the wire used is required (eg micrometer, Vernier calipers or travelling microscope) as well as equipment to measure the length of the sample.

Specific heat capacity

Class sets of apparatus to measure the specific heat capacity of a material. It is likely, and recommended, that the material used would be a purpose-made 1 kg cylinder of brass or aluminium. Thermometers with an appropriate range and degree of precision, along with a means of timing intervals between readings, will also be needed. Some means of insulating the cylinder would also be recommended.

There are other methods of measuring SHC (eg method of mixtures or continuous flow calorimetry) and if one of these is chosen then the equipment required will be different.

Useful links and publications

PO1 Demonstrate applied experimental techniques in biology

Rate of respiration

- Tips for measuring blood pressure
  bloodpressureuk.org/BloodPressureandyou/Homemonitoring/Howtomeasure
- Values for peak expiratory flow rate
  peakflow.com/top_nav/normal_values/index.html
- Method for measuring lung capacity
  glasgowsciencecentre.org/teacher-resources/lung-capacity.html

Photosynthesis

- Resources from the 'Science and Plants for Schools' website
  saps.org.uk/attachments/article/130/
  SAPSTheeffectoflightcolourandintensityontherateofphotosynthesis.doc
- Photosynthesis experiments from the Nuffield Foundation
  nuffieldfoundation.org/practical-biology/photosynthesis

PO2 Demonstrate applied experimental techniques in chemistry

- A range of resources for theoretical and practical Chemistry
  alevelchem.com
- A range of resources for theoretical and practical Chemistry
  avogadro.co.uk/chemist.htm
- Modules based on organic, inorganic, physical, analytical and theoretical chemistry
  chemwiki.ucdavis.edu/Core
- 'Chemistry – A Practical Guide – Support Materials' from Education Scotland
  educationscotland.gov.uk/Images/ChemistryPracticalGuide_tcm4-723689.doc
- Royal Society of Chemistry teaching and learning resources
  rsc.org
- RSC ChemNet registration and free membership
  members.rsc.org/Applogin.asp?AppliedGrade=CHN
- AQA teaching resources for AS and A-level Chemistry
  aqa.org.uk/subjects/science/as-and-a-level/chemistry-7404-7405/teaching-resources
- AQA textbooks for AS and A-level Chemistry
  aqa.org.uk/resources/science/as-and-a-level/chemistry-7404-7405/teach/textbooks

Volumetric analysis

- Detailed method for volumetric analysis
  wiredchemist.com/chemistry/instructional/laboratory-tutorials/volumetric-analysis

PO3 Demonstrate applied experimental techniques in physics

- Institute of Physics resources for teaching Advanced Physics
  iop.org/education/teacher/resources
- Association for Science Education resources
  ase.org.uk/resources
- Resources from the TES
  tes.co.uk/teaching-resources

Resistivity

- YouTube videos on measuring the resistivity of the material in a wire
  youtube.com/watch?v=Lf3eGar8Kss
  youtube.com/watch?v=Tt-_7nfAJ5U
- Measuring electrical resistivity (The Institute of Physics, 'Teaching Advanced Physics')
  tap.iop.org/electricity/resistance/112/file_45987.doc
- An experiment to find the resistivity of nichrome (from 'Marked by Teachers')
  markedbyteachers.com/gcse/science/an-experiment-to-find-the-resistivity-of-nichrome.html

Specific heat capacity

- Measuring specific heat capacity (The Institute of Physics, 'Teaching Advanced Physics')
  tap.iop.org/energy/thermal/607/file_47505.doc
  tap.iop.org/energy/thermal/607/file_47502.doc
  tap.iop.org/energy/thermal/607/page_47500.html
- Measurement of specific heat capacities (from 'School Physics')
  schoolphysics.co.uk/age16-19/Thermal%20physics/Heat%20energy/text/Specific_heat_capacity_measurement/index.html

PO4 Understand safety procedure and risk assessment when undertaking scientific practical work

- Student safety sheets
  science.cleapss.org.uk/Resource-Info/Student-Safety-Sheets-ALL.aspx

11.3 Unit 3: Science in the modern world

Title	Science in the modern world
Unit type	Mandatory
Unit assessment type	Externally assessed
Assessment method	Written examination (pre-released materials) 1 hour 30 minutes
Guided learning hours	60 guided learning hours
Opportunities for developing transferable skill(s)	• Research • Communication • Teamwork
Applied context	This unit will enable learners to develop their analytical, evaluative and critical thinking skills. These are important skills for scientists and technicians working in research, product development and scientific testing.
Synoptic assessment and learning	Elements of this unit can be taught concurrently with Unit 1 and Unit 2 when exploring topical scientific issues, ethical and moral issues involved in scientific advances and the roles and responsibilities undertaken by scientists and other professionals.

Aim and purpose

The aim of this unit is to build on the applied contexts explored by learners to enable them to analyse and evaluate scientific information, to develop critical thinking skills and to understand the use of the media to communicate scientific ideas and theories. Learners will develop an understanding of how science is used in organisations and of the roles and responsibilities of their scientifically-qualified staff.

Unit introduction

Scientists argue that if society is to support scientific research, the public needs to understand the nature of science. Society should know that science has its limitations as well as its benefits. The public should be aware that scientific answers to questions are not always easily found, but that they play an important role in improving the world in which we live.

The media are used to convey scientific information not only to scientists but also to the wider public. Those involved in the media are faced with the problem of trying to decide how much the reader or viewer wants to know about science and whether they will understand the content. The media also provide a vehicle through which ideas concerning moral, social and ethical issues may be discussed.

Various types of media may be used to communicate scientific theory and ideas, including:

- websites including blogs
- newspapers
- radio and television
- press releases
- scientific journals.

This unit is designed to enable learners to develop their ability to interpret information, to process and present data and to evaluate their usefulness and appropriateness. Through their reading of a range of scientific texts, learners will engage with topical scientific issues, discuss the ethical and social implications of scientific advances and explore how these issues are represented in the media. Through their research and their interaction with the scientific community, learners will also have the opportunity to explore how scientists work and the many varied roles they carry out.

Assessment outcomes

Learners will:

Assessment outcome 1:	Use information about topical scientific issues obtained from a variety of media sources.
Assessment outcome 2:	Understand the public perception of science and the influence that the media have.
Assessment outcome 3:	Understand the ethical, moral, commercial, environmental, political and social issues involved in scientific advances, and how these are represented in the media.
Assessment outcome 4:	Understand the roles and responsibilities that science personnel carry out in the science industry.

Unit content

Topical scientific issues obtained from a variety of media sources

Learners will develop their knowledge and understanding of the following key concepts and their applications:

- topical scientific issues and the related scientific ideas
- interpretation of both textual and numerical scientific information from the media and demonstration of clear understanding of the content
- processing of data acquired from the media and determining the usefulness and appropriateness of these data
- presenting of data in an appropriate form.

The public perception of science and the influence that the media have

Learners will develop their knowledge and understanding of the following key concepts and their applications:

- how scientific knowledge is developed and used when communicating with different audiences
- the differences in approach and style used by the media when communicating with scientists and wider society
- how scientists publish and share their work, including peer reviewing
- ways in which data, hypothesis, argument and theory are gained and used
- how society and the media interact with science; that the media give scientists a platform for explaining their work, and provide the public with a way to understand the key scientific features.

The ethical, moral, commercial, environmental, political and social issues involved in scientific advances, and how these are represented in the media

Learners will develop their knowledge and understanding of the following key concepts and their applications:

- the benefits and drawbacks of topical scientific advances and how these are represented in the media, eg GM crops, fracking
- the environmental and commercial considerations associated with these advances, and any health and safety implications
- the social, ethical and moral matters which might be raised by scientific advances, eg animal research, drug trials, transplants
- how the media treat these social, ethical and moral issues
- the importance of national and/or local political pressure groups in influencing scientific advancements.

The roles and responsibilities that science personnel carry out in the science industry

Learners will develop their knowledge and understanding of the following key concepts and their applications:

- the varied roles that scientists can perform in an organisation, including:
  - biologist (including marine and zoologist)
  - biomedical scientist, including microbiologist
  - chemist, including biochemistry and analysts
  - environmental scientist (ecologist)
  - geneticist
  - material scientist
  - pharmacologist
  - physicist
  - product/process developer or technologist, eg polymers or food (biotechnologist)
  - radiographer/radiologist
  - research scientist
  - scientific laboratory technician
  - sport and exercise scientist
  - toxicologist
- the scientifically-related skills, techniques and experience needed to undertake specific roles and responsibilities within an organisation
- the roles and responsibilities associated with science personnel within an organisation
- the benefits of scientific roles to society
- the relations between science personnel in an organisation.

Assessment

This unit will be assessed through an external examination set and marked by AQA. The examination will take place under controlled examination conditions and the date of the examination will be published at the start of each academic year. This unit will be available for assessment in January and June of each academic year.

The examination will consist of a written paper, in two sections, with no optional questions.

Learners will be allowed to use a non-programmable scientific calculator in the examination.

The examination will last 1 hour and 30 minutes and the total number of marks available in the examination will be 60.

AQA will ensure that the full content of the unit is covered equally over the life of the specification.

Section A

A selection of background material on a topical scientific issue will be released to centres by AQA each year, and should be provided by centres to learners on or around 31 March (depending on the date of the Easter holiday) for June assessment and on or around 1 November for January assessment. (**See section 12 for exam timetable**). This pre-released material will be chosen by AQA for topical scientific interest and will usually consist of four 'sources'.

The range of pre-released materials provided for study is likely to include:

- news article(s) from the popular press
- longer review article(s) from popular media (weekend newspapers, general magazines)
- article(s) from general science magazines (such as New Scientist, Scientific American)
- material from specialist scientific sources aimed at informing the general public (such as general publications from the British Association for the Advancement of Science, Royal Society, research councils)
- paper(s) from scientific journals (edited where necessary to remove excessive detail and to emphasise the form of the paper and the argument; detailed understanding of complex scientific explanation in a specialist area will not be expected).

Learners will be expected to familiarise themselves with the pre-released material in advance of the examination. In preparation for the exam, they should apply the same skills of analysis, interpretation and critical thinking that they have developed in meeting the assessment outcomes of this unit. For example, they should consider how scientific issues are treated in the different types of media, make judgements about the relevance of the scientific information presented, and reflect on any ethical, environmental, political, moral, commercial and social issues associated with the scientific topic. Learners will then answer questions based on these sources in Section A of the Unit 3 examination.

Learners will not be expected to carry out any wider reading around the scientific issue presented in the pre-released materials.

Learners will be provided with clean copies of the pre-released materials in the examination.

Section B

Questions in Section B of the Unit 3 examination will not be based on the sources in the pre-released materials, and may or may not be based on the same topical scientific issues. This section will assess learners' abilities to demonstrate Assessment outcomes 1–4.

Guided learning hours breakdown

	AO1	AO2	AO3	AO4	Total
Delivery time (hours)	15	15	15	15	60

Delivery guidance

In order to deliver this unit, tutors do not need to be specialists in all science areas. AQA have provided a number of sample teaching guides available under teaching resources on the website. This unit provides an ideal opportunity to bring in speakers from outside organisations, such as universities. Learners may benefit from having input from staff within other disciplines, such as geography or design and technology.

The unit aims to provide learners with the skills to be able to make balanced judgements on scientific issues. Although there is a need to have some understanding of the science behind the areas explored, the development of a wider set of skills, including communication, research and critical thinking, is at the core of the unit. Centres are encouraged to use the resources listed below as a means of teaching the unit content outlined and associated assessment outcomes.

AO1 Use information about topical scientific issues obtained from a variety of media sources

Learners should be introduced to topical scientific issues through a variety of sources, including radio and television, newspapers, websites and scientific journals. Teaching and learning can be structured around helping learners to understand the content, utilising their scientific knowledge from other units.

Discussion and debating could form part of the teaching and learning, drawing on recent and past scientific issues via the use of case studies. Learners should understand that there are many media channels from which information can be gathered and that these are not always impartial.

Learners could be made aware of the main bodies behind scientific issues and campaigns.

Learners should be able to develop the skills of data manipulation and interpretation, as well as summarising skills, when working with a range of sources.

AO2 Understand the public perception of science and the influence that the media have

Learners should consider how the general and specialist media report on scientific issues. Building on approaches from AO1, learners should be made aware of the different types of audience. The tone and language of scientific texts varies depending on the audience type (see different types of sources in AO1).

Learners should be introduced to the idea that the media give scientists a platform. The popular media play a part in providing information, setting the agenda and influencing opinion on issues. Learners should understand that media reports of scientific developments are often simplified and sometimes inaccurate. A newspaper report of a new development has not been through the stringent peer review process that articles in scientific journals must undergo. Learners should be introduced to the notion of peer reviewing and how the scientific community share information, including forums and blogs, etc.

Learners should be introduced to the notion of 'bad science' and the issue of poor use of science in the media.

Teaching may also allow for learners to consider topics in line with their particular interests.

AO3 Understand the ethical, moral, commercial, environmental, political and social issues involved in scientific advances, and how these are represented in the media

Building on AO1 and AO2, this allows learners to consider ethical and moral issues related to scientific advances. Learners should be made aware of national pressure groups such as Greenpeace and how they seek to exert pressure on government. There might be an opportunity to invite local pressure groups into centres to help learners understand how the process works.

In helping learners to understand environmental and commercial aspects of scientific advances, guest speakers, including those from conservation groups, could be invited to talk to learners.

Teaching may also allow for learners to consider topics in line with their particular interests.

AO4 Understand the roles and responsibilities that science personnel carry out in the science industry

Learners are encouraged to research the role of scientists working in organisations that manufacture or process scientific products and those that provide a scientific service. The aim is to help learners to understand the specific roles and responsibilities and the skills needed.

The use of specialist speakers and visits to laboratories in the manufacturing and service industries (both public and private) should be considered. Careers coordinators and advisers may also provide suitable information and support for this unit.

Synoptic assessment

Assessment outcome	Links to other units
AO1 Use information about topical scientific issues obtained from a variety of media sources	Synoptic across all units – 1, 2, 5, 6a, 6b, 6c
AO2 Understand the public perception of science and the influence that the media have	Synoptic across all units – 1, 2, 5, 6a, 6b, 6c
AO3 Understand the ethical, moral, commercial, environmental, political and social issues involved in scientific advances, and how these are represented in the media	Synoptic across all units – 1, 2, 5, 6a, 6b, 6c
AO4 Understand the roles and responsibilities that science personnelcarry out in the science industry	Synoptic across all units – 1, 2, 5, 6a, 6b, 6c **Unit 4: The human body** **AO3** Understand how oxygen is transported in the blood and how physiological measurements can be applied

This unit would logically be taught concurrently with Units 1 and 2, with opportunities for learners to demonstrate synoptic knowledge and skills that will benefit the assessment of this unit.

The amplification below identifies synoptic assessment and where learning from other units can be assessed within this unit.

AO1 Use information about topical scientific issues obtained from a variety of media sources

When exploring scientific topical issues, knowledge and understanding from Unit 1 Key concepts in science and Unit 2 Applied experimental techniques will be used.

When processing data and assessing it for its appropriateness, learners should apply their knowledge and skills gained while assessing results and recording data in Unit 2. The knowledge and skills then gained in this unit can be further applied in Unit 5 and the optional units when carrying out the investigations and analysing results.

AO2 Understand the public perception of science and the influence that the media have

When teaching Unit 1, content such as artificial pacemakers, meat-free diets and renewable fuels could be linked to media perception of the science of these related areas.

Learners can use information available on different digital platforms such as YouTube to reinforce their knowledge and understanding of Unit 1 Key concepts of science and the application of the concepts to the real world. The knowledge and skills then gained in this unit can be further applied in Unit 5 and the optional units when carrying out the investigations and analysing results.

AO3 Understand the ethical, moral, commercial, environmental, political and social issues involved in scientific advances, and how these are represented in the media

When teaching Unit 1, content such as artificial pacemakers, meat-free diets and renewable fuels could be linked to commercial and environmental issues and how these are represented in the media. The knowledge and skills then gained in this unit can be further applied in Unit 5 and the optional units when carrying out the investigations and analysing results.

AO4 Understand the roles and responsibilities that science personnel carry out in the science industry

When teaching the content for Unit 1 and Unit 2, reference should be made to the roles of scientists in industry and the benefits to society as a whole. The knowledge and skills then gained in this unit can be further applied in Unit 5 and the optional units when carrying out the investigations and analysing results.

Resources

- Access to topical scientific articles from a range of media sources
- Access to information detailing the roles and responsibilities of personnel in scientific organisations

Useful links and publications

AO1 Use information about topical scientific issues obtained from a variety of media sources

- Topical articles on science and the environment from the BBC bbc.co.uk/news/science_and_environment
- Institute of Science in Society i-sis.org.uk/index.php
- Articles on science related to humans and society from New Scientist magazine newscientist.com/subject/humans
- Articles on science in society from Horizon, the EU research and innovation magazine horizon-magazine.eu/topics/science-society
- Topical science news from the Centers for Disease Control and Prevention cdc.gov

AO2 Understand the public perception of science and the influence that the media have

- A rough guide to spotting bad science compoundchem.com/wp-content/uploads/2014/04/Spotting-Bad-Science.pdf
- Ben Goldacre's 'Bad Science' blog, covering media misrepresentations of science, with a particular focus on medicine badscience.net
- Sense About Science – a charitable trust that equips people to make sense of scientific and medical claims in public discussion senseaboutscience.org
- NHS Choices – 'How to Read Health News' nhs.uk/news/Pages/Howtoreadarticlesabouthealthandhealthcare.aspx
- 'Your guide to the science that make the news' from the NHS nhs.uk/news
- Guardian newspaper article, 'Science not helped by the media' theguardian.com/education/2002/sep/04/highereducation.uk1

AO3 Understand the ethical, moral, commercial, environmental, political and social issues involved in scientific advances, and how these are represented in the media

- Resources from the Biotechnology and Biological Sciences Research Council (BBSRC) bbsrc.ac.uk/engagement/schools
- Stem cells – science and ethics bbsrc.ac.uk/engagement/schools/keystage5/stem-cells
- Ethics, morality and biotechnology resources.schoolscience.co.uk/BBSRC/ethics/ethics_animal_biotech.pdf
- Greenpeace website greenpeace.org.uk
- Friends of the Earth website foe.co.uk
- Genewatch, a not-for-profit group that monitors developments in genetic technologies from a public interest, human rights, environmental protection and animal welfare perspective genewatch.org

A04 Understand the roles and responsibilities that science personnel carry out in the science industry

- Job profiles in science and research, from the National Careers Service
  nationalcareersservice.direct.gov.uk/advice/planning/jobfamily/Pages/scienceandresearch.aspx
- Information on careers in biomedical science, from the Institute of Biomedical Science
  ibms.org/go/biomedical-science/careers-jobs/careers
- Information about opportunities for biomedical scientists in the RAF
  raf.mod.uk/recruitment/roles/medical-and-medical-support/biomedical-scientist
- Information about the role and activities of laboratory technicians, from Prospects careers website
  prospects.ac.uk/scientific_laboratory_technician_job_description.htm
- Information about the role and activities of toxicologists, from Prospects careers website
  prospects.ac.uk/toxicologist_job_description.htm
- Information on scientific roles from Cogent, Skills for Science Based Industries
  sciencecareerpathways.com/a-z-of-roles
- Extensive information about scientific roles, opportunities and entry requirements
  sciencebuddies.org/science-engineering-careers
- Science careers open to graduates and how to apply for them, from the University of Kent
  kent.ac.uk/careers/ScienceJobs.htm

Useful textbooks

- Best, J. *Damned Lies and Statistics: Untangling Numbers from the Media, Politicians and Activists* (University of California Press, 2001) ISBN 9780520219786.
- Curran, J. *Mass Media and Society* (Hodder Arnold, 2005) ISBN 9780953910823.
- Michaels, P J. *Meltdown*: The Predictable Distortion of Global Warming by Scientists, Politicians and the Media (Cato Institute US, 2005) ISBN 9781930865792.
- Mur, C. *Animal Experimentation* (Greenhaven Press, 2004) ISBN 9780737720006.
- O'Sullivan, T et al. *Studying the Media* (Hodder Arnold, 2003) ISBN 9780340807651.

11.4 Unit 4: The human body

Title	The human body
Unit type	Mandatory
Unit assessment type	Externally assessed
Assessment method	Written examination, 1 hour 30 minutes
Guided learning hours	60 guided learning hours
Opportunities for developing transferable skill(s)	• Research • Communication • Problem-solving
Resources required for this unit	• Standard science laboratory equipment and chemicals for food and enzyme tests • Equipment for physiological measurements • Equipment for reaction time assessments
Applied context	This is predominantly a theoretical unit in which learners develop their knowledge and understanding of human anatomy and physiology. However, the applications of these ideas in the health and sports science industries can be explored through practical work.
Synoptic learning and assessment	Learners should be taught this unit after Unit 1 and Unit 2, building on the knowledge, understanding and practical skills associated with biological sciences and their application to the human body.

Aim and purpose

The aim of this unit is that learners develop an understanding of human anatomy and physiology, building on their knowledge and understanding of the National Curriculum KS4 Science subject content gained in previous studies.

Unit introduction

Healthcare professionals are required to make various measurements of the functions of human biological systems. These measurements can assist with the diagnosis of disease, improvement of performance in sport, or recovery from illness or injury.

In this unit, learners will consider some physiological measurements used to monitor the activity of the body, and applications of these measurements, such as fitness screening and management in sports centres, or referral of patients recovering from heart attacks. They will learn how monitoring the cardiovascular and pulmonary systems, and analysis of blood samples, provides healthcare workers and sports scientists with information about a person's state of health and fitness.

Healthcare workers might also provide advice about diet. Learners will investigate the components of a healthy diet for different groups, including children, the elderly and athletes, and the effects of an imbalanced diet on health, as studied by dieticians.

They will explore the structure and function of the digestive system, the chemical reactions that are needed to sustain cells, and the impact of different enzymes involved in chemical digestion, as studied by biochemists.

Learners will investigate why the respiratory process is so important to the functioning of all cells, in that it provides ATP from food. They will learn about oxygen transportation and saturation levels, and the use of pulse oximetry by nurses.

Learners will also investigate the structure and function of the nervous and musculoskeletal systems, and the application of this knowledge by sports therapists.

In the assessment of this unit, questions will be set in applied contexts.

Assessment outcomes

Learners will:

Assessment outcome 1:	Understand the digestive system and diet.
Assessment outcome 2:	Understand the musculoskeletal system and movement.
Assessment outcome 3:	Understand how oxygen is transported in the blood and how physiological measurements can be applied.
Assessment outcome 4:	Understand the structure and function of the nervous system and brain.
Assessment outcome 5:	Understand nerve impulses.

Unit content

The digestive system and diet

Learners will develop their knowledge and understanding of the following key concepts and their applications:

- the key components of the digestive system, including the liver, gall bladder and pancreas
- the roles of each organ in the digestive system and how they play a part in mechanical and/or chemical digestion
- the role of condensation and hydrolysis reactions in the bond-making and bond-breaking of carbohydrates, proteins and lipids in chemical digestion and assimilation
- the roles of hydrochloric acid, bile and mucus in the digestive system and how each of these affects enzyme-controlled digestion
- the roles of carbohydrases, proteases and lipases in the digestion of carbohydrates, proteins and lipids
- the role of the small intestine in absorption of the small soluble products of digestion, including how the structure of the small intestine ensures efficient absorption
- the process of co-transport used to absorb glucose and amino acids
- the effect of gastrin on digestion
- the uses of macronutrients and micronutrients in the body, including:
  - carbohydrates
  - proteins
  - lipids
  - sodium
  - calcium
  - iron
  - vitamin C
  - vitamin D
- the symptoms of deficiency of these macronutrients and micronutrients
- foods that can help to maintain healthy levels of macronutrients and micronutrients
- diseases/disorders that can develop from deficiency of these macronutrients and micronutrients, and their symptoms.

The musculoskeletal system and movement

Learners will develop their knowledge and understanding of the following key concepts and their applications:

- structure of the skeleton:
  - axial and appendicular
  - cartilage
  - bone
- function of the skeleton:
  - support
  - protection
  - movement
  - marrow/blood cell production
  - resorption (the breaking down of old bone) and ossification (formation of new bone) as processes in bone remodelling
- structure and functions of synovial joints:
  - adaptations for movement
  - types of synovial joint and range of movement:
    - gliding
    - hinge
    - ball and socket
    - pivot
- the main features of a myofibril, including:
  - myosin filaments (thick filaments)
  - actin filaments (thin filaments) Z line, A band, H band and I band
- the sliding filament theory for muscle contraction, including:
    - myosin heads attaching to actin, forming a cross bridge
    - myosin head changing shape to slide the actin further along the myosin
    - cross bridges forming and breaking at a rate of up to 100 times per second
    - how this mechanism shortens the sarcomere
    - cross bridges (actinomyosin formation) in the presence of calcium ions
    - how adenosine triphosphate (ATP) releases the energy needed by this mechanism
- the role of calcium:
  - tropomyosin (in the thin/actin filaments) prevents myosin heads from attaching to actin by blocking the binding sites
  - nerve impulses (action potentials) cause calcium ions to be released
  - calcium ions bind with troponin (in the thin/actin filaments)
  - causing tropomyosin to change shape and unblock the binding sites
  - when action potentials stop arriving, the calcium ions are actively transported out of the sarcoplasm and the muscle stops contracting (relaxes)

The musculoskeletal system and movement

- fast-twitch (white) and slow-twitch (red) fibres
- how slow-twitch fibres do not produce ATP very quickly so are not very powerful
- how fast-twitch fibres generate ATP very quickly and are used for short bursts of explosive action
- the adaptations of slow-twitch fibres, to include:
  - ability to function over long periods
  - ability to respire aerobically
  - ability to store glycogen as a metabolic fuel store
  - ability to respire fat stores in the body
  - myoglobin
  - good blood supply
  - high density of mitochondria
- the adaptations of fast-twitch fibres, to include:
  - ability to function for short periods of time
  - ability to respire anaerobically
  - storage of creatine phosphate for anaerobic respiration
  - fatiguing quickly due to anaerobic respiration of lactate
- how the breakdown of creatine phosphate transfers energy and releases phosphate ions which are used to make ATP
- how creatine phosphate is regenerated during aerobic respiration
- the effect of exercise on the proportion of fast-twitch and slow-twitch muscle fibres
- possible adaptations of diet for athletes in training, including the use of creatine supplements.

How oxygen is transported in the blood and how physiological measurements can be applied

Learners will develop their knowledge and understanding of the following key concepts and their applications:

- how oxygen does not dissolve well so most oxygen is carried by haemoglobin (Hb) in the red blood cells
- the structure of haemoglobin
- how the degree of oxygenation depends on the partial pressure of oxygen $p(O_2)$
- using an oxygen dissociation curve to explain how oxygen is carried by haemoglobin
- how the presence of carbon dioxide assists in the dissociation of oxygen and shifts the curve to the right (the Bohr effect)
- how training at high altitudes affects oxygen transportation
- how to use a pulse oximeter to measure oxygen saturation as a non-invasive method
- the normal range for oxygen saturation levels (95–99 %)
- using SaO_2 % to represent oxygen saturation
- the effect of diseases such as emphysema or cystic fibrosis on oxygen saturation levels
- how to use a sphygmomanometer to measure blood pressure
- the effect of high/low blood pressure on health.

The structure and function of the nervous system and brain

Learners will develop their knowledge and understanding of the following key concepts and their applications:

- the organisation of the nervous system into the central nervous system (CNS) and the peripheral nervous system (PNS)
- the somatic and autonomic nervous systems, and the difference in their roles
- the sympathetic and parasympathetic nervous systems
- the role of the sympathetic nervous system in controlling physiological responses, such as increasing heart rate and dilating pupils, to threatening situations
- the role of the parasympathetic nervous system in maintaining normal physiological functioning, such as decreasing heart rate, stimulating the digestive system
- the lobes of the cerebral cortex, cerebellum and brain stem
- the roles of the four lobes of the cerebral cortex:
  - frontal lobe, associated with reasoning, planning, movement, emotions and problem-solving
  - parietal lobe, associated with movement, orientation, recognition
  - occipital lobe, associated with visual processing
  - temporal lobe, associated with perception and recognition of auditory stimuli, memory and speech
- the role of the cerebellum in controlling skeletal muscle for fine movement, coordination, posture and balance
- the role of the brain stem in maintaining vital functions such as breathing and heart rate
- how brain damage may result in symptoms that indicate the area of the brain that has been affected.

Nerve impulses

Learners will develop their knowledge and understanding of the following key concepts and their applications:

- the sensory and motor nerves, including dendrites, cell body, myelin sheath and nodes of Ranvier
- the movement of ions into and out of the neurone causing an action potential:
  - resting potential
  - the role of the sodium–potassium pump in maintaining resting potential
  - action potential
- how nerve impulses travel rapidly along a nerve fibre
- how the structure of myelinated nerve fibres enables them to conduct impulses more quickly
- the components of a synapse:
  - presynaptic membrane
  - synaptic cleft
  - postsynaptic membrane
  - synaptic vesicles
  - (neurotransmitter) receptors
- the sequence of events from when the action potential arrives at the presynaptic membrane, including
- the role of Ca^2+ ions and Ca^2+ channels, synaptic vesicles, neurotransmitter, receptors
- the role of enzymes in recycling the neurotransmitter
- the wide range of different neurotransmitters, including acetylcholine, dopamine and serotonin
- disorders arising from problems with neurotransmitters and synaptic transmission, such as:
  - Alzheimer's, linked to a lack of acetylcholine
  - Parkinson's, linked to a lack of dopamine
  - depression, linked to a lack of serotonin
- the symptoms of Alzheimer's, Parkinson's and depression
- the effects on synaptic transmission of drugs used to treat disorders, including:
  - Alzheimer's
  - Parkinson's
  - depression.

Assessment

This unit will be assessed through an external examination, set and marked by AQA. The examination will take place under controlled examination conditions and the date will be published at the start of each academic year.

Learners will be allowed to use a non-programmable scientific calculator in the examination. The examination will consist of a written paper with short-answer questions. Learners will be required to answer all of the questions.

The examination will last 1 hour and 30 minutes and the total number of marks available in the examination will be 60.

AQA will ensure that the full content is covered equally over the life of the specification.

Guided learning hours breakdown

	AO1	AO2	AO3	AO4	AO5	Total
Delivery time (hours)	10	20	5	15	10	60

Delivery guidance

Wherever possible, theory should be supported by experimental work. It is also important that learners consider everyday applications of the theory studied.

AO1 Understand the digestive system and diet

The structure and function of the digestive system, and the enzymes involved in chemical digestion, could be investigated using the main enzymes involved, ie amylase, pepsin and lipase. These experiments could use different concentrations of enzyme or substrate, different pH or a range of temperatures, in order to relate the enzymes to their natural environments. Experiments to identify the main biological components of foods could also be carried out.

AO2 Understand the musculoskeletal system and movement

Work on the structure and function of muscles and contractions has to be mainly theoretical. There are experiments for muscle twitch using pork or rabbit muscle (and frogs' legs) and adenosine triphosphate (ATP), but these are not always successful.

AO3 Understand how oxygen is transported in the blood and how physiological measurements can be applied

Work on oxygen transport in the blood will mainly be theoretical, but some physiological measurements can be carried out in the laboratory.

Learners can have their blood pressure and heart rate monitored using a sphygmomanometer before and after exercise, or before and after having caffeine, to see if there are any changes. Learners can then be monitored to see when they reach their resting blood pressure and heart rate. The fitter they are, the more quickly their readings will return to normal.

Oxygen levels in the blood can be measured using a pulse oximeter which uses infrared light to measure oxygen saturation. This is non-invasive and measures across a finger or earlobe.

AO4 Understand the structure and function of the nervous system and brain

The nervous system consists of the central nervous system and the peripheral nervous system. It controls all of our voluntary (eg writing) and involuntary (eg blinking) actions and reactions. Reflex actions and the reflex arc can be demonstrated through a variety of experiments, including testing of the reflex arc in the knee and catching a falling ruler.

AO5 Understand nerve impulses

Nerve impulses are biochemical reactions occurring along the nerve axons. There are no practical experiments that can be carried out for nerve impulses at this level, but learners could carry out a research project into a brain condition such as Alzheimer's, Parkinson's or depression.

Synoptic assessment

Assessment outcome	Links to other units
AO1 Understand the digestive system and diet	**Unit 1: Key concepts in science** AO1(d) Homeostasis
AO2 Understand the musculoskeletal system and movement	**Unit 1: Key concepts in science** AO1(a) Cell structure AO1(e) Breathing and cellular respiration
AO3 Understand how oxygen is transported in the blood and how physiological measurements can be applied	**Unit 1: Key concepts in science** AO1(e) Breathing and cellular respiration **Unit 2: Applied experimental techniques** PO1(a) Rate of respiration **Unit 3: Science in the modern world** AO4 Understand the roles and responsibilities that science personnel carry out in the science industry
AO4 Understand the structure and function of the nervous system and brain	**Unit 1: Key concepts in science** AO1(c) The heart AO1(e) Breathing and cellular respiration
AO5 Understand nerve impulses	**Unit 1: Key concepts in science** AO1(a) Cell structure AO1(b) Transport mechanisms

This is an externally assessed unit. This unit would logically be taught after Units 1 and 2 and there are opportunities for learners to use elements of other units to support the development of knowledge and understanding for this unit. There are also synoptic teaching and learning opportunities and links Unit 5 Investigating science (depending on the investigation chosen).

The amplification below identifies synoptic assessment and where learning from other units can be assessed within this unit.

AO1 Understand the digestive system and diet

Learners will be able to build on their knowledge of homeostasis from Unit 1 and the role of different organs in the digestive system when learning about the process of digestion and the role of different enzymes in this process.

AO2 Understand the musculoskeletal system and movement

Learners will be able to build on knowledge and understanding gained in Unit 1 on cell structure and cellular respiration when assessed on how ATP is generated and utilised by muscle fibres.

AO3 Understand how oxygen is transported in the blood and how physiological measurements can be applied

Learners will be able to build on their knowledge of breathing and cellular respiration from Unit 1, and rate of respiration and physiological measurements from Unit 2, when assessed on oxygen transportation and measuring oxygen saturation levels. Knowledge and understanding gained in Unit 3 about the roles and responsibilities of different professionals and scientist will inform learners about where the physiological measurements can be applied in the health sector.

AO4 Understand the structure and function of the nervous system and brain

Knowledge and understanding gained in Unit 1 on the heart and cellular respiration will help learners to explore the functions of different parts of the brain and how it controls physiological responses, eg the brain stem maintaining vital functions such as breathing and heart rate.

AO5 Understand nerve impulses

Learners will be able to apply their knowledge of cell structure and transport mechanisms from Unit 1 when being assessed on movement of ions into and out of a neurone, causing the action potential.

Resources

Basic laboratory glassware and chemicals.

AO1 Understand the digestive system and diet

Enzyme preparations, buffers, water baths, thermometers, stop clocks.

For food tests: standard laboratory equipment, iodine solution, Benedict's solution, biuret solution, filter paper.

AO2 Understand the musculoskeletal system and movement

Microscope and slides, scalpel, muscle (meat), Ringers solution, ATP solution.

AO3 Understand how oxygen is transported in the blood and how physiological measurements can be applied

Pulse oximeter.

Sphygmomanometer.

AO4 Understand the structure and function of the nervous system and brain

Stop clocks, metre rulers.

There are also synoptic teaching and learning opportunities and links with Unit 3 Science in the modern world (the science underpinning the topical scientific issues chosen in this unit) and Unit 5 Investigating science (depending on the investigation chosen).

Useful links and publications

- Physiology experiments from the Wellcome Trust getinthezone.org.uk/schools/ages-11-19/ages-16-19/ages-16-19-experiments
- Information and resources based on cells, genetics and human biology biologymad.com/frontpage.htm
- Revision notes on a range of biological topics biology-innovation.co.uk
- Resources for teachers and learners from the Association of the British Pharmaceutical Industry (ABPI) abpischools.org.uk
- Kimball's Biology Pages, an online Biology textbook biology-pages.info

AO1 Understand the digestive system and diet

- Investigating effects of temperature on the activity of lipase, from the Nuffield Foundation nuffieldfoundation.org/practical-biology/investigating-effect-temperature-activity-lipase

AO2 Understand the musculoskeletal system and movement

- Experiment showing the effect of ATP on muscle fibres home.earthlink.net/~dwyerg/HL%20Labs/ATP%20Muscle%20Lab.doc

AO3 Understand how oxygen is transported in the blood and how physiological measurements can be applied

- Instructions on using a pulse oximeter Nonin.com/How-to-Use-a-Pulse-Oximeter
- Instructions on using a Sphygmomanometer practicalclinicalskills.com/sphygmomanometer.aspx

AO4 Understand the structure and function of the nervous system and brain

- Resources from 'Neuroscience for Kids' faculty.washington.edu/chudler/experi.html
- Reaction time ruler test topendsports.com/testing/tests/reaction-stick.htm

AO5 Understand nerve impulses

- Information about nerve impulses from the Science Museum sciencemuseum.org.uk/WhoAmI/FindOutMore/Yourbrain/Howdoesyourbrainwork/Howdoesyournervoussystemwork/Whatarenerveimpulses.aspx
- Information on neurological disorders from the National Institute of Neurological Disorders brainfacts.org/diseases-disorders/diseases-a-to-z-from-ninds
- Extensive information about nerve impulses biologymad.com/nervoussystem/nerveimpulses.htm
- Video animation showing the nerve impulse mechanism youtube.com/watch?v=SdUUP2pMmQ4
- Neuroscience for kids faculty.washington.edu/chudler/neurok.html

11.5 Unit 5: Investigating science

Title	Investigating science
Unit type	Mandatory
Unit assessment type	Internally assessed
Assessment method	Practical assignment
Guided learning hours	60 guided learning hours
Opportunities for developing transferable skill(s)	• Research • Communication • Problem-solving
Resources required for this unit	• Online facilities for research. • Access to a science laboratory and appropriate scientific equipment.
Applied context	Many industries employ scientists who are involved in research and investigation. They test out new ideas and report their findings to a suitable audience, to fellow scientists, and eventually to the public. These scientists are responsible for developments in industries which provide both services and products, such as pharmaceuticals, automotive, construction, food production, radiology and countless others. The context of the investigation will enable learners to use their knowledge and skills in carrying out a scientific investigation that relates to science in the real world.
Synoptic learning and assessment	Learners will carry out an original, extended practical investigation that draws together the knowledge, skills and understanding that they have developed in other units.

Aim and purpose

The aim of this unit is to provide learners with an opportunity to undertake the role of a research scientist, following standard procedures to complete a scientific investigation.

Unit introduction

This unit is designed to enable learners to demonstrate and extend their scientific knowledge and skills. Learners may choose one investigation from the list of titles provided (see Delivery guidance). Alternatively, learners may choose their own investigation in consultation with their tutor, but it is strongly recommended that before work commences, the tutor first has the investigation approved by AQA.

There may be links to the science content in other units but the investigation chosen should be completed specifically for this unit. Learners' choices may be influenced by the career pathway they are following, by their particular interests, or by the resources available to them.

In this unit, learners will:

- use secondary sources to research a scientific topic and develop an outline for the practical investigation
- plan the practical investigation and justify the approaches suggested
- prepare risk assessments and carry out the practical investigation
- record data in an appropriate format
- analyse data to draw conclusions

- evaluate the techniques used and the outcomes achieved
- produce a scientific report on their investigation
- prepare a presentation of their investigation for an appropriate audience.

Contextual setting

For internal assessment, AQA has produced model assignments for each unit. However, centres are permitted to modify the assignment within specified parameters. This will allow centres to tailor the assessment to local needs. The model assignment has been written to ensure that the following controls are in place:

- each unit is assessed through one or more assignments
- each assignment must have a brief that sets out an applied purpose. An applied purpose is a reason for completing the tasks that would benefit society, a community, organisation or company. Further details are in the Statement of purpose in Section 3.6
- the assignments should show how the assessment requirements all contribute to the achievement of the applied purpose of the assignment
- the assignments must provide each learner with the opportunity to address all grading criteria requirements
- the assignments must indicate the acceptable forms of evidence. These must conform to those forms set out in the model assignments
- where a centre has adapted the model assignments, there must be evidence of quality assuring its fitness for purpose and this must be provided in writing to AQA.

Performance outcomes

Learners will:

Performance outcome 1:	Prepare for a scientific investigation.
Performance outcome 2:	Carry out the investigation and record results.
Performance outcome 3:	Analyse results, draw conclusions and evaluate the investigation.
Performance outcome 4:	Present the findings of the investigation to a suitable audience.

Unit content

Prepare for a scientific investigation

In completing investigations, learners will develop their knowledge and understanding of the following concepts:

- tasks involved in the investigation and the aim of each task
- the scientific theories involved
- equipment required to carry out the investigation
- the standard procedures/techniques to be used in the investigation, including measurements, observations, accuracy, reliability and validity
- trials done to practise techniques or determine parameters
- modifications made as a result of the trials
- related commercial and industrial uses.

Carry out the investigation and record results

In completing investigations, learners will develop their knowledge and understanding of the following concepts:

- risk assessments. (Refer to CLEAPPS student safety sheets – link in 'Useful links and publications')
- recording qualitative data in an appropriate format
- recording quantitative data accurately in an appropriate format, to a suitable level of precision and with correct units.

Analyse results, draw conclusions and evaluate the investigation

In completing investigations, learners will develop their knowledge and understanding of the following concepts:

- anomalous data and reasons for anomalies
- carrying out appropriate calculations
- appropriate ways to present quantitative data, including graphs and charts
- appropriate use of IT to process and analyse data
- drawing conclusions that are valid and relevant to the purpose of the investigation
- explaining conclusions by referring to information obtained from secondary sources
- evaluation of the techniques used and the results obtained
- identification and explanation of any sources of quantitative and qualitative error
- making justified recommendations for improvements to the investigation.

Present the findings of the investigation to a suitable audience

In completing investigations, learners will develop their knowledge and understanding of the following concepts:

- combining text and images to prepare an effective presentation for a suitable audience
- summarising the purpose, data obtained and conclusions of the practical investigation
- correct use of appropriate scientific terminology
- relevance to industrial processes
- production of a bibliography that makes use of the Harvard Reference System.

Grading criteria

Performance outcomes	Pass	Merit	Distinction
	To achieve a pass the learner must evidence that they can:	**In addition to the pass criteria, to achieve a merit the learner must evidence that they can:**	**In addition to fulfilling the pass and merit criteria, to achieve a distinction the learner must evidence that they can:**
PO1 **Prepare for a scientific investigation**	**P1** Research and outline the science behind the investigation.	**M1** Explain the scientific principles behind the investigation.	**D1** Provide a detailed account of the scientific principles behind the investigation and relate these to commercial and industrial uses.
	P2 Produce a plan for the investigation which includes standard procedures/techniques to be followed and the aims of individual tasks.	**M2** Record details of trials completed, describing any changes made to the plan as a result of these trials.	**D2** Justify the techniques chosen and the accuracy, reliability and validity shown.
PO2 **Carry out the investigation and record results**	**P3** Correctly identify hazards and assess risks in carrying out the investigation.	**M3** Explain the control measures taken to ensure the safe use of equipment.	
	P4 Correctly follow standard procedures to use a range of practical equipment and materials safely.		
	P5 Record the data obtained in appropriate ways using correct conventions and units.	**M4** Assess the effectiveness of the methods used to collect data.	**D3** Make justified suggestions for any improvements that could be made.

Performance outcomes	Pass	Merit	Distinction
	To achieve a pass the learner must evidence that they can:	**In addition to the pass criteria, to achieve a merit the learner must evidence that they can:**	**In addition to fulfilling the pass and merit criteria, to achieve a distinction the learner must evidence that they can:**
PO3 **Analyse results, draw conclusions and evaluate the investigation**	**P6** Analyse the data obtained using appropriate methods.	**M5** Manipulate data using appropriate methods, including use of IT.	**D4** Justify the methods and formats used to analyse and manipulate data.
	P7 Identify sources of error and any anomalous data.	**M6** Explain the sources of error, give possible reasons for anomalous data and explain how they can be minimised.	
	P8 Draw conclusions from the data obtained.	**M7** Review the use of primary and secondary data.	**D5** Evaluate the outcomes of the investigation.
PO4 **Present the findings of the investigation to a suitable audience**	**P9** Produce a report on the investigation and make a presentation to a suitable audience. Include results and a conclusion which are clear and concise.	**M8** Refer to secondary data. Use correct scientific terminology throughout.	**D6** Identify the relevance of the investigation and results to appropriate industrial processes.
	P10 Record sources of information used to support research and conclusions, using the Harvard Reference System.	**M9** Evaluate the sources of information used in terms of their usefulness and validity.	
Total criteria for each grade	10	15	20

Assessment amplification

The following section contains guidance for centres on the unit grading criteria. This guidance is only provided where we feel that the criteria require amplification of what is specifically required or exemplification of the responses learners are expected to provide.

Where guidance hasn't been provided, it is felt that the grading criteria have been written in sufficient detail so that centres can fully understand the requirements of the assessment.

Observation record (see Appendix B)

This unit requires the completion of an *Observation record* for each learner, to support evidence of their practical work and verify the independence they have shown in completing practical laboratory techniques in the scientific investigation. Although not directly linked to grading criteria, the *Observation record* is a mandatory requirement and will form part of the external moderation process. Assessors are likely to comment on the learner's approach to practical work, including practical techniques, investigative methods, accuracy, precision and performance, as well as the safe and correct use of laboratory equipment.

PO1 Prepare for a scientific investigation

For **P2**, learners should produce a plan which includes the overall purpose of the investigation, details of the individual practical tasks to be undertaken and the aims of these tasks. Learners should ensure that they have included details of the observations or measurements to be made.

PO2 Carry out the investigation and record results

For **P3**, learners should prepare risk assessments for each individual task in the investigation. It should be clear that the learners can differentiate between hazard and risk.

For **P4**, there should be evidence of the standard procedures being followed correctly by the learner for each task. This should be an observation statement completed by the assessor and may be accompanied by video or photographic evidence.

For **P5**, learners should prepare their own tables to record their results.

For **M4**, learners' tables should all have correct headings and units, and data should be recorded accurately and to an appropriate number of significant figures.

PO3 Analyse results, draw conclusions and evaluate the investigation

For **M7**, the expectation is that learners will have made use of primary and secondary sources as part of their planning.

PO4 Present the findings of the investigation to a suitable audience

For **P9**, learners should write a report on their scientific investigation. This report should include an introduction, risk assessment, method and procedures, results, analysis, conclusion and a bibliography which follows the Harvard Referencing System.

Guided learning hours breakdown

	PO1	PO2	PO3	PO4	Total
Delivery time (hours)	5	5	5	5	20
Assessment time (hours)	5	15	15	5	40
Total	10	20	20	10	60

Delivery guidance

For this unit, learners will carry out an original, extended practical investigation that draws together the knowledge, skills and understanding that they have developed in other units.

Learners may select an investigation from the titles below.

Suggested titles for scientific investigation

- **Investigate the use of immobilised cells in bioreactors**
  Immobilise yeast cells by entrapping them in spheres of alginate gel and then use the yeast cells to perform enzyme experiments.
- **Investigate the factors that affect the efficiency of electroplating using copper**
  Investigate how the concentration of the solution, the temperature, the presence of other ions in solution (using small volumes), the shape of the electrode and the condition of the electrode surface affect the electro- deposition rates.
- **Investigate how electrochemical cells work and the factors that can change the voltage output**
  Make a number of different electrochemical cells by pairing up various metal/metal ion half cells and then investigate how the voltage changes depending on the salt concentration, the size and shape of the electrode and the temperature of the salt solution.
- **Investigate the factors that affect fermentation in the brewing industry**
  Use yeast to investigate how different substrates, temperature, pH, nutrients and a range of media can be used in brewing.
- **Investigate the properties of modern shampoos**
  Determine the relative viscosity, pH, foaming ability, cleansing effectiveness, and oil-emulsification abilities of different shampoos.
- **Investigate the response of LDRs**
  Determine how the resistance of selected LDRs is related to different intensities and different wavelengths of light.
- **Investigate the factors that affect the output of a wind turbine**
  Determine the useful energy generated by model turbines with different numbers of blades, blades of different shapes and blades of different areas.
- **Investigate the factors that affect reaction time**
  Use real or virtual reaction timers to determine the effect of various factors such as caffeine, practice, age, gender, etc, on reaction times.

Alternatively, learners/centres may choose their own investigation(s), but centres are strongly advised to contact AQA tvq@aqa.org.uk in order to confirm the suitability of the investigation in allowing learners to access P, M and D grading criteria.

The scientific investigation should be set in a particular vocational context (as part of an assignment brief) and applied to a specific industry either locally, nationally or internationally.

Supervision of practical work

Laboratory practical work should be supervised at all times. Note that in accordance with CLEAPSS guidelines, learners should not undertake fieldwork alone. Photographic evidence of work being undertaken in the laboratory may be included and should be clearly annotated.

PO1 Prepare for a scientific investigation

A class discussion should take place to explain the idea of conducting a scientific investigation and the protocols involved, including the following of standard procedures and the writing of a scientific report.

Learners should undertake independent research into the topic concerned to decide what questions need to be asked before beginning their investigation. They should research and outline the science involved and the standard procedures that could be used.

They should then put together their plan of the investigation. Decisions about techniques, quantities and concentrations should be made by undertaking trial experiments, and the details of these and any changes made as a result should be recorded and justified.

PO2 Carry out the investigation and record results

Learners should prepare risk assessments for the investigation. It is suggested that risk assessment templates are used that encourage learners to differentiate between hazard and risk. For example, the column headings ‘equipment’, ‘hazard’, ‘risk’, ‘control measures’ and ‘emergency measures’ could be used. Refer to CLEAPPS student safety sheets – link in ‘Useful links and publications’.

PO3 Analyse results, draw conclusions and evaluate the investigation

Learners should process their results using appropriate calculations and then present them in suitable graphs and charts. The ways in which the results have been processed and presented should be justified.

Learners should understand about different types of errors that can occur in practical activities. They should then identify and explain the sources of error in their own investigation. Anomalous results should be identified and reasons for these results should be suggested.

Conclusions should be drawn from each task and comparisons made to secondary data. These should be collated to form an overall conclusion to the investigation.

PO4 Present the findings of the investigation to a suitable audience

Learners should prepare a scientific report that summarises the investigation. This should include the purpose of the investigation, the data obtained and the conclusions drawn.

Learners should also prepare and give a presentation to a suitable audience, which may include their peers, tutors, members of the local community and members of the scientific community. The presentation should be clearly structured and concise, and use images, charts, graphs etc as well as correct scientific terminology. This presentation could be produced in PowerPoint, as a booklet or leaflet, a scientific magazine article, a webpage or in any other suitable format.

Synoptic assessment

Performance outcome	Links to other units
PO1 Prepare for a scientific investigation	Synoptic across all units 1, 2, 3, 4, 6a, 6b, 6c
PO2 Carry out the investigation and record results	Synoptic across all units 1, 2, 3, 4, 6a, 6b, 6c
PO3 Analyse results, draw conclusions and evaluate the investigation	Synoptic across all units 1, 2, 3, 4, 6a, 6b, 6c
PO4 Present the findings of the investigation to a suitable audience	**Unit 3 Science in the modern world** AO1 Use information about topical scientific issues obtained from a variety of media sources. AO3 Understand the ethical, moral, commercial, environmental, political and social issues involved in scientific advances, and how these are represented in the media.

This unit would logically be taught after Units 1 and 2 and could be concurrently taught with the optional unit chosen.

The amplification below identifies assessment and where learning from other units can be assessed within this unit.

PO1 Prepare for a scientific investigation

The topic for the scientific investigation could be considered during delivery of Units 1, 2 and 4, and learners will be able to make an informed decision based on their knowledge of key concepts and applied experimental techniques. Learners will then be able to build on this knowledge and understanding further in the optional unit 6a (PO2) to cultivate microorganisms, 6b (PO3) to measure half-life of radioisotopes, or 6c (PO3) to prepare organic compounds. Ethical and moral issues associated with any scientific investigations must be considered when selecting topics for investigation.

PO2 Carry out the investigation and record results

When carrying out the scientific investigation and recording results, learners will be able to build on their knowledge of key concepts from Unit 1 and of applied experimental techniques from Unit 2. Learners should be able to make specific reference to standard procedures in Unit 2 (PO1, PO2 and PO3) and risk assessments in Unit 2 (PO4). Learners will then be able to build on this knowledge and understanding further in the optional unit 6a (PO2) to cultivate microorganisms, 6b (PO3) to measure half-life of radioisotopes, or 6c (PO3) to prepare organic compounds. Ethical and moral issues associated with any scientific investigation, the role of science professionals and the application of these scientific investigations must be considered.

PO3 Analyse results, draw conclusions and evaluate the investigation.

When analysing data, drawing conclusions and evaluating the techniques used in investigations, learners should be able to demonstrate the knowledge they gained in earlier units, with specific reference to recording results in Unit 2 (PO1, PO2, PO3) and using information about scientific issues in Unit 3 (AO1).

When considering different types of errors that can occur in practical activities, learners will apply their own knowledge and understanding of errors faced while conducting different experiments in Unit 4, such as measuring oxygen levels in the blood, using a pulse oximeter. Ethical and moral issues associated with any scientific investigation, the role of science professionals and the application of these scientific investigations must be considered.

PO4 Present the findings of the investigation to a suitable audience

When presenting the findings of their investigations, learners should be able to apply their knowledge and understanding from Unit 3 (AO1) Exploring topical scientific issues and Unit 3 (AO3) Considering ethical and moral issues and how these are represented in the media.

Resources

See investigation card available for each suggested scientific investigation.

Useful links and publications

- Helping learners to choose, design and plan their own investigation
  nuffieldfoundation.org/applied-science/scientific-investigations-getting-started
- Evaluating a scientific report
  nuffieldfoundation.org/applied-science/scientific-investigations-reporting
- Student safety sheets
  science.cleapss.org.uk/Resource-Info/Student-Safety-Sheets-ALL.aspx

11.6 Unit 6a: Microbiology

Title	Microbiology
Unit type	Optional
Unit assessment type	Internally assessed
Assessment method	Practical assignment
Guided learning hours	60 guided learning hours
Opportunities for developing transferable skill(s)	• Research • Communication • Problem-solving
Resources required for this unit	Access to: • a science laboratory • equipment such as Petri dishes, McCartney bottles and media • microorganisms • an autoclave • an incubator • microscopes and a haemocytometer • online facilities for research.
Applied context	The biotechnology industry employ scientists and technicians to carry out research, product development and scientific testing which requires knowledge and understanding of microbiology and the associated practical techniques.
Synoptic assessment and learning	Learners will carry out practical investigation that draws together the knowledge and understanding developed in Unit 1 and the skills demonstrated in Units 2 and 5.

Aim and purpose

The aim of this unit is to develop learners' knowledge and understanding of key microbiological concepts and techniques used when working in biotechnological industries.

Unit introduction

Microorganisms are vitally important in the modern world we live in. In natural habitats, microorganisms play a crucial role in the decomposition of organic matter and the recycling of nutrients. In traditional biotechnological industries, such as brewing and cheese production, microorganisms have been exploited for many years. More recent beneficial uses include their involvement in the production of novel food products, enzymes, pharmaceuticals and in genetic engineering.

Microorganisms also cause disease and are responsible for millions of deaths every year, despite ongoing advances in medicines and healthcare.

The roles of microbiologists in industry are varied but there are fundamental concepts and techniques underpinning all these different roles.

Contextual setting

For internal assessment, AQA has produced model assignments for each unit. However, centres are permitted to modify the assignment within specified parameters. This will allow centres to tailor the assessment to local needs. The model assignment has been written to ensure the following controls are in place:

- each unit is assessed through one or more assignments
- each assignment must have a brief that sets out an applied purpose. An applied purpose is a reason for completing the tasks that would benefit society, a community, organisation or company. Further details are in the statement of purpose in Section 3.6
- the assignments should show how the assessment requirements all contribute to the achievement of the applied purpose of the assignment
- the assignments must provide each learner with the opportunity to address all grading criteria requirements
- the assignments must indicate the acceptable forms of evidence. These must conform to those forms set out in the model assignments
- where a centre has adapted the model assignments, there must be evidence of quality assuring its fitness for purpose and this must be provided in writing to AQA.

Performance outcomes

Learners will:

Performance outcome 1:	Identify the main groups of microorganisms in terms of their structure.
Performance outcome 2:	Use aseptic techniques to safely cultivate microorganisms.
Performance outcome 3:	Use practical techniques to investigate factors that affect the growth of microorganisms.
Performance outcome 4:	Identify the use of microorganisms in biotechnological industries.

Unit content

The main groups of microorganisms in terms of their structure and function

In completing investigations, learners will develop their knowledge and understanding of the following concepts:

- characteristic structural features of:
  - akaryotes
  - prokaryotes
  - eukaryotes
- structural features of akaryotes, prokaryotes and eukaryotes related to their function
- identification of microorganisms using:
  - Gram staining
  - microscopy
  - colony characteristics
- relating techniques used to identify microorganisms to their structure
- identification techniques used in biotechnological industries.

Using aseptic techniques to safely cultivate microorganisms

In completing investigations, learners will develop their knowledge and understanding of the following concepts:

- preparation of sterile growth media for use in cultivating microorganisms
- importance of risk assessments in the safe cultivation of microorganisms
- appropriate aseptic techniques used to cultivate a range of microorganisms, including safe disposal of
- microorganisms and equipment
- inoculation of media using techniques including:
  - streak plates
  - lawn plates
  - pour plates
  - mycelial discs
  - viral plaque counts.

Using practical techniques to investigate factors that affect the growth of microorganisms

In completing investigations, learners will develop their knowledge and understanding of the following concepts:

- factors affecting the growth of microorganisms, such as:
  - temperature
  - pH
  - aerobic and anaerobic conditions
  - antibiotics
  - antivirals
  - disinfection
  - sterilisation
  - irradiation
  - osmotic potential
  - other antimicrobials such as toothpaste, mouthwash or plant derivatives such as lavender oil
- determine how factors affect growth, using counting and measuring techniques such as:
  - viable counts of colonies on plates
  - a haemocytometer to count directly
  - a colorimeter to count indirectly
  - serial dilution
  - measurement of clear zones
  - viral plaque assay.

The use of microorganisms in biotechnological industries

In completing investigations, learners will develop their knowledge and understanding of the following concepts:

- use of a range of microorganisms in biotechnological industries
- the main features of an industrial fermenter (bioreactor)
- the use of industrial fermenters in biotechnological industries
- industrial processes and techniques such as:
  - batch and continuous processing
  - microbial fermentation
  - immobilisation of enzymes
  - genetic engineering
  - biodegradation
- the use of microorganisms in a range of biotechnological industries, such as:
  - food production
  - environmental health
  - pharmaceuticals
  - forensic science
  - agriculture
  - alternative energies
  - waste water treatment.

Grading criteria

Performance outcomes	Pass	Merit	Distinction
	To achieve a pass the learner must evidence that they can:	**In addition to the pass criteria, to achieve a merit the learner must evidence that they can:**	**In addition to fulfilling the pass and merit criteria, to achieve a distinction the learner must evidence that they can:**
PO1 **Identify the main groups of microorganisms in terms of their structure**	**P1** Describe akaryotes, prokaryotes and eukaryotes in terms of their characteristic features (ultrastructure). **P2** Describe techniques used to identify microorganisms. **P3** Use Gram staining techniques to identify microorganisms.	**M1** Relate the characteristic features of akaryotes, prokaryotes and eukaryotes to their function. **M2** Explain how techniques used to identify microorganisms relate to the structure of the microorganisms.	**D1** Compare the use of different identification techniques in biotechnological industries.
PO2 **Use aseptic techniques to safely cultivate microorganisms**	**P4** Prepare risk assessments for the safe cultivation of microorganisms. **P5** Cultivate microorganisms using **three** different cultivation techniques. Use aseptic techniques.	**M3** Explain the control measures taken to ensure the safe cultivation of microorganisms. **M4** Explain the principles underlying the cultivation techniques used.	**D2** Evaluate the effectiveness of the aseptic and cultivation techniques used and make justified suggestions for improvement.

Performance outcomes	Pass	Merit	Distinction
	To achieve a pass the learner must evidence that they can:	**In addition to the pass criteria, to achieve a merit the learner must evidence that they can:**	**In addition to fulfilling the pass and merit criteria, to achieve a distinction the learner must evidence that they can:**
PO3 **Use practical techniques to investigate the factors that affect the growth of microorganisms**	**P6** Describe a range of factors that affect the growth of microorganisms. **P7** Use **one** suitable technique to count/measure microorganisms. **P8** Use serial dilution techniques in **one** practical activity.	**M5** Perform practical activities to investigate **three** factors that affect the growth of microorganisms. **M6** Explain the use of the technique used and perform appropriate calculations. **M7** Perform calculations to identify numbers of microorganisms in the original sample.	**D3** Draw conclusions about how the **three** factors affect the growth of microorganisms. **D4** Evaluate the effectiveness of the measuring and counting techniques used and make justified suggestions for improvement.
PO4 **Identify the use of microorganisms in biotechnological industries**	**P9** Describe the main features of continuous and batch processes in biotechnological industry. **P10** Describe the use of named microorganisms and the relevant industrial processes or techniques used in **two** different biotechnological industries.	**M8** Explain the benefits of an industrial fermenter. **M9** Explain the benefits to society of the use of microorganisms in the biotechnological industries described.	**D5** Compare the relevant industrial processes or techniques used for **two** named microorganisms in specific biotechnological industries. **D6** Evaluate the use of genetic engineering of microorganisms in **one** biotechnological industry.
Total criteria for each grade	10	15	20

Assessment amplification

The following section contains guidance for centres on the unit grading criteria. This guidance is only provided where we feel that the criteria require amplification of what is specifically required or exemplification of the responses learners are expected to provide.

Where guidance hasn't been provided, it is felt that the grading criteria have been written in sufficient detail so that centres can fully understand the requirements of the assessment.

For any of the descriptions and explanations, such as **P1/M1** and **P2/M2/D2**, learners are expected to produce written reports which may take the form of Word documents, posters, leaflets, magazine articles or PowerPoint presentations. It would be good to see a variety of different reports in each learner's unit portfolio.

For each criterion which asks learners to use techniques (**P3**, **P5**, **M5**, **P7** and **P8**), there should be evidence of the techniques being used correctly by the learner. This should be an observation statement completed by the assessor, perhaps accompanied by video or photographic evidence.

PO1 Identify the main groups of microorganisms in terms of their structure

For **P1** and **M1**, the characteristic features found in eukaryotes (nucleus, cell membrane etc), prokaryotes (plasmid, slime coat etc) and akaryotes (capsid and envelope etc).

PO2 Use aseptic techniques to safely cultivate microorganisms

For **P4**, learners should complete risk assessments; it is recommended that they use a template which has headings such as 'equipment', 'hazard', 'risk', 'precautions' and 'emergency measures'. This will enable them to demonstrate that they understand the difference between hazard and risk. Most educational establishments are likely to have suitable 'in house' templates.

For **M3**, learners can include the explanations in their risk assessment template, produce a further template or present their explanations in a Word document.

Guided learning hours breakdown

	PO1	PO2	PO3	PO4	Total
Delivery time (hours)	9	15	15	8	47
Assessment time (hours)	3	3	5	2	13
Total	12	18	20	10	60

Delivery guidance

It is expected that portfolios will be individual to each learner and clearly not centre-led or -directed (including reliance on VLE or similar sources). The choice of format is the learner's. One or two page summaries should demonstrate all the descriptions and explanations required by the Unit content, presented clearly and with appropriate referencing.

The emphasis is on content, and the learner's ability to summarise information in their own style. Posters are an acceptable format (and portfolios could include clear photographic representations of suitable size and clarity) as are copies of slides from a PowerPoint presentation or an aide-memoire in, say, short booklet form. Whichever format is selected, it is essential that the content demonstrates detailed knowledge and understanding of the unit content.

PO1 Identify the main groups of microorganisms in terms of their structure

Learners will use appropriate research techniques to investigate the characteristic features of akaryotes (viruses), prokaryotes (bacteria) and eukaryotes (fungi) in terms of component parts and/or cell components. They could produce tables showing these features and include the functions of each feature within the type of organism.

Learners will then undertake a practical activity to identify different types of bacteria using Gram staining, before researching how the differences in structure of different types of bacteria enable them to be identified using the Gram staining technique.

They will research the use of other identification techniques (microscopy and colony characteristics) to find out how the structure of the microorganisms enables them to be identified using these different techniques. Learners will then consider how these identification techniques are used in industry.

PO2 Use aseptic techniques to safely cultivate microorganisms

Learners will undertake practical activities to cultivate microorganisms. They will give consideration to health and safety aspects and ensure that a risk assessment is produced for each activity before starting any practical work.

Aseptic techniques should be demonstrated by the tutor beforehand and learners should have an opportunity to practise these techniques before handling any microorganisms. It would be good practice to ensure that learners prepare their own sterile media on at least one occasion.

Learners should perform three different cultivation techniques from the list given, which includes streak plate, lawn plate, pour plate, mycelial discs and viral plaque counts, and should ensure that they have used at least two different types of microorganism (eg bacteria and fungi).

Whilst it is possible to combine the practical activities in Performance outcome 2 with those in Performance outcome 3, it is preferable that learners have the opportunity to practise these cultivation techniques in Performance outcome 2 alone first.

A suggested example which meets the practical requirements for Performance outcome 2 might be:

- learners prepare their own sterile media for a pour plate experiment using yeast
- learners prepare a lawn plate using bacteria
- learners prepare a steak plate using bacteria.

Aseptic techniques must be followed in all three experiments and a risk assessment for each should be prepared before the experiment.

PO3 Use practical techniques to investigate the factors that affect the growth of microorganisms

Learners should be familiar with the cultivation techniques used in the Performance outcome 2, although they are able to use the same or different cultivation techniques here appropriate to the factors being investigated. A range of cultivation techniques should be used.

Learners should investigate three different factors that promote or inhibit growth from the list, including temperature, pH, nutrients, aerobic/anaerobic conditions, antibiotics, antivirals, disinfection, sterilisation, irradiation, osmotic potential and antimicrobials such as toothpaste or mouthwash. Learners should use a range of counting or measuring techniques including viable counts and measurement of clear zones.

Learners will then use a haemocytometer (or other suitable technique) and a light microscope to perform a total count of a microorganism such as yeast. Learners should ensure that one of the practical activities completed in Performance outcome 3 includes performing a serial dilution, either as part of investigating one of the three factors or as an additional activity. Research should be done to find out about the use of a haemocytometer and serial dilution techniques and calculations should be performed to establish numbers of microorganisms in the original samples used in the haemocytometer and serial dilution activities. In order to achieve the distinction criterion, learners should evaluate the effectiveness of the techniques used to count or measure microorganisms.

A suggested example which meets all the practical requirements for Performance outcome 3 might be:

- learners prepare lawn plates of bacteria using nutrient agar and place antibiotic discs on the plates
- the clear zones around the antibiotic discs can be measured after incubation for 48 hours
- learners use yeast and pour plates with malt agar to investigate the effect of temperature on growth by placing plates in areas such as the incubator, room temperature, the fridge, a cool place; viable counts (of visible colonies) can be made from the plates after 48 hours
- learners use serial dilutions and lawn plates to investigate numbers of microorganisms in a set of original cultures of bacteria that have been prepared at different pH values
- learners use a haemocytometer to count yeast cells under the light microscope; a total count should include numbers of both viable and non-viable microorganisms.

PO4 Identify the use of microorganisms in biotechnological industries

Learners will undertake some independent research to find out about the use of continuous and batch processing and industrial fermenters in biotechnological industries. They will also investigate the use of named microorganisms and processes in two different biotechnological industries. Learners should consider the benefits to society of the use of these microorganisms. Learners should research the use of genetic engineering of microorganisms in a further biotechnological industry.

Synoptic assessment

Performance outcome	Links to other units
PO1 Identify the main groups of microorganisms in terms of their structure	**Unit 1 Key concepts in science** AO1(a) Cell structure
PO2 Use aseptic techniques to safely cultivate microorganisms	**Unit 2 Applied experimental techniques** PO4 Understand safety procedure and risk assessment when undertaking scientific practical work
PO3 Use practical techniques to investigate factors that affect the growth of microorganisms	**Unit 1 Key concepts in science** AO1(a) Cell structure **Unit 2 Applied experimental techniques** PO1(a) Rate of respiration **Unit 2 Applied experimental techniques** PO4 Understand safety procedure and risk assessment when undertaking scientific practical work **Unit 5 Investigating science** PO2 Carry out the investigation and record results PO3 Analyse results, draw conclusions and evaluate the investigation
PO4 Identify the use of microorganisms in biotechnological industries	**Unit 2 Applied experimental techniques** PO4 Understand safety procedure and risk assessment when undertaking scientific practical work.

This unit would logically be taught after Units 1 and 2 and could be concurrently taught with the Unit 5.

The amplification below identifies assessment and where learning from other units can be assessed within this unit.

PO1 Identify the main group of microorganisms in terms of their structure

Learners will be able to build on their knowledge of cell structure and functions from Unit 1 when exploring the structures of different microorganisms using identification techniques such as Gram staining and microscopy.

PO2 Use aseptic techniques to safely cultivate microorganisms

Learners will be able to build on their knowledge, understanding and practical skills (particularly safety procedures and risk assessments) from Unit 2, and investigative techniques and recording of data from Unit 5.

PO3 Use practical techniques to investigate factors that affect the growth of microorganisms

The investigative and analytical techniques used here build on previously gained knowledge of cell structure from Unit 1, different factors affecting rate of respiration in Unit 2 and use of safety procedures including risk assessments from Unit 2. Knowledge and skills gained from Unit 5 on carrying out investigations, recording and analysing results to draw conclusions and evaluate the investigations when assessing factors affecting the growth of microorganisms.

P04 Identify the use of microorganisms in biotechnological industries

When considering the use of microorganisms in different industries, learners should be able to build on their knowledge of role and responsibilities that science personnel carry out in the science industry. from Unit 3.

Resources

Basic microbiological equipment is required, including plastic Petri dishes, nutrient agar, glass spreaders, inoculating loops, and appropriate microorganisms such as E. coli, B. subtilis and M. luteus.

An autoclave, oil immersion microscopes and incubator are also required. Binocular microscopes are useful for looking at colony characteristics.

Useful links and publications

- Society for General Microbiology
  sgm.ac.uk
- Microbiology resources for teachers and learners from the Society for General Microbiology
  microbiologyonline.org.uk
- Society for Applied Microbiology
  sfam.org.uk

11.7 Unit 6b: Medical physics

Title	Medical physics
Unit type	Optional
Unit assessment type	Internally assessed
Assessment method	Practical assignment
Guided learning hours	60 guided learning hours
Opportunities for developing transferable skill(s)	• Research • Communication • Problem-solving
Resources required for this unit	• Equipment to measure half-life and penetration of radioisotopes. • Equipment to measure the refractive index of glass or Perspex.
Applied context	Many professionals working in medicine need to have an understanding of physics and its applications when using diagnostic and therapeutic equipment and techniques.
Synoptic assessment and learning	Learners will carry out practical investigation that draws together the knowledge and understanding developed in Unit 1 and the skills demonstrated in Units 2 and 5.
Endorsement	The practical work required to be undertaken by learners has been safety checked by, but not trialled by, CLEAPPS. CLEAPSS

AQA acknowledges the guidance provided by the Royal College of Radiologists rcr.ac.uk in the development of this unit.

Aim and purpose

This unit is designed to give learners an understanding of some of the key areas in modern medical physics. It will allow them to look at the scientific basis for modern diagnostic and therapeutic techniques and evaluate the advantages and disadvantages of a range of methods of diagnosing and/or treating different conditions.

Unit introduction

Healthcare professionals use a variety of techniques to assess and monitor the health of patients. They need to consider the use to which radiation is to be put before deciding on the most appropriate type of radiation to use, the dosage and how it is to be applied.

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

This unit will provide learners with an understanding of some key aspects of medical physics and how physics forms the basis of the technology which can be used in the diagnosis and treatment of illness.

They will consider the principles involved in a range of equipment used for diagnosis and treatment, and how these principles are used to provide modern healthcare technology.

They will learn about different diagnostic techniques and different types of therapy. They will also learn about the nature and application of radioactivity, X-rays, thermography, magnetic resonance, ultrasound, endoscopy and lasers. The unit requires learners to understand the physics of these areas and be able to perform calculations relevant to their use.

Learners will perform specific experiments with radioisotopes and light, safely and to a high standard. They will apply their knowledge to a range of situations and make judgements as to which techniques are appropriate in specific situations.

Contextual setting

For internal assessment, AQA has produced model assignments for each unit. However, centres are permitted to modify the assignment within specified parameters. This will allow centres to tailor the assessment to local needs. The model assignment has been written to ensure the following controls are in place:

- each unit is assessed through one or more assignments
- each assignment must have a brief that sets out an applied purpose. An applied purpose is a reason for completing the tasks that would benefit society, a community, organisation or company. Further details are in the Statement of purpose in Section 3.6
- the assignments should show how the assessment requirements all contribute to the achievement of the applied purpose of the assignment
- the assignments must provide each learner with the opportunity to address all grading criteria requirements
- the assignments must indicate the acceptable forms of evidence. These must conform to those forms set out in the model assignments
- where a centre has adapted the model assignments, there must be evidence of quality assuring its fitness for purpose and this must be provided in writing to AQA.

Performance outcomes

Learners will:

Performance outcome 1:	Understand imaging methods.
Performance outcome 2:	Understand radiotherapy techniques and the use of radioactive tracers.
Performance outcome 3:	Demonstrate the ability to work with radioisotopes in the laboratory.
Performance outcome 4:	Understand the medical uses of optical fibres and lasers.

Unit content

Imaging methods

In completing investigations, learners will develop their knowledge and understanding of the following concepts:

- the science behind imaging methods, including relevant calculations, and their appropriateness in
- identifying particular medical conditions, for:
  - traditional X-rays
    - the nature and properties of X-rays
    - how X-rays and X-ray images are produced
    - why X-rays are suitable for imaging some organs but not others
    - the precautions to be taken when using X-rays for diagnosis and/or therapy
  - CAT scans
    - how CAT scans are produced, including how 3D images are produced
  - X-ray digital imaging
    - how digital X-ray images are formed
  - PET scans
  - MRI scans
    - how MRI scans work in terms of interaction between magnetic fields and radio waves
    - the limitations of the use of MRI scans
  - ultrasound
    - the nature of ultrasound
    - how ultrasound images are produced
    - why ultrasound is suitable for imaging some organs but not others
    - why coupling agents are used and how they work
  - thermography
- the use of filters and contrast media
- the dangers of ionising radiation including exposure to X-rays
- factors affecting the dose of ionising radiation received by a patient
- the nature of radio waves, infrared waves, light waves and X-rays
- how the properties relate to their photon energy, frequency and wavelength for electromagnetic waves and ultrasound waves
- calculations of the reflection coefficient between two media and its implication
- Use of $v = f\lambda$ to calculate wave velocity, frequency and wavelength.

Radiotherapy techniques and the use of radioactive tracers

In completing investigations, learners will develop their knowledge and understanding of the following concepts:

- the use of radioisotopes in diagnosis and therapy
- how some radioisotopes have properties that make them more suitable for therapy than for diagnosis
- how some radioisotopes have properties that make them more suitable to use as tracers for diagnosis
- than for therapy
- different types of radiotherapy including:
  - implants
  - external therapy
    - radioisotopes
    - gamma radiation
    - proton beam therapy
    - X-rays
  - how the therapy is administered
  - how appropriate the technique is for treating diseases
  - properties of the radioisotope used
- how radioisotopes can be used as tracers
- the dangers of using X-rays and radioisotopes and the precautions taken to protect both medical
- professionals and patients
- the meaning of the terms stochastic, non-stochastic, somatic and hereditary
- the effects of ionising radiation
- how the choice of radioisotope for a particular application depends on the properties of the radioisotope, considering the factors below:
  - organ affinity
  - toxicity
  - type of radiation
  - half-life of radioisotope
  - effectiveness of radioisotope
  - ability to cause minimal damage
- the nature and properties of alpha, beta and gamma radiation
- the concept of half-life
- reasons for the widespread use of technetium-99m
- factors affecting the dose received and calculation of dose equivalent
- how medical applications of X-rays and radioisotopes are invasive to varying degrees.

Working with radioisotopes in the laboratory

In completing investigations, learners will develop their knowledge and understanding of the following concepts:

- Properties of a range of radioisotopes.
- Determination of the half-life of a radioisotope in the laboratory.
- Comparing the penetration of alpha, beta and gamma radiation.
- Precautions that have to be taken to ensure safety when working with radioisotopes in the school or college laboratory.
- Nature and properties of alpha, beta and gamma radiation.
- Use of a Geiger counter for detecting appropriate radiation.
- The meaning and importance of background radiation and how to measure it.
- Precautions to be taken when using radioisotopes in the school laboratory and how these relate to the properties of the radiation used.
- Calculation of effective half-life.

The medical uses of optical fibres and lasers

In completing investigations, learners will develop their knowledge and understanding of the following concepts:

- The structure of optical fibres.
- How optical fibres transmit light.
- The importance of using glass with an appropriate critical angle and refractive index.
- Determination of the refractive index and critical angle of a sample of glass or Perspex.
- Optical fibres used in medical treatments.
- Laser light used in medical treatments.
- How laser light can be used with and without optical fibres during surgery.
- Total internal reflection.
- Refractive index and critical angle and the relationship between them.
- Calculating the refractive index and critical angle for a sample of glass or Perspex using:
  - $n = \sin i / \sin r$
  - $n = 1/\sin c$
- Why endoscopes use glass with a high refractive index.
- Why cladding is used and how the refractive index of the cladding relates to the refractive index of the core.
- Measuring the refractive index and critical angle for a sample of glass or Perspex.

Grading criteria

Performance outcomes	Pass	Merit	Distinction
	To achieve a pass the learner must evidence that they can:	**In addition to the pass criteria, to achieve a merit the learner must evidence that they can:**	**In addition to fulfilling the pass and merit criteria, to achieve a distinction the learner must evidence that they can:**
PO1 **Understand imaging methods**	**P1** Describe the underlying theory behind **two** of the imaging methods listed.	**M1** Link the underlying theory behind both of the imaging methods to explain how the images are produced.	**D1** For both methods, use calculations to support descriptions of the underlying theory.
	P2 Select **one** medical condition and identify a suitable and an unsuitable technique for investigating the condition.	**M2** Explain why the selected technique is suitable and why the unsuitable technique selected is not appropriate.	
PO2 **Understand radiotherapy techniques and the use of radioactive tracers**	**P3** Describe, with the aid of diagrams, **two** radiotherapy techniques, including the disease or disorder linked with each.	**M3** Explain how each technique is used to treat specific diseases.	**D2** Discuss the invasive nature of the techniques on patients.
	P4 Identify the properties of **one** radioisotope used for a radiotherapy technique.	**M4** Explain the importance of these properties.	**D3** Provide quantitative support for the explanations.
	P5 Outline how radioisotopes can be used as tracers.	**M5** Describe the properties of **two** radioisotopes that make them suitable for use as tracers.	**D4** Source and evaluate quantitative/graphical data of the **two** radioactive tracers.
	P6 Describe the dangers of radioactivity and the precautions taken to protect medical staff and patients.	**M6** Explain the scientific principles behind the precautions.	

Performance outcomes	Pass	Merit	Distinction
	To achieve a pass the learner must evidence that they can:	**In addition to the pass criteria, to achieve a merit the learner must evidence that they can:**	**In addition to fulfilling the pass and merit criteria, to achieve a distinction the learner must evidence that they can:**
PO3 **Demonstrate the ability to work with radioisotopes in the laboratory**	**P7** Follow standard procedure to measure the half-life of **one** radioisotope.	**M7** Relate the results of the experiments to the use of radioisotopes in medical treatments.	**D5** Summarise the advantages and disadvantages of alpha, beta and gamma radioisotopes in medical treatments.
PO4 **Understand the medical uses of optical fibres and lasers**	**P8** Describe the structure of optical fibres and how they transmit light.	**M8** Explain how optical fibres are used in medical treatments.	
	P9 Follow standard procedure to measure the refractive index of a sample of glass or Perspex.		
	P10 Identify **two** medical conditions where laser light is used as a treatment.	**M9** Explain the basic scientific principles behind the use of lasers in treating both medical conditions.	**D6** Compare the advantages and disadvantages of laser and non-laser treatments for a specific medical condition.
Total criteria for each grade	10	15	20

Assessment amplification

The following section contains guidance for centres on the unit grading criteria. This guidance is only provided where we feel that the criteria require amplification of what is specifically required or exemplification of the responses learners are expected to provide.

Where guidance hasn't been provided, it is felt that the grading criteria have been written in sufficient detail so that centres can fully understand the requirements of the assessment.

PO1 Understand imaging methods

For **P1**, learners are expected to describe the physical principles behind both of the listed imaging methods and should include reference to the use of filters and contrast media and the dangers of ionising radiation, including exposure to X-rays.

For **D1**, learners should make reference to calculations of the reflection coefficient between two media and its implication, showing use of $v = f\lambda$ to calculate wave velocity, frequency and wavelength. Learners could also refer to photon energy of the different types of electromagnetic waves involved in various imaging techniques listed, linking this to the dangers of using each technique.

For **M2**, as a minimum, learners should consider both the quality of images and possible dangers to the patient when discussing suitable and unsuitable techniques.

PO2 Understand radiotherapy techniques and the use of radioactive tracers

For **P4**, learners should identify half-life and type of radiation emitted for one radioisotope, and these should be explained for **M4**.

For **P5**, learners should outline toxicity and organ affinity for two radioisotopes, and these should be described for **M5**.

To attain **D3**, suitable calculations could include the time it would take for the activity of the chosen isotopes to decay to a level that would make them unsuitable for further use, or calculations of effective half-life. Other calculations, for example photon energy for gamma rays and X-rays, could also be relevant.

For **D4**, learners need to perform calculations related to penetration power and effective half-life.

PO3 Demonstrate the ability to work with radioisotopes in the laboratory

For **P7**, learners should describe the experiment in full, including:

- list of equipment
- safety precautions taken
- relevant diagrams
- detailed method (showing attempts at fair testing and attempts at achieving accuracy, taking account of background radiation)
- results (in a suitable format)
- analysis
- conclusions.

For **M7**, other experiments could be done as a group, tutor demonstration or online.

PO4 Understand the medical uses of optical fibres and lasers

For **P8**, learners should explain the principles behind total internal reflection.

For **M8**, learners should discuss the use of cladding.

For **P10**, **M9** and **D6**, learners should ensure that the treatments identified are for medical conditions and not merely cosmetic, eg tattoo removal and wrinkle reduction.

Guided learning hours breakdown

	PO1	PO2	PO3	PO4	Total
Delivery time (hours)	15	15	9	9	48
Assessment time (hours)	3	3	3	3	12
Total	18	18	12	12	60

Delivery guidance

Learners will need to have opportunities to observe and undertake practical work. Ideally, assessed practical work should be performed individually but it is appreciated that this is unlikely to be practicable. In this case, it is acceptable for the experiments to be performed in pairs or small groups, but even if this is the case, results should be analysed and conclusions drawn on an individual basis.

There are many aspects of this unit where learners are able to demonstrate their understanding through supporting discussions and explanations with calculations, so opportunities to practise these should be provided.

PO1 Understand imaging methods

Learners will report on their research into each of the different imaging techniques listed. In order for this research to make sense, it is likely that some tutor input would be needed, particularly in relation to the nature and properties of each type of radiation involved and also in relation to relevant calculations. Learners should be taught the nature of radio waves, infrared waves, light waves and X-rays, and how the properties relate to their photon energy, frequency and wavelength for electromagnetic waves and ultrasound.

PO2 Understand radiotherapy techniques and the use of radioactive tracers

Tutors are likely to need to support learners' understanding by explaining, in particular, the nature of radioactivity and X-rays, the difference between gamma radiation and X-rays and the meaning of half-life, and through practising relevant calculations. Without this understanding it will be difficult for learners to explain and compare radiotherapy techniques and tracers to a sufficient degree.

PO3 Demonstrate the ability to work with radioisotopes in the laboratory

This performance outcome requires learners to perform experiments with radioactive sources themselves. It is important that suitable sources are selected, especially when attempting to measure half-life. If an isotope with too long or too short a half-life is selected then it will be very difficult for learners to achieve meaningful results. Protactinium (which can be made from uranyl nitrate) is a suitable source for half-life measurement.

Accounting for background radiation is also important when measuring half-life and comparing penetrating powers of alpha, beta and gamma radiation.

It is important that appropriate safety precautions are taken at all times when using radioisotopes. Tutors will need to ensure that learners are aware of these precautions before they use the radioactive sources.

PO4 Understand the medical uses of optical fibres and lasers

This performance outcome requires a good understanding of total internal reflection and the conditions necessary for this to occur. Learners should perform experiments that show light totally internally reflecting to consolidate their understanding of critical angle.

Synoptic assessment

Performance outcome	Links to other units
PO1 Understand imaging methods	**Unit 4 The Human Body** AO1–4
PO2 Understand radiotherapy techniques and the use of radioactive tracers	**Unit 1 Key concepts in science** AO2(a) Atomic structure
PO3 Demonstrate the ability to work with radioisotopes in the laboratory	**Unit 1 Key concepts in science** AO2(a) Atomic structure **Unit 2 Applied experimental techniques** PO4 Understand safe procedure and risk assessment when undertaking scientific practical work **Unit 5 Investigating science** PO2 Carry out the investigation and record results PO3 Analyse results, draw conclusions and evaluate the investigation
PO4 Understand the medical uses of optical fibres and lasers	**Unit 4 The Human Body** AO1–4 **Unit 3** AO4 Understand the roles and responsibilities that science personnel carry out in the science industry

This unit would logically be taught after Units 1 and 2 and could be concurrently taught with the Unit 5.

The amplification below identifies assessment and where learning from other units can be assessed within this unit.

PO1 Understand imaging methods

PO4 Understand the medical uses of optical fibres and lasers

When considering different imaging methods and medical uses of optical fibres and lasers, learners will be able to build on their knowledge of body systems from Unit 4, especially on damage to the brain and nervous system.

PO2 Understand radiotherapy techniques and the use of radioactive tracers

Learners will build on their knowledge and understanding of the Periodic Table, atomic structure and isotopes from Unit 1 when considering the use of radioactive tracers.

PO3 Demonstrate the ability to work with radioisotopes in the laboratory

When conducting the practical experiment on measuring half-life of radioisotopes, learners will be able to build on their knowledge, understanding and practical skills (particularly safety procedures and risk assessments) from Unit 2, and investigative techniques and recording of data from Unit 5.

Resources

Equipment to measure half-life and penetration of radioisotopes, including:

- radioisotopes (alpha, beta and gamma emitters)
- Geiger counter or other suitable radiation detector
- appropriate materials to use to compare penetration of alpha, beta and gamma radiation (eg lead and aluminium shields).

Equipment to measure the refractive index of glass or Perspex, including:

- glass or Perspex semicircular and rectangular blocks
- ray lamp and accessories.

Useful links and publications

- CLEAPSS resource on managing ionising radiations and radioactive substances in schools and colleges
  science.cleapss.org.uk/Resource-Info/L093-Managing-Ionising-Radiations-and-Radioactive-Substances-in-Schools-and-Colleges.aspx
- Resources from the National Stem Centre
  nationalstemcentre.org.uk/elibrary/collection/565/teaching-medical-physics
- Resources for teachers and learners from the TES website
  tes.co.uk/teaching-resource/medical-physics-powerpoint-6255709
  tes.co.uk/teaching-resource/ultrasound-powerpoint-6255710
  tes.co.uk/teaching-resource/p6-radioactive-materials-medical-uses-6241979
  tes.co.uk/teaching-resource/radiotherapy-pub-quiz-6452498
  tes.co.uk/teaching-resource/ultrasound-and-magnetic-resonance-imaging-6255885
- Information and resources from the Institute of Physics
  iop.org/education/teacher/resources/teaching-medical-physics/page_54690.html
- Free medical physics e-books to download
  freebookcentre.net/Physics/Medical-Physics-Books.html
- How to become an ultrasound technician
  money.howstuffworks.com/how-to-become-an-ultrasound-technician.htm
- Muncaster, R. *Medical Physics* (1996) (ISBN: 9780748723249).
- Crundell, M and Proctor, K. *Advanced Physics Readers: Medical Physics* (2003) (ISBN: 9780719585913).
- Many hospitals have information booklets that provide basic information on how diagnostic and therapeutic techniques work.

PO1 Understand imaging methods

- Many helpful links on the use of X-rays nlm.nih.gov/medlineplus/xrays.html
- Description of scintillation detectors
  radiationanswers.org/radiation-introduction/detecting-measuring/scintillation.html
- Information on gamma cameras and technetium-99m, from the Institute of Physics
  iop.org/education/teacher/resources/teaching-medical-physics/gamma/page_54689.html
- Imaging using X-rays – a resource for patients
  medicalradiation.com/types-of-medical-imaging/imaging-using-x-rays
- Explanation of different types of scans, from Alliance Medical
  alliancemedical.co.uk/what-we-do/patient-services/types-of-scan
- The history of the use of X-rays for diagnosis and therapy
  sciencemuseum.org.uk/broughttolife/techniques/xrays.aspx

PO2 Understand radiotherapy techniques and the use of radioactive tracers

- Information on technetium-99m generators
  wordpress.mrreid.org/2012/01/15/technetium-99m-generators
- The history of radiation therapy
  healthsciences.ucsd.edu/som/radiation-medicine/about/Pages/history-radiation-therapy.aspx
- Information on radionuclide therapies in oncology
  snm.org/docs/mwm13/Presentations/Thursday/Novel%20Radionuclide%20Therapies%20-%20Erik%20Mittra.pdf
- Extensive information on radioisotopes in medicine
  world-nuclear.org/info/Non-Power-Nuclear-Applications/Radioisotopes/Radioisotopes-in-Medicine

PO3 Demonstrate the ability to work with radioisotopes in the laboratory

- Information on radioisotope half-life
  nde-ed.org/EducationResources/HighSchool/Radiography/halflife2.htm
- Advice on ionising radiation from the Health and Safety Executive
  hse.gov.uk/radiation/ionising

PO4 Understand the medical uses of optical fibres and lasers

- Activities based around the science of light optics4kids.org/home

11.8 Unit 6c: Organic chemistry

Title	Organic chemistry
Unit type	Optional
Unit assessment type	Internally assessed
Assessment method	Practical assignment
Guided learning hours	60 guided learning hours
Opportunities for developing transferable skill(s)	• Research • Communication
Resources required for this unit	• A range of organic compounds and common reagents (for a typical college laboratory) • Access to fume cupboards • Laboratory glassware for preparative organic chemistry • Apparatus for melting point and boiling point determinations • Access to online spectral databases
Applied context	Learners will acquire a good understanding of the structures of functional groups and their reactions, the importance of isomerism, and the variety of practical synthetic methods that are available to preparative chemists.
Synoptic assessment and learning	Learners will carry out practical investigation that draws together the knowledge and understanding developed in Unit 1 and the skills demonstrated in Units 2 and 5.

Aim and purpose

This unit is designed to introduce learners to the importance of preparative organic chemistry in a wide range of contexts, from pharmaceuticals, dyes, flavours and fragrances, to solvents and bio-diesel. The importance of yield, rate, purity of the compound made and characterisation using spectroscopic techniques will also be established.

Learners will acquire a good understanding of the structures of functional groups and their reactions, the importance of isomerism, and the variety of practical synthetic methods that are available to preparative chemists. The importance of yield, rate, purity of the compound made and characterisation using spectroscopic techniques will also be established

Unit introduction

Many of the materials we use today are made by chemical synthesis. The majority of new compounds made today are organic, based on the element carbon, and there is a vast industry centred on the synthesis of organic molecules. In addition, many organic molecules occur naturally, and these are extracted using physical rather than chemical means.

Preparative chemists will need a firm understanding of the basic building blocks of organic compounds, functional groups, structure and isomerism. They will also require knowledge, understanding and experience of a range of laboratory skills related to practical synthetic methods, separation, purification and characterisation.

Learners will synthesise two organic compounds and in doing so will develop the following practical skills:

- following standard procedures
- applying practical techniques
- using safely a range of practical equipment and materials including hazard identification and risk assessment
- making and recording observations and measurements
- researching, referencing sources and producing reports (including evaluation of results and practical methodologies).

Contextual setting

For internal assessment, AQA has produced model assignments for each unit. However, centres are permitted to modify the assignment within specified parameters. This will allow centres to tailor the assessment to local needs. The model assignment has been written to ensure the following controls are in place:

- each unit is assessed through one or more assignments
- each assignment must have a brief that sets out an applied purpose. An applied purpose is a reason for completing the tasks that would benefit society, a community, organisation or company. Further details are in the Statement of purpose in Section 3.6
- the assignments should show how the assessment requirements all contribute to the achievement of the applied purpose of the assignment
- the assignments must provide each learner with the opportunity to address all grading criteria requirements
- the assignments must indicate the acceptable forms of evidence. These must conform to those forms set out in the model assignments
- where a centre has adapted the model assignments, there must be evidence of quality assuring its fitness for purpose and this must be provided in writing to AQA.

Performance outcomes

Learners will:

Performance outcome 1:	Identify molecular structure, functional groups and isomerism.
Performance outcome 2:	Understand reactions of functional groups.
Performance outcome 3:	Prepare organic compounds.

Unit content

Molecular structure, functional groups and isomerism

Organic compounds are based on the element carbon which is unique in its ability to form extensive chains and ring-based structures. Multiple bonding and incorporation of hetero-atoms, primarily oxygen and nitrogen, add to the range and types of compounds formed. Organic chemists must understand how a wide range of functional groups can exist and be able to identify these and predict their properties and reactions. Identification of organic compounds can be achieved via qualitative analysis and spectroscopy.

The range of organic compounds used or met in everyday situations is vast, and includes flavours and fragrances, pharmaceuticals, biofuels, terpenes and their derivatives, fats, liquid crystals and polymers.

Isomerism is a key property of organic compounds and leads to a wide range of compounds with the same formula, but with often widely different properties. Of particular importance is the preponderance of optically active compounds in biochemical and living systems from enzymes to proteins, sugars, oils, and the need for many pharmaceuticals to be synthesised in enantiopure form.

In completing investigations, learners will develop their knowledge and understanding of the following concepts:

- carbon's ability to form strong C-C bonds and multiple bonds based on:
  - small atomic size
  - short bond length
  - high mean bond enthalpy
- carbon's ability to catenate and to make multiple bonds
- the terms aliphatic, alicyclic, aromatic, arene, saturated and unsaturated, with reference to a range of examples
- how spectra are obtained and the science behind this
- assigning peaks
- spectroscopic techniques, eg nuclear magnetic resonance (NMR), mass spectroscopy (MS), infrared (IR), and how they support the characterisation of compounds, including structure and purity
- the structures of the functional groups:
  - alcohol (1°, 2°, 3°)
  - aldehyde
  - ketone
  - alkene
  - halogen
  - carboxylic acid
  - amine (1°)
  - amide
  - benzene ring
  - phenol
- compounds with industrial or commercial use, such as flavours, fragrances, lipids, pharmaceuticals, liquid crystals, terpenes, diesel fuels including bio-diesel, etc
- International Union of Pure and Applied Chemistry (IUPAC) nomenclature for the specified range of functional groups limited to aliphatic compounds up to a maximum chain length C_6

Molecular structure, functional groups and isomerism

- structural (displayed) formulas for named compounds up to C6 containing the specified functional groups
- interpretation of skeletal formulas
- how a large number of organic compounds can exist in isomeric forms, including a consideration of molecular shapes
- the terms structural isomerism and stereoisomerism
- isomers:
  - chain
  - functional group
  - position
  - geometric and optical, including a consideration of molecular shapes and restricted rotation around carbon-carbon double bonds
- definitions of:
  - asymmetric carbon
  - chiral centre
  - optical activity
  - racemic mixture
- the relationship between the three-dimensional shapes of enantiomers
- the importance of stereoisomerism in biochemical systems and living organisms.

Reactions of functional groups

Synthetic organic chemistry in industry is a key part of the economy and produces many compounds for use in everyday life and in life saving medicines and pharmaceuticals. Chemists in research and chemical engineers involved in production need an extensive knowledge of the reactions of different functional groups and the reagents to use to bring about the required changes in structures. Some reactions will also find use in the qualitative analysis of organic compounds and identification of functional groups present.

In completing investigations, learners will develop their knowledge and understanding of the following concepts:

- types of reaction including:
  - redox
  - hydrolysis
  - esterification (condensation)
  - addition
  - elimination (eg dehydration)
  - enzyme-catalysed reaction
  - polymerisation
- the reagents used to bring about change, including:
  - acidified potassium dichromate (oxidation of alcohols, aldehydes)
  - NaOH(aq) or H_2SO_4(aq) (hydrolysis of esters)
  - alcohols with carboxylic acids or anhydrides (esterification)
  - aqueous bromine (addition across alkene double bonds)
  - concentrated sulfuric or phosphoric acid (dehydration of alcohols)
  - Fehling's (or Benedict's) and Tollens' tests (oxidation of aldehydes)
- typical conditions used to carry out each type of change
- how functional groups change in the reactions specified above and observations that accompany each of these changes.

Preparing organic compounds

In addition to knowledge relating to the reagents and conditions required to prepare new compounds, chemists and technicians involved in synthetic organic chemistry must be aware of the correct techniques to use and also be able to characterise the products of the reaction. Yield and purity are key in all the industries where these activities are carried out, for example in developing new medicines, extracting or synthesising natural products such as flavours and flavourings, making dyes, pigments, biofuels, food additives.

In completing investigations, learners will develop their knowledge and understanding of the following concepts:

- basic preparative techniques including:
  - reflux to heat volatile compounds safely and without loss of material
  - distillation to separate a volatile liquid from a mixture
  - fractional distillation
  - steam and water distillation to extract relatively volatile water-immiscible components from a natural material
- examples of preparations which use each technique, including industrial/commercial synthesis of compounds
- how reaction mixtures can be separated and products purified, including:
  - precipitation, filtration under reduced pressure, and recrystallisation
  - the use of a separating funnel for washing and separating immiscible liquids
  - final re-distillation or fractional distillation
- example of preparations which use each of these techniques including industrial/commercial
- how melting point and boiling point are criteria for purity
- how the presence of impurities may affect values of melting point and boiling point (values, range, sharpness)
- how melting and boiling points are measured
- how the choice of method for synthesis is based on:
  - yield
  - rate
  - purity of the product
  - safety
- risk assessment
- recording measurements
- calculating percentage yields
- evaluating methodology
- how infrared, NMR and mass spectra can be used to characterise the compounds prepared or extracted.

Grading criteria

Performance outcomes	Pass	Merit	Distinction
	To achieve a pass the learner must evidence that they can:	**In addition to the pass criteria, to achieve a merit the learner must evidence that they can:**	**In addition to fulfilling the pass and merit criteria, to achieve a distinction the learner must evidence that they can:**
PO1 **Identify molecular structure, functional groups and isomerism**	**P1** Outline bonding, structure, nomenclature and types of formulas for compounds and functional groups.		
	P2 Research suitable spectroscopic techniques and spectra.	**M1** Describe how infrared, NMR and mass spectra are obtained and outline the scientific principles involved.	**D1** Explain how spectra can provide specific information about structure of compounds.
	P3 Identify **one** group of compounds with a commercial or industrial use and outline their structures and uses.	**M2** For **two** compounds in the group, provide: structures, skeletal formulas and identify functional groups using correct nomenclature and scientific terminology throughout.	**D2** Explain why the structure and/or functional groups of group of compounds make them suitable for use in medical, commercial or industrial applications.
	P4 Outline the different types of structural isomerism and geometric isomerism including suitable examples of each.	**M3** Explain the different types of isomerism with detailed examples linked to discussions of structures, shapes and molecular geometry.	**D3** Provide a detailed account of **one** compound which is biologically active, explaining the benefits and/or detrimental effects of its isomers in medical, commercial or industrial applications.
	P5 Outline optical isomerism including suitable examples from compounds found in biochemical systems.	**M4** Explain the importance of stereoisomerism in biochemical systems. Provide **one** example of a compound with specific uses, effects or actions.	

Performance outcomes	Pass	Merit	Distinction
	To achieve a pass the learner must evidence that they can:	**In addition to the pass criteria, to achieve a merit the learner must evidence that they can:**	**In addition to fulfilling the pass and merit criteria, to achieve a distinction the learner must evidence that they can:**
PO2 **Understand reactions of functional groups**	**P6** Provide examples of the reactions of **five** functional groups, stating: • reagents • conditions • observations and providing equations and explanations of the changes that occur to the functional groups.	**M5** Explain how **two** of the reactions may be used as qualitative tests for functional groups.	

Performance outcomes	Pass	Merit	Distinction
	To achieve a pass the learner must evidence that they can:	**In addition to the pass criteria, to achieve a merit the learner must evidence that they can:**	**In addition to fulfilling the pass and merit criteria, to achieve a distinction the learner must evidence that they can:**
PO3 **Prepare organic compounds**	**P7** Describe standard preparative and purification techniques used in organic chemistry, with **one** example of a preparation that uses each type of technique.	**M6** Describe how melting points and boiling points are measured and give a full description of the effects of impurities on their values.	
	P8 Carry out risk assessments and use standard procedures to prepare **two** different types of organic compounds.	**M7** Justify the choice of preparative methods including reference to yield, rate and purity or any other relevant factors.	**D4** Compare the preparative methods used with those used for the industrial/ commercial synthesis of the compounds.
	P9 Calculate percentage yields for each compound made and carry out melting or boiling points to assess purity.	**M8** Compare the differences between researched literature values and experimental values for: • melting and boiling points • yield obtained.	**D5** For **one** of the compounds prepared/ extracted, choose a suitable spectroscopic technique and provide a detailed explanation of how it is used to assess purity and characterise the compound.
	P10 Produce a report on each preparation, describing the methodology, equipment used and outcomes for each.	**M9** Draw conclusions which are linked to the yields obtained and levels of purity achieved for each organic compound.	**D6** Suggest improvements to increase the yield and purity of the compounds.
Total criteria for each grade	10	15	20

Assessment amplification

The following section contains guidance for centres on the unit grading criteria. This guidance is only provided where we feel that the criteria require amplification of what is specifically required or exemplification of the responses learners are expected to provide.

Where guidance hasn't been provided, it is felt that the grading criteria have been written in sufficient detail so that centres can fully understand the requirements of the assessment.

PO1 Identify molecular structure, functional groups and isomerism

For **P1**, learners are expected to produce a concise report which may take the form of, for example, a revision guide, posters, or a PowerPoint presentation. This should cover the separate sections (i) bonding and structure and (ii) functional groups and nomenclature. Both sections should have sufficient examples to exemplify the requirements of the unit content.

For **P2**, **M1**, **D1**, learners are expected to produce a report on mass spectroscopy, infrared spectroscopy and NMR spectroscopy, briefly outlining how spectra are obtained and the underlying scientific basis for the techniques. Typical spectra should be used to enhance the explanations, peaks assigned and related to structure, and the effect of impurities in the sample mentioned.

For **P3**, learners independently select a group of compounds of commercial importance (for example flavours, fragrances, liquid crystals, biofuels, painkillers, dyes) and outline their structures (between four and six specific examples of compounds in the chosen group should be sufficient to exemplify the similarities and differences in their structures). This can then be extended in **M2** to a more detailed consideration of two compounds within this group with specific reference to their structures, skeletal formulae, and functional groups. In **D2**, this consideration of structure and functional groups is taken a stage further, with links made to why they are suitable for their specific applications (eg medicines, flavours, fragrances, liquid crystals, biofuels, dyes, etc). Note: for **D2**, a different group of compounds from that described in **P3** and **M2** may be chosen if it allows clearer links between structure and use to be established.

For **P4**, **P5**, **M3**, learners are expected to produce a concise report which may take the form of, for example, a revision guide, posters, or a PowerPoint presentation. The report should contain explanations and examples of the different types of structural isomerism and stereoisomerism found in organic chemistry. The examples for optical isomerism should be taken from molecules found in biochemical systems, for instance lactic acid, alanine, limonene. In **M3**, the explanations relating to structural and geometric isomerism should be extended to include details of molecular shapes and geometries.

For **M4**, the importance of optical isomerism in biochemical systems should include a discussion of the abundance of optically active compounds in living systems, such as amino acids, sugars, proteins and enzymes, and the idea that, often, only one enantiomer is present or biochemically active. A good report will include a range of correct scientific terminology including enantiomer, racemate, optically active, etc.

For **D3**, examples could include an enantiopure drug (eg Naproxen, Thalidomide), flavours and fragrances (eg limonene, carvone) and food additives (eg aspartame). In these cases, one enantiomer may have desired effects, but the other could cause serious side effects or have undesired properties. As the emphasis here is primarily on the interaction of isomers with biochemical systems, it would also be acceptable to choose an inorganic compound with specific biochemical activity such as cis-platin.

PO2 Understand reactions of functional groups

For **P6**, learners are expected to produce a concise report covering the reactions of five functional groups. Examples of each reaction should be included, and these can be drawn from simple aliphatic compounds to exemplify each change. The type of reaction, reagents used, conditions employed, important observations if relevant, an equation for a suitable example, correct nomenclature and correct formulae should all be evident in the report.

For **M5**, two of the reactions from **P6** should be considered in more detail and their use in the qualitative analysis of organic compounds and identification of functional groups reported. Typical examples could include the use of acidified potassium dichromate (VI), Fehlings/Tollens, aqueous bromine.

PO3 Prepare organic compounds

For **P7**, a concise report is required that exemplifies the four standard practical techniques available to synthesise or extract organic compounds and the purification techniques stipulated in the Unit content. Diagrams of the apparatus used in each case, with a short explanation are expected, together with examples of their application.

M6 is concerned with melting point and boiling point as criteria for purity and the effect on the values and their sharpness and range. This can be linked to the outcomes of the two preparations.

For **D4**, a comparison of a laboratory preparative method with that used in industry is needed. Factors which need to be considered could include, where relevant, some of: the reactions employed, the scale, batch or continuous process, the apparatus, level of automation or mechanisation, computer control, monitoring and feedback, yield, purity, and health and safety.

For **P8**, learners should apply two techniques to prepare or extract two organic compounds selected from a fragrance or flavouring, a common pharmaceutical, a dye, solvent, biofuel, etc. The assessment evidence should include the risk assessment, standard procedure (and evidence relating to yield and purity to indicate successful outcomes).

For **M7**, further reference to the % yield, the melting or boiling point, the rate of reaction and any other relevant factors should be made. These will provide evidence to support the choice of methodology employed. For one of the two compounds, a suitable spectroscopic technique should be applied using library spectra (available online). The discussion should centre on the use of the spectra to characterise the compound and how it can identify levels of impurity in the sample. The use of spectra for precursors and likely side products may also be relevant.

For **P9** and **M8**, due regard must be given to the presentation of data including correct units and precision of recording, which should also be evident in the calculations.

For **P10**, learners should produce two reports. The reports for each synthesis/extraction should include:

- the identification, including the structure, of the compound and evidence of research into possible methods for its synthesis or extraction
- a detailed procedure chosen (to include both the preparation/extraction stage and all purification stages) and justified
- a description of the type of reaction or, for an extraction, the theory behind the method)
- the identification of hazards and a full risk assessment
- tabulated data (masses, volumes as relevant, and melting points or boiling points)
- calculation of percentage yield (see **P9**).

For **M9** and **D6**, learners should evaluate the yields and purities obtained with reference to the methodologies used, and go on to suggest modifications which might improve yields or result in increased levels of purity.

Guided learning hours breakdown

	PO1	PO2	PO3	Total
Delivery time (hours)	15	5	30	50
Assessment time (hours)	3	1	6	10
Total	18	6	36	60

Delivery guidance

It is expected that portfolios will be individual to each learner and clearly not centre-led or -directed (including reliance on Virtual Learning Environment (VLE) or similar sources). The choice of format is the learner's. One or two page summaries should demonstrate all the explanations or definitions required by the Unit content, presented clearly and supplemented with appropriate examples of organic compounds and structures. Here, it is likely that structures will be derived from source material, and this is acceptable in this section if appropriate citations are included.

The emphasis is on content, and the learner's ability to summarise information in their own style. Posters are an acceptable format (and portfolios could include clear photographic representations of suitable size and clarity) as are copies of slides from a PowerPoint presentation or an aide-memoire in, say, short booklet form. Whichever format is selected, it is essential that the content demonstrates detailed knowledge and understanding of the unit content.

PO1 Identify molecular structure, functional groups and isomerism

Learners will report on their research into structures, types of compounds and functional groups present in a group of compounds commonly met in everyday life. Suitable examples could be those extracted from naturally occurring plant materials (eg limonene, linalool, citral, menthol, vanillin, etc), common over-the-counter pharmaceuticals, lipids, liquid crystals, fuels, dyes and so on.

The emphasis is on presenting clear diagrammatic structural (displayed) and skeletal formulas which can then be suitably annotated and described. It is likely that the structures will be derived from source material, but all further work demonstrating the individual name, type of compound, structures, functional groups, description, uses and applications, and basic physical properties should be original. A sufficient number to show learners' abilities will be between four and six suitably chosen examples.

In researching spectroscopic techniques, the emphasis should be on their use in the characterisation of organic compounds. Whilst the basic principles of the techniques (IR, NMR, MS) will need to be covered, and form part of the portfolio evidence, these should be kept brief, and could result from research and/or teaching. The main thrust of this section should be the interpretation of spectra (available from online databases) and the assignment of major peaks.

Learners will also report on their research into a compound which demonstrates isomerism, where the isomers have different effects or properties. The compound chosen is most likely to exhibit stereoisomerism.

PO2 Understand reactions of functional groups

Learners will most likely combine classwork and research with simple test tube level experimental work into the reactions of functional groups. There is no necessity to report on the practicals, although they will provide observations which can be later used within the summary. The emphasis is on selection of key chemical information, suitably supported with examples, formulas, structures and observations.

PO3 Prepare organic compounds

Before commencing practical work, learners should have a firm understanding of the techniques used to prepare and purify organic compounds.

Learners will synthesise two different types of compounds (or, alternatively, synthesise one compound and extract another compound from naturally occurring material) and write a detailed report. The portfolio evidence should start with a review of preparative and extraction methods commonly applied by synthetic chemists, to include reflux, distillation, fractional distillation, steam and water distillation. Types of heating, to include sand bath, water bath and heating mantle, should also be considered. The emphasis here should be on the experimental applications, and learners should be sufficiently confident with the techniques to apply them competently to the chosen synthesis/extraction.

It is clearly important that the centre should always have the final say on the syntheses to be carried out. This should reflect resources available and, of course, safety, for which the centre is ultimately responsible. Whilst the hazard identification and risk assessment by the learner should be part of the portfolio evidence, it must be checked by the centre before application, and a modified version issued if necessary. A degree of guided choice is therefore likely and acceptable in this area. It follows that some syntheses should be avoided (eg ethanol, ethanoic acid, ethanal) as they would restrict the overall levels of attainment.

It is important that the two compounds are capable of being prepared in good yield, and that full purification procedures are followed. Thin layer chromatography is one of many methods used to test for purity (eg Aspirin). This method can also be used to identify unknown chemical compounds. Where two syntheses are chosen, they should involve different types of reaction and not, say, two esterifications. It would also aid breadth of study and thus portfolio evidence of attainment if one solid and one liquid product were selected for synthesis.

Whilst the initial choice of compound may be guided, the content of the portfolio reports must reflect the research and application by each individual learner. The actual synthesis may require some degree of pair work, but larger group approaches should be avoided.

The procedures selected should be fully detailed, and justifications of methods selected should encompass the reasons for using the reagents chosen, the temperature, use of catalysts, reaction time, purity of products and safety issues, where relevant. Links between these factors and the effects on rate of reaction and yields of products should be made, and the underlying chemical reasons considered.

Synoptic assessment

Performance outcome	Links to other units
PO1 Identify molecular structure, functional groups and isomerism	**Unit 1 Key concepts in science** AO2(a) Atomic structure AO2(b) The Periodic Table AO2(d) Bonding and structure
PO2 Understand reactions of functional groups	**Unit 1 Key concepts in science** AO2(a) Atomic structure AO2(b) The Periodic Table AO2(d) Bonding and structure
PO3 Prepare organic compounds	**Unit 2 Applied experimental techniques** PO2(a) Volumetric analysis **Unit 5 Investigating science** PO2 Carry out the investigation and record results PO3 Analyse results, draw conclusions and evaluate the investigation

This unit would logically be taught after Units 1 and 2 and could be concurrently taught with the Unit 5.

The amplification below identifies assessment and where learning from other units can be assessed within this unit.

PO1 Identify molecular structure, functional groups and isomerism

PO2 Understand reactions of functional groups

When considering the research into structure, types of compounds and functional groups, including reactions, learners will be able to build on their knowledge of atomic structure, the Periodic Table and bonding and structure from Unit 1.

PO3 Prepare organic compounds

When conducting the practical experiment on preparing organic compounds, learners will be able to build on the knowledge, understanding and practical skills developed in the volumetric analysis in Unit 2, the work on safety procedures and risk assessments, also from Unit 2, and the work on investigative techniques and recording data from Unit 5.

Resources

Learners will require access to ICT facilities in order to complete the necessary research and to

produce their written reports. This should include routine access to standard software such as Word (or equivalent), PowerPoint (or equivalent), and DTP (eg Publisher), depending on the methods chosen to present the various reports required.

For practical work supporting the section on the reactions of functional groups, a range of organic compounds and common reagents (for a typical college laboratory) will be required, as will access to fume cupboards.

For work on identifying structure, functional groups and isomerism, learners should have access to molecular models.

For the two syntheses, laboratory glassware for preparative organic chemistry, including reflux, distillation, washing and separation of liquids, filtration including under vacuum, water or steam distillation, as relevant, will be required. Access to standard melting point apparatus and glassware suitable for boiling point determinations is also required. (Note that a formal boiling point determination is expected, not just a distillation range; a simple microscale determination is all that is required, but there are other recognised methods that can be used).

Learners should have access to online spectral databases, infrared absorption frequencies, chemical shifts and mass spectroscopy data.

Where possible, centres should work with employers who have laboratory facilities that could support with assessing the purity of compounds produced. Site visits may also help with understanding of commercial or industrial applications.

Useful links and publications

- Resources from the Royal Society of Chemistry, including ‘infographics’, lab experiments, ‘screen experiments’, video links (eg IR, NMR spectroscopy, hot filtration, melting point determination, distillation, vacuum filtration, and many more), tutorials, curriculum resources, downloads/handouts rsc.org
- CLEAPSS cleapss.org.uk
- Spectral Database for Organic Compounds sdbs.db.aist.go.jp/sdbs/cgi-bin/cre_index.cgi
- AQA teaching resources for organic syntheses aqa.org.uk/subjects/science/as-and-a-level/chemistry-7404-7405/teaching-resources
- AQA textbooks for AS and A-level Chemistry aqa.org.uk/resources/science/as-and-a-level/chemistry-7404-7405/teach/textbooks

12 External assessment

12.1 Introduction

Unit J/507/6497 (Key concepts in science), unit R/507/6499 (Science in the modern world) and unit A/507/6500 (The human body) are assessed via an externally set and externally marked AQA examination. Note that unit R/507/6499 (Science in the modern world) will have pre-released material available before the exam. External examinations are set and marked by AQA, and are sat by learners in a controlled examination environment, at a preset time and date.

Examinations are available for externally assessed units in January and June and entries must be made in accordance with AQA's procedures.

Further information on how to make entries for examinations can be found in the AQA *Centre Administration Guide for Technical and Vocational Qualifications*.

12.2 Examination format and structure

Unit 1: Key concepts in science

Unit title	Key concepts in science
Exam sessions	January and June
Duration	1 hour and 30 minutes
Type of exam	Written exam A mixture of multiple-choice, short-answer questions.
Number of marks	60
Weighting of unit	33.3 % of the AQA Level 3 Certificate in Applied Science 16.6 % of the AQA Level 3 Extended Certificate in Applied Science

Unit 3: Science in the modern world

Unit title	Science in the modern world
Exam sessions	January and June
Duration	1 hour and 30 minutes
Type of exam	Written exam with pre-released material A mixture of multiple-choice, short-answer and extended-answer questions.
Number of marks	60
Weighting of unit	33.3 % of the AQA Level 3 Certificate in Applied Science 16.6 % of the AQA Level 3 Extended Certificate in Applied Science

Unit 4: The human body

Unit title	The human body
Exam sessions	January and June
Duration	1 hour and 30 minutes
Type of exam	Written exam A mixture of multiple-choice, short-answer questions.
Number of marks	60
Weighting of unit	16.6 % of the AQA Level 3 Extended Certificate in Applied Science

Assessment objectives

The exams for Units 1, 3 and 4 will measure how learners have achieved the following assessment objectives.

AO1 – Demonstrate knowledge and understanding of scientific ideas, processes, techniques and procedures.

AO2 – Apply knowledge and understanding of scientific ideas, processes, techniques and procedures:

- in a theoretical context
- in a practical context
- when handling qualitative data
- when handling quantitative data.

AO3 – Analyse, interpret and evaluate scientific information, ideas and evidence, including in relation to issues, to:

- make judgements and reach conclusions
- develop and refine practical design and procedures.

The table below shows the approximate number of marks that will be allocated to each assessment objective in the examinations for Units 1, 3 and 4.

Assessment objective (AO)	Number of marks (approximate)		
	Unit 1	Unit 3	Unit 4
AO1	40	10	40
AO2	15	10	15
AO3	5	40	5
Total	**60**	**60**	**60**

12.3 Reasonable adjustments and special considerations

Information on the reasonable adjustments allowed for the external examinations within this qualification can be found in the AQA *Centre Administration Guide for Technical and Vocational Qualifications*.

12.4 Availability of past examination papers

Sample and past examination papers for this qualification are available from AQA.

13 Internal assessment and quality assurance

13.1 Overview

Unit L/507/6498 (Applied experimental techniques) of the Level 3 Certificate in Applied Science and units F/507/6501 (Investigating science), J/507/6502 (Microbiology), L/507/6503 (Medical physics) and R/507/6504 (Organic chemistry) of the Level 3 Extended Certificate in Applied Science are internally assessed by the centre.

All assessment decisions that are made internally within a centre are externally moderated by AQA.

AQA has worked with higher education institutions and professional bodies to produce guidance on what is the most appropriate form of assessment or evidence for all internal centre assessment. The most appropriate method of assessment is detailed against each unit.

Centres should tailor the assessment to suit the needs of the learner, and internal assessments can take place at a time to suit the centre or learner.

Centres should take a 'best practice' approach, with learners being assessed through real life or work-based activities to generate the required evidence.

13.2 Role of the assessor

The role of the assessor is to:

- carry out initial assessments of learners to identify their current level of skills, knowledge and understanding and any training or development needs
- mark the work presented against the requirements of the qualification, to make a judgement on the overall competence of learners
- provide feedback to learners on their performance and progress. This feedback needs to give learners a clear idea of the quality of the work produced, where more work is required and how best to do this.

13.3 Assessor qualifications and experience

In order to assess learners working towards these qualifications, assessors must:

- have appropriate knowledge, understanding and skills relevant to the units within this qualification
- have experience as a practitioner and/or within teaching and training with significant experience of creating programmes of study in relevant subject areas
- undertake activities which contribute to their continuing professional development (CPD).

13.4 Authentication of learner work

The centre must be confident that a learner's work is their own. You must inform your learners that to present material copied directly from books or other sources such as the Internet, without acknowledgement, will be regarded as deliberate deception. This also includes original ideas, as well as the actual words or artefacts produced by someone else.

Learners' work for assessment must be undertaken under conditions that allow the centre to authenticate the work. If some work is done unsupervised, then the centre must be confident that the learners' work can be authenticated with confidence, eg being sufficiently aware of an individual learner's standard and level of work to appreciate whether the evidence submitted is beyond the level of the learner.

The learner is required to sign a declaration that the work submitted for assessment is their own. The centre will also countersign this declaration that the work was carried out under any specified conditions, recording details of any additional assistance. This must be included with the learner's work for external quality assurance purposes.

Any assistance given to an individual learner beyond that given to the group as a whole, even if within the parameters of the specification, must also be recorded.

If some work is done as a part of a team, the centre must be confident that the learner's contribution to that team activity can be clearly identified and authenticated.

13.5 Tutor assistance and feedback

Whilst learners are undertaking assignment tasks, tutors must ensure that any assistance given, or offered as a result of a learner's question and/or request for help, does not compromise the learner's ability to independently perform the task in hand.

During assessment, tutors can give general feedback and support to learners, most notably on the following:

- development of the required knowledge and skills underpinning the assignment at hand
- confirmation of the assessment criteria being assessed
- clarification of the requirements of the assignment brief
- identification of assignment deadlines.

However, tutors must not assist learners directly and specifically with assignment tasks.

Tutors are not permitted to provide 'formative' feedback on learners' work, ie feedback, prior to submission for marking, on an assignment/task that will enable the learner to amend the assignment/task to improve it.

Once learner work has been submitted for marking, then tutors must give clear and constructive feedback on the criteria successfully achieved by the learner. Tutors should also provide justification and explanation of their assessment decisions. Where a learner has not passed an assignment, then feedback should not provide explicit instructions on how the learner can improve their work to achieve the outstanding criteria. This is to ensure that the learner is not assisted in the event that their work is considered for resubmission.

13.6 Research and references

Where learners are required to undertake research towards the completion of a task, they should reference their research results in a way that is informative, clear and consistent throughout their work. We do not prescribe a specific way to organise references, but we expect tutors to discuss this with learners and identify a ‘house style’ that learners are then expected to use. Learners may include a bibliography of relevant sources on larger assignments where there has been significant research and there is value in recording all sources fully.

13.7 Role of the internal quality assurer

An internal quality assurer (IQA) must be appointed to ensure the quality and consistency of assessments within the centre. Each assessor’s work must be checked and confirmed by an internal quality assurer.

The IQA must review assessment decisions from the evidence provided and hold standardisation meetings with the assessment team to ensure consistency in the use of documentation and interpretation of the qualification requirements.

All assessment decisions made within a centre must be standardised to ensure that all learners’ work has been assessed to the same standard and that assessment is fair, valid and reliable.

Evidence of all standardisation activity should be retained by the centre and could take the form of, for example, records of training or feedback provided to assessors, minutes of meetings or notes of discussions.

Internal standardisation activity may involve:

- all assessors marking trial pieces of work and identifying differences in marking standards
- discussing any differences in marking at a training meeting for all assessors
- cross-moderation of work between assessors.

13.8 Internal quality assurer qualifications and experience

In order to internally quality assure the assessment of learners working towards these qualifications, IQAs must:

- have appropriate knowledge, understanding and skills relevant to the role
- undertake activities which contribute to their continuing professional development (CPD).

13.9 Record keeping

The centre must be able to produce records that show:

- the assessor
- the evidence assessed
- the dates of assessment
- details of internal standardisation activities of the assessor (ie what, when and by whom)
- the grade awarded and the rationale for this.

14 External moderation

14.1 Overview

AQA's approach to quality assurance for this qualification is described within each unit specification.

External moderation of the Certificate and Extended Certificate is concerned with maintaining the quality of assessment and checking that the assessment process has been undertaken appropriately by centre staff.

It focuses on re-marking a selected sample of learners' work to check that centre marking has been conducted validly and reliably.

14.2 Moderation

You must send all your students' marks to us by the date given at aqa.org.uk/deadlines. You will be asked to send a sample of your students' NEA evidence to your moderator.

You must show clearly how marks have been awarded against the assessment criteria in this specification. Your comments must help the moderator see, as precisely as possible, where you think the students have met the assessment criteria. You must:

- Record your comments on the candidate record form (CRF)
- Check that the correct marks are written on the CRF and that the total is correct

The moderator re-marks a sample of the evidence and compares this with the marks you have provided to check whether any changes are needed to bring the marking in line with our agreed standards. Any changes to marks will normally keep your rank order but, where major inconsistencies are found, we reserve the right to change the rank order.

14.3 Sanctions

Sanctions are used to help process improvement and are a way of protecting the validity and reliability of assessment decisions. We will only ever impose sanctions on a centre that are proportionate to the extent of the risk identified during the moderation process. Sanctions can be applied at a learner, centre or centre staff level. They can be at qualification or centre level, and take the following form:

Level 1: Action point in *Moderator's feedback report*: a requirement to act on the moderator's findings

Level 2: Suspension of learner registration and/or certification

Level 3: Withdrawal of centre approval for a specific qualification.

It should be noted that these sanctions are not necessarily cumulative in nature and may be used in proportion to the seriousness of the issue found at moderation.

Further information on levels and application of sanctions can be found in the AQA *Centre Administration Guide for Technical and Vocational Qualifications*.

15 Resits, resubmissions and retakes

15.1 Note on terminology

Resits refer to learners taking further attempts at an examined/externally assessed unit.

Resubmissions refer to learners undertaking a second attempt at an internally assessed unit task/assignment prior to external moderation.

Retakes refer to learners undertaking a second attempt at an internally assessed unit after external moderation.

15.2 Rules on resits, resubmissions and retakes

Resits and retakes are permitted where a learner has either failed the requirements of the unit, or where they wish to improve on a grade awarded.

For certification purposes, AQA will recognise the best achievement by the learner and not the most recent.

Resitting an exam or external assessment
The learner is permitted **three** attempts (one initial and two resits) in relation to each examined/externally assessed unit of the specification.

Learners who have been awarded the Certificate qualification and have progressed to the Extended Certificate are allowed to use the resit opportunities to go back and improve the grade achieved in the external assessment. Any improvement cannot be used to upgrade and reclaim the previously awarded Certificate.

Resubmitting internal assessments
The learner is permitted **one** resubmission in relation to each internally assessed unit of the qualification, but only when the tutor believes the learner can achieve the outstanding criteria without further guidance. Any resubmission of work must be undertaken prior to external moderation.

Retaking internal assessments
The learner is permitted **one** retake in relation to each internally assessed unit of the qualification. This could mean the learner doing the entire unit work again, or simply correcting a task/assignment before the unit is again submitted for external moderation by AQA. With a retake, learners are not allowed a resubmission opportunity.

Any retake and/or resubmission of work must be completed within a defined and reasonable period of time following learner feedback of the initial assessment. Any work provided as evidence must be authenticated by the learner as their own.

16 Grading

16.1 Overview

Performance in all units is graded at Pass, Merit or Distinction. Each internally assessed and external assignment unit is worth a specific uniform mark scale (UMS) value (ie 100 UMS points) and individual unit grades represent the value of UMS points achieved in the unit. Each examination for an examined unit is worth 60 marks. Learners' individual exam mark scores are converted into UMS values in order to calculate a final grade for the qualification.

The overall Certificate and Extended Certificate qualifications are each graded: Pass, Merit, Distinction, Distinction*. The UMS points for each unit are added together and an overall grade for the qualification is determined.

16.2 Internally assessed units

Learners should seek to achieve all unit performance criteria at each of the levels of grade (ie Pass, Merit and Distinction), and tutors should ensure that learners are set tasks and activities that enable them to access this full range of the performance criteria.

Learners' work should meet the performance criteria set for the unit. The following grade boundaries are applicable to internally assessed units:

- Pass –10 criteria
- Merit – 15 criteria
- Distinction – 20 criteria

Learners are not required to achieve all the pass criteria to achieve a Pass in the unit (and the same applies for the Merit and Distinction grades). The learner's failure to achieve a pass performance criterion can be 'compensated' for, for example, by achievement of a merit performance criterion elsewhere in the unit, where the learner's achievement has been stronger.

Similarly, the learner's failure to achieve a merit performance criterion can be 'compensated' for, for example, by achievement of a distinction performance criterion elsewhere in the unit, where, again, the learner's achievement has been stronger.

However, it must be noted that learners can only be awarded a merit or distinction performance criterion where they have already achieved the corresponding pass and merit criterion. This places important limits on the extent to which learners can be compensated for any particular performance criterion at any given level.

Applying these principles, the learner will pass the unit when they have achieved 10 criteria (40 UMS points), and the same applies for the merit: 15 criteria (60 UMS points) and distinction: 20 criteria (80 UMS points). Each criteria is worth 4 UMS points.

16.3 Examined units

These units are assessed by AQA using a mark scheme offering a total of 60 marks. After the examination has taken place and been marked, the grade boundaries are set by AQA. These grade boundaries are based on the level of demand of the assessment and the performances of all learners.

When the assessment results are shared with the centre, AQA will report on the grade boundaries.

Note: these grade boundaries may change for each assessment window according to the demand of the assessment; this is important in maintaining standards across each window.

Learners' results are then converted into UMS points in order to determine overall grades for the qualification. The following UMS grade boundaries are applicable to examined units:

Pass – 40 UMS points

Merit – 60 UMS points

Distinction – 80 UMS points.

16.4 Final grade for overall qualification

Learners must achieve at least a Pass grade in each unit in order to pass the qualification (subject to the 'Near Pass' rule (see section 16.5 below). So, for example, where a learner does not achieve a Pass for Unit 1, but achieves Pass and Merit grades across all other units, the learner will not pass the overall qualification. The final grade for the overall qualification is calculated by adding together the points achieved for each unit. To achieve a Pass, Merit, Distinction or Distinction* grade, learners must obtain the minimum UMS mark for the qualification grade.

The table below identifies how the overall qualification grade is calculated.

Qualification grade	Certificate (300 UMS available)	Extended Certificate (600 UMS available)	Grade boundary as percentage of total UMS
Distinction*	270–300	540–600	90 %
Distinction	240–269	480–539	80 %
Merit	180–239	360–479	60 %
Pass	120–179	240–359	40 %

16.5 The 'Near Pass' rule

A near pass will be applied to **any unit** for those learners who may fall just short of a pass grade. To qualify as a Near Pass, the unit score must be between 30 and 39 UMS points. The unit grade will still be reported as a grade U, since the learner will not have performed to the minimum standard required for a Pass grade, but will qualify as a near pass for the purposes of determining the overall qualification grade.

A learner is allowed one Near Pass result in the Certificate and up to two Near Pass results in the Extended Certificate to qualify for an overall qualification grade.

All other eligibility requirements for achieving the qualification will remain the same:

- the total points score is above the Pass threshold; **and**
- all other units are passed

17 Administration arrangements

Full details of all of the administration arrangements relating to these qualifications can be found in the AQA *Centre Administration Guide for Technical and Vocational Qualifications*, including:

- how to apply for centre approval
- registration of learners
- dealing with recognition of prior learning (RPL)
- how to make examination entries
- dealing with missed examination dates
- examination invigilation arrangements
- how to make claims for certificates
- how to appeal against an assessment, IQA or EQA decision
- retention of learner work and assessment/IQA records
- dealing with potential malpractice or maladministration.

Details of all AQA fees can be found on the AQA website at [aqa.org.uk](aqa.org.uk)

17.1 Assessment units and entry details

Applied Science					Weighting%	
Level 3 Certificate and Extended Certificate in Applied Science						
Specification code 1775				Entry Code	Certificate	Extended Certificate
Qualification numbers: Certificate: 601/7104/2 Extended Certificate: 601/7105/4						
Qualification	Unit	Title	Assessment			
Certificate; Extended Certificate	Unit 1	Key concepts in science	External exam	ASC1	33.3	16.6
Certificate; Extended Certificate	Unit 2	Applied experimental techniques	Centre assessed	ASC2	33.3	16.6
Certificate; Extended Certificate	Unit 3	Science in the modern world	External exam (pre-release)	ASC3	33.3	16.6
Extended Certificate	Unit 4	The human body	External exam	ASC4	-	16.6
Extended Certificate	Unit 5	Investigating science	Centre assessed	ASC5	-	16.6
Extended Certificate	Unit 6A	Microbiology	Centre assessed	ASC6A	-	16.6
Extended Certificate	Unit 6B	Medical physics	Centre assessed	ASC6B	-	16.6
Extended Certificate	Unit 6C	Organic chemistry	Centre assessed	ASC6C	-	16.6
Certificate in Applied Science		ASC1 + ASC2 + ASC3		1776	-	
Extended Certificate in Applied Science		ASC1 + ASC2 + ASC3 + ASC4 + ASC5 + ASC6A or ASC6B + ASC6C		1777	-	

18 Appendix A

Unit 2: Applied experimental techniques

Witness confirmation

Name of learner:

Name of witness:	Role of witness:

Witness statement

I confirm that ____
has safely undertaken applied experimental techniques in biology, chemistry and physics in completing the following activities.

Please tick boxes to indicate those techniques that the learner has undertaken.

	Measuring the effect of different factors on rate of respiration.
	Investigating the light-dependent reaction in photosynthesis (the Hill reaction).
	Conducting a volumetric analysis.
	Conducting a colorimetric analysis.
	Measuring the resistivity of a material.
	Measuring the specific heat capacity of a material.
	I confirm that the learner has produced risk assessments for one applied experimental technique from each of biology, chemistry and physics.

You should sign and date your evidence. If the statement is not signed and dated, the witness statement is incomplete.

Signed: Date:

Once completed, this Witness confirmation should be included with the rest of the learner's assignment evidence for this unit.

19 Appendix B

Unit 5: Investigating science

Observation record

Name of learner:

Investigation title:

Name of observer:	Role of observer:

Observation statement Please record here what you observed the learner doing. Your description should be clear and should focus upon the skills and safety demonstrated in undertaking practical work as part of their scientific investigation. The Observation record will form part of the learner evidence.

You should sign and date your evidence. If the statement is not signed and dated, the witness statement is incomplete.

Signed: Date:

Once completed, this Observation record should be included with the rest of the learner's assignment evidence for this unit.

Get help and support

Visit our website for information, guidance, support and resources at aqa.org.uk/applied-general

E: tvq@aqa.org.uk

T: 0800 085 0391

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