

**Specification**

**LEVEL 3 ALTERNATIVE ACADEMIC QUALIFICATION  
CAMBRIDGE ADVANCED NATIONAL IN**

# **APPLIED SCIENCE**

**Certificate H051**

**Extended Certificate H151**

For first teaching in 2025



## Tell us what you think

Your feedback plays an important role in how we develop, market, support and resource qualifications now and into the future. Here at OCR, we want teachers and students to enjoy and get the best out of our qualifications and resources, but to do that we need honest opinions to tell us whether we're on the right track or not. That's where you come in.

You can email your thoughts to [ProductDevelopment@OCR.org.uk](mailto:ProductDevelopment@OCR.org.uk) or visit the [OCR feedback page](#) to learn more about how you can help us improve our qualifications.



Designing and testing in collaboration with teachers and students



Helping young people develop an ethical view of the world



Equality, diversity, inclusion and belonging (EDIB) are part of everything we do

## Are you using the latest version of this specification?

The latest version of our specifications will always be on our website and may differ from printed versions. We will inform centres about changes to specifications.

### Disclaimer

Specifications are updated over time. Whilst every effort is made to check all documents, there may be contradictions between published resources and the specification, therefore, please use the information on the latest specification at all times. Where changes are made to specifications these will be indicated within the document, there will be a new version number indicated, and a summary of the changes. If you do notice a discrepancy between the specification and a resource please contact us at: [resources.feedback@ocr.org.uk](mailto:resources.feedback@ocr.org.uk)

### Copyright

© 2024 OCR. All rights reserved.

OCR retains the copyright on all its publications, including the specifications. However, registered centres for OCR are permitted to copy material from this specification booklet for their own internal use.

## 1 Contents

1	Why choose OCR?	6
1.1	Our specifications	6
1.2	Our support	6
1.2.1	More help and support	7
1.3	Aims and learning outcomes	7
1.4	What are the key features of this specification?	7
1.5	Acknowledgements	8
2	Qualification overview	9
2.1	OCR Level 3 Alternative Academic Qualification Cambridge Advanced National in Applied Science (Certificate) at a glance	9
2.2	OCR Level 3 Alternative Academic Qualification Cambridge Advanced National in Applied Science (Extended Certificate) at a glance	11
2.3	Qualification structure	13
2.4	Purpose statement – Certificate	14
2.5	Purpose statement – Extended Certificate	17
3	About these qualifications	22
3.1	Qualification size	22
3.2	Availability and language	22
3.3	Prior knowledge and experience	22
4	Units	23
4.1	Guidance on unit content	23
4.1.1	Externally assessed units (F180 and F181)	23
4.1.2	NEA units (F182-F186)	24
4.1.3	Command words	24
4.1.4	Performance Objectives (POs):	24
4.2	Externally assessed units	25
4.2.1	Unit F180: Fundamentals of science	25
4.2.2	Unit F181: Science in society	54
4.3	NEA Units	64
4.3.1	Unit F182: Investigating science	64
4.3.2	Unit F183: Analytical techniques in chemistry	76
4.3.3	Unit F184: Environmental studies	86
4.3.4	Unit F185: Forensic biology	100
4.3.5	Unit F186: Medical physics	113
5	Assessment and grading	124
5.1	Overview of the assessment	124

5.2	Synoptic assessment	127
5.3	Transferable skills	127
5.4	Grading and awarding grades	128
5.5	Performance descriptors	130
6	Non examined assessment (NEA) units	132
6.1	Preparing for NEA unit delivery and assessment	132
6.1.1	Centre and teacher/assessor responsibilities	132
6.1.2	Health and safety	133
6.2	Requirements and guidance for delivering and marking the OCR-set assignments	134
6.2.1	Ways to authenticate work	137
6.2.2	Group work	137
6.2.3	Plagiarism	137
6.3	Feedback	139
6.3.1	Reporting suspected malpractice	141
6.3.2	Student and centre declarations	141
6.3.3	Generating evidence	141
6.3.4	Teacher Observation Records (TOR)	142
6.3.5	Presentation of the final piece of work	143
6.4	Assessing NEA units	143
6.4.1	Applying the assessment criteria	143
6.4.2	Annotating students' work	144
6.4.3	Internal standardisation	144
6.4.4	Reattempting work to improve the grade before submitting marks to OCR	145
6.4.5	Submitting outcomes	145
6.4.6	Resubmitting moderated work to OCR to improve the grade	145
6.5	Moderating NEA units	146
6.5.1	Sample requests	146
7	Administration	147
7.1	Assessment availability	147
7.2	Collecting evidence of student performance to ensure resilience in the qualifications system	147
7.3	Equality Act information relating to Cambridge Advanced Nationals	147
7.4	Accessibility	147
7.5	Requirements for making an entry	148
7.5.1	Making estimated unit entries	148
7.5.2	Making final unit entries	148
7.6	Certification rules	149
7.7	Unit and qualification results	149
7.8	Post-results services	149

Appendix A: Guidance for the production of electronic evidence .....	151
Structure for evidence	151
Data formats for evidence	151
Appendix B: Command Words .....	153
External assessment	153
Non examined assessment (NEA)	154
Appendix C: How Science Works Concepts and Skills .....	155
Appendix D: Mathematical skills for Applied Science .....	159
Appendix E: Units in science .....	162
Appendix F: Data, Formulae and Relationships Booklet .....	164

## 1 Why choose OCR?

Choose OCR and you've got the reassurance that you're working with one of the UK's leading exam boards. We've developed our specifications in consultation with teachers, employers, subject experts and higher education institutions (HEIs) to give students a qualification that's relevant to them and meets their needs.

We're part of Cambridge University Press & Assessment. We help millions of people worldwide unlock their potential. Our qualifications, assessments, academic publications and original research spread knowledge, spark curiosity and aid understanding around the world.

We work with a range of education providers in both the public and private sectors. These include schools, colleges, HEIs and other workplaces. Over 13,000 centres choose our A Levels, GCSEs and vocational qualifications including Cambridge Nationals and legacy Cambridge Technicals.

### 1.1 Our specifications

We provide specifications that help you bring the subject to life and inspire your students to achieve more.

We've created teacher-friendly specifications based on extensive research and engagement with the teaching community. Our specifications are designed to be straightforward to deliver and accessible for students. The design allows you to tailor the delivery of the course to suit your needs.

### 1.2 Our support

We provide a range of support services to help you at every stage, from preparation to delivery:

- A wide range of high-quality creative resources including resources created by leading organisations in the industry.
- Textbooks and teaching and learning resources from leading publishers. The Cambridge Advanced Nationals page on our website has more information about all the published support for the qualifications that we have endorsed.
- Professional development for teachers to meet a range of needs. To join our training (either face-to-face or online) or to search for training materials, go to the **Professional Development page** on our website.
- **Active Results** which is our free results analysis service. It helps you review the performance of individual students or whole groups.
- **ExamBuilder** which is our free question-building platform. It helps you to build your own tests using past OCR exam questions.
- OCR Subject Advisors, who give information and support to centres. They can help with specification and non examined assessment (NEA) advice, updates on resources developments and a range of training opportunities. They use networks to work with subject communities and share ideas and expertise to support teachers.

### 1.2.1 More help and support

Whether you are new to OCR or already teaching with us, you can find useful information, help and support on our **website**. Or get in touch:

[support@ocr.org.uk](mailto:support@ocr.org.uk)

[@ocrexams](https://www.ocr.org.uk/exams)

01223 553998

## 1.3 Aims and learning outcomes

Our Cambridge Advanced Nationals in Applied Science will encourage students to:

- develop key knowledge, understanding and skills, relevant to the subject
- think creatively, innovatively, analytically, logically and critically
- develop valuable communication skills that are important in all aspects of further study and life
- develop transferable learning and skills, such as evaluation, planning, presentation and research skills, that are important for progression to HE and can be applied to real-life contexts and work situations
- develop independence and confidence in applying the knowledge and skills that are vital for progression to HE and relevant to the sciences sector and more widely.

## 1.4 What are the key features of this specification?

The key features of OCR's Cambridge Advanced Nationals in Applied Science for you and your students are:

- a simple and intuitive assessment model, that has:
  - externally assessed units, which focus on subject knowledge and understanding
  - applied and practical non examined assessment units (NEA)
  - optional NEA units to provide flexibility
- a specification developed with teachers specifically for teachers. The specification lays out the subject content, assessment criteria, teacher guidance and delivery requirements clearly
- a flexible support package made based on teachers' needs. The support package will help teachers to easily understand the qualification and how it is assessed
- a team of OCR Subject Advisors who directly support teachers
- a specification designed to:
  - complement A Levels in a Post-16 curriculum
  - develop wider transferable skills, knowledge and understanding desired by HEIs. More detail about the transferable skills these qualifications may develop is in **Section 5.3**.

All Cambridge Advanced National qualifications offered by OCR are regulated by Ofqual, the Regulator for qualifications offered in England.

The qualification numbers for OCR's Alternative Academic Qualification Cambridge Advanced Nationals in Applied Science are:

- Certificate: QN 610/3947/0
- Extended Certificate: 610/3948/2

## 1.5 Acknowledgements

We would like to acknowledge the following Higher Education Providers/organisations for their input and support in designing these qualification(s):
Aston University
Cardiff University
Coventry University
Field Studies Council
Nottingham Trent University
Staffordshire University
Teesside University
University of Bradford
University of East Anglia
University of Gloucester
University of Leeds
University of Lincoln
University of Manchester
University of Southampton
University of the West of England

## 2 Qualification overview

### 2.1 OCR Level 3 Alternative Academic Qualification Cambridge Advanced National in Applied Science (Certificate) at a glance

Qualification number	610/3947/0
First entry date	01 September 2025
Guided learning hours (GLH)	180
Total qualification time (TQT)	220
OCR entry code	H051
Approved age range	16-18, 18+, 19+
Offered in	England only
Performance table information	This qualification is designed to meet the Department for Education's requirements for qualifications in the Alternative Academic Qualifications category of the 16-19 performance tables.
Eligibility for funding	This qualification meets funding approval criteria.
UCAS Points	This qualification is recognised in the UCAS tariff tables. You'll find more information on the <b>UCAS website</b> .
This qualification is suitable for students who:	<ul style="list-style-type: none"> <li>are age 16-19 and on a full-time study programme</li> <li>want to develop applied knowledge and skills in applied science</li> <li>want to progress onto other related study, such as higher education courses, for example: Biological Science degree, Allied Health and Nursing degree, Life Sciences degree and Forensic Science degree</li> </ul>
Entry requirements	<p>We recommend that students have achieved a science qualification at Level 2, for example:</p> <ul style="list-style-type: none"> <li>a GCSE in Combined Science at grade 4-4 or above</li> <li>a Level 2 vocational qualification such as OCR Level 2 Cambridge Technical in Science</li> </ul> <p>We also recommend that:</p> <ul style="list-style-type: none"> <li>students have grade 4/grade C or above in Maths and English GCSE</li> <li>you carry out an initial assessment to make sure students can reach the required standards of the qualification</li> </ul>
Qualification requirements	Students must complete two units: <ul style="list-style-type: none"> <li>one externally assessed unit</li> <li>one NEA unit</li> </ul>

Assessment method/model	<p>Unit F180 is assessed by an exam and marked by us.</p> <p>You will assess the NEA unit and we will moderate it.</p> <p>The NEA assignments are live for 2 years. The front cover details the intended cohort. You must make sure you use the live assignment that relates to the student's cohort for assessment and submit in the period in which the assignments are live</p> <p>For example, a cohort beginning a 2-year course in September 2026 should use the set of assignments marked as being for 2026-2028 so that whatever order assignments are taken in, they will be able to resubmit improved work on the same NEA assignment if they wish to during their study of the qualification.</p> <p>Centres should avoid allowing new cohorts to use assignments which have already been live for a year, e.g. students who start the course in September 2027 using assignments for the 2026-2028 cohorts.</p> <p>Centres must have suitable controls in place to ensure that NEA assignment work is completed by each student independently and must not allow previously completed work for assignments which are still live to be shared as examples with other students.</p>
Exam series each year	<ul style="list-style-type: none"> <li>• January</li> <li>• June</li> </ul>
Exam resits	Students can resit the examined unit twice before they complete the qualification.
NEA submission	<p>There are two windows each year to submit NEA outcomes and request a moderation visit by an OCR Assessor.</p> <p>You must make unit entries for students before you can submit outcomes to request a visit.</p> <p>All dates are on our administration pages.</p>
Resubmission of students' NEA work	<p>If students have not performed at their best in the NEA assignments they can improve their work and submit it to you again for assessment. They must have your agreement and you must be sure it is in the student's best interests.</p> <p>We use the term 'resubmission' when referring to student work that has previously been submitted to OCR for moderation. Following OCR moderation, a student can attempt to improve their work for you to assess and provide the final mark to us. There is one resubmission opportunity per NEA assignment.</p> <p>All work submitted (or resubmitted) must be based on the assignment that is live for assessment.</p> <p>For information about feedback see <b>Section 6</b>. The final piece of work must be completed solely by the student and teachers must not detail specifically what amendments should be made.</p>
Grading	Information about unit and qualification grading is in <b>Section 5</b> .

## 2.2 OCR Level 3 Alternative Academic Qualification Cambridge Advanced National in Applied Science (Extended Certificate) at a glance

Qualification number	610/3948/2
First entry date	01 September 2025
Guided learning hours (GLH)	360
Total qualification time (TQT)	440
OCR entry code	H151
Approved age range	16-18, 18+, 19+
Offered in	England only
Performance table information	This qualification is designed to meet the Department for Education's requirements for qualifications in the Alternative Academic Qualifications category of the 16-19 performance tables.
Eligibility for funding	This qualification meets funding approval criteria.
UCAS Points	This qualification is recognised in the UCAS tariff tables. You'll find more information on the <a href="#">UCAS website</a> .
This qualification is suitable for students who:	<ul style="list-style-type: none"> <li>are age 16-19 and on a full-time study programme</li> <li>want to develop applied knowledge and skills in applied science</li> <li>want to progress onto other related study, such as higher education courses, for example: Biological Science degree, Allied Health and Nursing degree, Life Sciences degree and Forensic Science degree</li> </ul>
Entry requirements	<p>We recommend that students have achieved a science qualification at Level 2, for example:</p> <ul style="list-style-type: none"> <li>GCSEs in science subjects at grade 4 (4-4) or above</li> <li>a Level 2 vocational qualification such as OCR Level 2 Cambridge Technical in Science</li> </ul> <p>We also recommend that:</p> <ul style="list-style-type: none"> <li>students have grade 4/grade C or above in Maths and English GCSE</li> <li>you carry out an initial assessment to make sure students can reach the required standards of the qualification</li> </ul>
Qualification requirements	Students must complete five units: <ul style="list-style-type: none"> <li>two externally assessed units</li> <li>three NEA units</li> </ul>
Assessment method/model	Units F180 and F181 are assessed by an exam and marked by us. You will assess the NEA units and we will moderate them.

	<p>The NEA assignments are live for 2 years. The front cover details the intended cohort. You must make sure you use the live assignment that relates to the student's cohort for assessment and submit in the period in which the assignments are live.</p> <p>For example, a cohort beginning a 2-year course in September 2026 should use the set of assignments marked as being for 2026-2028 so that whatever order assignments are taken in, they will be able to resubmit improved work on the same NEA assignment if they wish to during their study of the qualification.</p> <p>Centres should avoid allowing new cohorts to use assignments which have already been live for a year, e.g. students who start the course in September 2027 using assignments for the 2026-2028 cohorts.</p> <p>Centres must have suitable controls in place to ensure that NEA assignment work is completed by each student independently and must not allow previously completed work for assignments which are still live to be shared as examples with other students.</p>
Exam series each year	<ul style="list-style-type: none"> <li>• January</li> <li>• June</li> </ul>
Exam resits	Students can resit each examined unit twice before they complete the qualification.
NEA Submission	<p>There are two windows each year to submit NEA outcomes and request a moderation visit by an OCR Assessor.</p> <p>You must make unit entries for students before you can submit outcomes to request a visit.</p> <p>All dates are on our administration pages.</p>
Resubmission of students' NEA work	<p>If students have not performed at their best in the NEA assignments they can improve their work and submit it to you again for assessment. They must have your agreement and you must be sure it is in the student's best interests.</p> <p>We use the term 'resubmission' when referring to student work that has previously been submitted to OCR for moderation. Following OCR moderation, a student can attempt to improve their work for you to assess and provide the final mark to us. There is one resubmission opportunity per NEA assignment.</p> <p>All work submitted (or resubmitted) must be based on the assignment that is live for assessment.</p> <p>For information about feedback see <b>Section 6</b>. The final piece of work must be completed solely by the student and teachers must not detail specifically what amendments should be made.</p>
Grading	Information about unit and qualification grading is in <b>Section 5</b> .

## 2.3 Qualification structure

Key to units for these qualifications:

M = Mandatory	Students must complete these units.
O = Optional	Students must complete some of these units.
E = External assessment	We set and mark the exams.
N = NEA	We set the assignment. You assess the assignment and we moderate it.

### OCR Level 3 Alternative Academic Qualification Cambridge Advanced National in Applied Science (Certificate)

For this qualification, students must complete two units:

- One mandatory externally assessed unit
- One mandatory NEA unit

Unit no	Unit title	Unit ref no (URN)	Guided learning hours (GLH)	How is it assessed?	Mandatory or optional
F180	Fundamentals of science	J/651/0649	90	E	M
F182	Investigating science	R/651/0651	90	N	M

### OCR Level 3 Alternative Academic Qualification Cambridge Advanced National in Applied Science (Extended Certificate)

For this qualification, students must complete five units:

- Two mandatory externally assessed units
- one mandatory NEA unit
- two optional NEA units

Unit no	Unit title	Unit ref no (URN)	Guided learning hours (GLH)	How is it assessed?	Mandatory or optional
F180	Fundamentals of science	J/651/0649	90	E	M
F181	Science in society	M/651/0650	60	E	M
F182	Investigating science	R/651/0651	90	N	M
F183	Analytical techniques in chemistry	T/651/0652	60	N	O
F184	Environmental studies	Y/651/0653	60	N	O
F185	Forensic biology	A/651/0654	60	N	O
F186	Medical physics	D/651/0655	60	N	O

## 2.4 Purpose statement – Certificate



OCR Level 3 Alternative Academic Qualification Cambridge Advanced National in Applied Science (Certificate)

Qualification number: 610/3947/0

### Overview

#### **Who this qualification is for**

The OCR Level 3 Alternative Academic Qualification Cambridge Advanced National in Applied Science (Certificate) is for students aged 16-19 years old. It will develop knowledge, understanding and skills that will help you to progress to university and are relevant to the Applied Science sector.

When taken in addition to A Levels, OCR's Level 3 Alternative Academic Qualification Cambridge Advanced National in Applied Science (Certificate) qualification aims to prepare you for undergraduate study in a wide range of science related courses by developing and assessing specific skills and foundational knowledge not covered in A Levels. This qualification provides you with an understanding of applied science practical techniques and applications. Through a combination of theoretical study and hands on experience, you will develop the necessary knowledge and skills that can support progression to higher education study.

You might be interested in this qualification if you want to develop key theoretical knowledge and understanding of the subject, but also apply what you learn to different situations and contexts and practical tasks, such as:

- Researching the fundamentals of science
- Planning and performing laboratory investigations

The qualification will also help you develop independence and confidence in using skills that are relevant to the sector and that prepare you for progressing to university courses where independent study skills are needed. You will develop the following transferable skills that can be used in both higher education and other life and work situations:

- Communicating effectively with individuals or groups.
- Researching topic areas and recording research sources, then using them to interpret findings and present evidence.
- Problem solving when matching and analysing data.

This qualification will complement other learning that you're completing at Key Stage 5. If you are a full-time student, it will be part of your studies along with your A Levels.

#### **What you will study when you take this qualification**

The qualification is made up of 50% examined content and 50% non examined assessment (NEA) content. This approach supports you to develop both theoretical knowledge and understanding **and** the skills needed to apply it in different contexts, helping you to develop a broad and relevant set of skills and experiences.

In the examined unit, you will study key knowledge and understanding relevant to Applied Science. In the non examined assessment (NEA) unit, you will demonstrate knowledge and skills you learn by completing a practical assignment. More information about the knowledge and skills you will develop is below.

The qualification has 2 mandatory units.

These are the mandatory units – you must take **both** of these units:

- Unit F180: Fundamentals of science

This unit is assessed by an exam.

In this unit you will learn about the key topics that are important in biology, chemistry and physics. You will study two key practicals for each of those components to be assessed as part of section D of the exam. Topics include:

Section A (Biology)

- Topic Area 1 Cell structure and microscopy
- Topic Area 2 Bioenergetics
- Topic Area 3 Structure and function of biological molecules
- Topic Area 4 Biodiversity and ecosystems

Section B (Chemistry)

- Topic Area 1 Atomic structure and the Periodic Table
- Topic Area 2 Quantitative chemistry
- Topic Area 3 Structure and bonding
- Topic Area 4 Rates of reactions and enthalpy changes

Section C (Physics)

- Topic Area 1 Electricity
- Topic Area 2 Motion
- Topic Area 3 Medical physics

Section D

- Practicals

- Unit F182: Investigating Science

This unit is assessed by an assignment.

In this unit you will learn about the role of a research scientist in industry by learning how to conduct your own scientific investigation. You will develop the skills to research, plan and risk assess your investigation before safely undertaking the practical tasks. Topics include:

- Topic Area 1 Planning a scientific investigation
- Topic Area 2 Performing a scientific investigation
- Topic Area 3 Analysing and communicating results
- Topic Area 4 Evaluating a scientific investigation

## **The subjects that complement this course**

This qualification is designed to be taken alongside A Levels to enhance learning and support a balanced, engaging, broad and relevant programme of study.

These A Level subjects might complement this qualification:

- A Level Biology
- A Level Chemistry
- A Level Geography
- A Level Environmental Science
- A Level Physical Education

## **The types of courses you may progress to**

Both the subject-specific knowledge, understanding and skills, and broader transferable skills developed through this qualification, will help you progress to further study in related areas such as:

- Biomedical Science degree
- Allied Health and Nursing degree
- Life Sciences degree
- Forensic Science degree

## **Why you should take the OCR Level 3 Alternative Academic Qualification Cambridge Advanced National in Applied Science (Certificate)**

There are two qualifications available in Applied Science. These are:

OCR Level 3 Alternative Academic Qualification Cambridge Advanced National in Applied Science (Certificate) – this is 180 GLH in size

OCR Level 3 Alternative Academic Qualification Cambridge Advanced National in Applied Science (Extended Certificate) – this is 360 GLH in size

You should take this Certificate qualification if you want a Level 3 qualification that builds applied knowledge and skills in Applied Science. This qualification is an Alternative Academic Qualification that is the same size as an AS Level. When it is taken alongside A Levels it will complement them, helping you to build broader knowledge and skills that are valued in undergraduate study, and relevant for progression to higher education. You would take this qualification alongside A Levels as part of your programme of study at Key Stage 5.

## **More information**

More information about the OCR Level 3 Alternative Academic Qualification Cambridge Advanced National in Applied Science (Certificate) is in these documents:

- Specification: <<insert link>>
- Sample Assessment Material (SAM) Question Paper:
  - F180: <<insert link>>
- Guides to our SAM Question Paper:
  - F180: <<insert link>>
- SAM Set assignment(s):
  - F182: <<insert link>>
- Student Guide to NEA Assignments: <<insert link>>

## 2.5 Purpose statement – Extended Certificate



OCR Level 3 Alternative Academic Qualification Cambridge Advanced National in Applied Science (Extended Certificate)

Qualification number: 610/3948/2

### Overview

#### Who this qualification is for

The OCR Level 3 Alternative Academic Qualification Cambridge Advanced National in Applied Science (Extended Certificate) is for students aged 16-19 years old. It will develop knowledge, understanding and skills that will help you to progress to university and are relevant to the Applied Sciences sector.

When taken in addition to A Levels, OCR's Level 3 Alternative Academic Qualification Cambridge Advanced National in Applied Science (Extended Certificate) qualification aims to prepare you for undergraduate study in a wide range of science related courses by developing and assessing specific skills and foundational knowledge not covered in A Levels. This qualification provides you with an understanding of applied science practical techniques and applications. Through a combination of theoretical study and hands on experience, you will develop the necessary knowledge and skills that can support progression to higher education study.

You might be interested in this qualification if you want to develop key theoretical knowledge and understanding of the subject, but also apply what you learn to different situations, contexts and practical tasks, such as:

- Researching the fundamentals of science
- Planning and performing laboratory investigations
- Researching and undertaking an ecological survey report
- Conducting a forensic crime scene investigation and evidence analysis
- Testing unknown organic and inorganic compounds

The qualification will also help you develop independence and confidence in using skills that are relevant to the sector and that prepare you for progressing to university courses where independent study skills are needed. You will develop the following transferable skills that can be used in both higher education and other life and work situations:

- Communicating effectively with individuals or groups.
- Researching topic areas and recording research sources, then using them to interpret findings and present evidence.
- Presenting information, this will involve managing time and identifying aims, purpose, resources, methods.
- Problem solving when matching and analysing data.

This qualification will complement other learning that you're completing at Key Stage 5. If you are a full-time student, it will be part of your studies along with your A Levels.

## What you will study when you take this qualification

The qualification is made up of 40% examined content and 60% non examined assessment (NEA) content. This approach supports you to develop both theoretical knowledge and understanding **and** the skills needed to apply it in a range of contexts, helping you to develop a broad and relevant set of skills and experiences.

In the examined units, you will study key knowledge and understanding relevant to Applied Science. In the non examined assessment (NEA) units, you will demonstrate knowledge and skills you learn by completing applied and practical assignments. More information about the knowledge and skills you will develop is below.

The qualification has three mandatory units and four optional units.

These are the **mandatory** units – you must take **all** these units:

- F180: Fundamentals of science

This unit is assessed by an exam.

In this unit you will learn about the key topics that are important in biology, chemistry and physics and you will study two key practicals for each of those components to be assessed as part of section D of the exam. Topics include:

Section A (Biology)

- Topic Area 1 Cell structure and microscopy
- Topic Area 2 Bioenergetics
- Topic Area 3 Structure and function of biological molecules
- Topic Area 4 Biodiversity and ecosystems

Section B (Chemistry)

- Topic Area 1 Atomic Structure and the Periodic Table
- Topic Area 2 Quantitative Chemistry
- Topic Area 3 Structure and Bonding
- Topic Area 4 Rates of reactions and enthalpy changes

Section C (Physics)

- Topic Area 1 Electricity
- Topic Area 2 Motion
- Topic Area 3 Medical physics

Section D

- Practicals

- F181: Science in society

This unit is assessed by an exam.

In this unit you will learn about the skills scientists use and the roles they perform in an international scientific community. You will examine different types of scientific data and learn how scientists use them to draw conclusions that can contribute to scientific advancement.

Topics include:

- Topic Area 1 What scientists do
- Topic Area 2 Handling scientific data
- Topic Area 3 Scientific developments
- Topic Area 4 Communicating science

- F182: Investigating science

This unit is assessed by an assignment.

In this unit you will learn about the role of a research scientist in industry by learning how to conduct your own scientific investigation. You will develop the skills to research, plan and risk assess your investigation before safely undertaking the practical tasks. Topics include:

- Topic Area 1 Planning a scientific investigation
- Topic Area 2 Performing a scientific investigation
- Topic Area 3 Analysing and communicating results
- Topic Area 4 Evaluating a scientific investigation

These are **optional** units – you must take **two** of these units:

- F183: Analytical techniques in chemistry

This unit is assessed by an assignment.

In this unit you will learn how to plan and perform practical investigations to separate substances and purify them. Topics include:

- Topic Area 1: Techniques to categorise and separate chemical substances
- Topic Area 2: Quantitative and qualitative analytical techniques to quantify and identify substances
- Topic Area 3: The principles of spectroscopic techniques and interpreting spectra for chemical substances

- F184: Environmental studies

This unit is assessed by an assignment.

In this unit, you will learn to use primary and secondary data to study ecosystems. You will develop the skills to carry out *in situ* fieldwork investigations to survey an area using different sampling techniques. Topics include:

- Topic Area 1: Ecosystems and biodiversity
- Topic Area 2: Impact of human activity and natural events
- Topic Area 3: Waste management
- Topic Area 4: Environmental management and conservation
- Topic Area 5: Fieldwork

- F185: Forensic biology

This unit is assessed by an assignment.

In this unit you will learn how to perform investigations of the macro- and ultrastructure of cells and tissues from fresh and prepared material, using optical microscope techniques and electron micrographs. Topics include:

- Topic Area 1: Forensic biology disciplines and evidence
- Topic Area 2: Cells, Tissues and Organs in Forensic Biology
- Topic Area 3: Investigation and Evidence Collection
- Topic Area 4: Analytical Techniques and Evidence Interpretation

- F186: Medical physics

This unit is assessed by an assignment.

In this unit you will learn about the different diagnosis techniques and therapies used in medicine. Topics include:

- Topic Area 1: Application of non-ionising diagnosis techniques
- Topic Area 2: Application of ionising diagnosis techniques
- Topic Area 3: Application of ionising therapy techniques
- Topic Area 4: Application of non-ionising therapy techniques
- Topic Area 5: Planning for diagnosis and therapy

### **The subjects that complement this course**

This qualification is designed to be taken alongside A Levels to enhance learning and support a balanced, engaging, broad and relevant programme of study.

These A Level subjects might complement this qualification:

- A Level Biology
- A Level Chemistry
- A Level Geography
- A Level Environmental Science
- A Level Physical Education

### **The types of courses you may progress to**

Both the subject-specific knowledge, understanding and skills, and broader transferable skills developed through this qualification, will help you progress to further study in related areas such as:

- Biomedical Science degree
- Allied Health and Nursing degree
- Life Sciences degree
- Forensic Science degree

### **Why you should take the OCR Level 3 Alternative Academic Qualification Cambridge Advanced National in Applied Science (Extended Certificate)**

There are 2 qualifications available in Applied Science. These are:

OCR Level 3 Alternative Academic Qualification Cambridge Advanced National in Applied Science (Certificate) – this is

180 GLH in size

OCR Level 3 Alternative Academic Qualification Cambridge Advanced National in Applied Science (Extended Certificate) – this is 360 GLH in size

You should take this Extended Certificate qualification if you want a Level 3 qualification that builds applied knowledge and skills in applied science. This qualification is an Alternative Academic Qualification that is the same size as an A Level. When it is taken alongside A Levels it will complement them, helping you to build broader knowledge and skills that are valued in undergraduate study, and relevant for progression to higher education. You would take this qualification alongside A Levels as part of your programme of study at Key Stage 5.

### **More information**

More information about the OCR Level 3 Alternative Academic Qualification Cambridge Advanced National in Applied Science (Extended Certificate) is in these documents:

- Specification: <<insert link>>
- Sample Assessment Material (SAM) Question Papers:
  - F180: <<insert link>>
  - F181: <<insert link>>
- Guides to our SAM Question Papers:
  - F180: <<insert link>>
  - F181: <<insert link>>
- SAM Set assignment(s):
  - F182: <<insert link>>
  - F183: <<insert link>>
  - F184: <<insert link>>
  - F185: <<insert link>>
  - F186: <<insert link>>
- Student Guide to NEA Assignments: <<insert link>>

## 3 About these qualifications

### 3.1 Qualification size

The size of each qualification is described in terms of Guided Learning Hours (GLH) and Total Qualification Time (TQT).

GLH indicates the approximate time (in hours) you will spend supervising or directing study and assessment activities. We have worked with people who are experienced in delivering related qualifications to determine the content that needs to be taught and how long it will take to deliver.

TQT includes two parts:

- GLH
- an estimate of the number of hours a student will spend on unsupervised learning or assessment activities (including homework) to successfully complete their qualification.

The OCR Level 3 Alternative Academic Qualification Cambridge Advanced National in Applied Science (Certificate) is 180 GLH and 220 TQT.

The OCR Level 3 Alternative Academic Qualification Cambridge Advanced National in Applied Science (Extended Certificate) is 360 GLH and 440 TQT.

### 3.2 Availability and language

The Level 3 Alternative Academic Qualification Cambridge Advanced Nationals are available in England only. They are **not** available in Wales or Northern Ireland.

The qualifications and their assessment materials are available in English only. We will only assess answers written in English.

### 3.3 Prior knowledge and experience

Recognition of prior learning (RPL) is the process for recognising learning that never received formal recognition through a qualification or certification. It includes knowledge and skills gained in school, college or outside of formal learning situations. These may include:

- domestic/family life
- education
- training
- work activities
- voluntary activities.

In most cases RPL will not be appropriate for directly evidencing the requirements of the NEA assignments for the Cambridge Advanced National qualifications. However, if you feel that your student could use RPL to support their evidence, you must follow the guidance provided in our **RPL Policy**.

## 4 Units

### 4.1 Guidance on unit content

This section describes what must be taught so that students can access all available marks and meet assessment criteria.

#### 4.1.1 Externally assessed units (F180 and F181)

The externally assessed units contain a number of topic areas.

For each topic area, we list the **teaching content** that must be taught and give information on the **breadth and depth** of teaching needed.

#### Teaching content

Questions can be asked about anything in the teaching content or breadth and depth columns.

#### Breadth and depth

The breadth and depth column:

- clarifies the breadth and depth of teaching needed
- indicates the range of knowledge and understanding that can be assessed in the exam
- confirms any aspects that you do not need to teach as 'does not include' statements.

Teaching must cover **both** the **teaching content** and **breadth and depth** columns.

#### Knowledge and understanding

This is what we mean by knowledge and understanding:

Knowledge	<ul style="list-style-type: none"><li>Be able to identify or recognise an item, for example on a diagram.</li><li>Use direct recall to answer a question, for example the definition of a term.</li></ul>
Understanding	<ul style="list-style-type: none"><li>To assess and evidence the perceived meaning of something in greater depth than straight identification or recall.</li><li>Understanding will be expressed and presented using terms such as: how; why; when; reasons for; advantages and disadvantages of; benefits and limitations of; purpose of; suitability of; recommendations for improvement; appropriateness of something to/in different contexts.</li></ul>

Students will need to **understand** the content, unless the breadth and depth column identifies it as knowledge only.

Any item(s) that should be taught as **knowledge** only will start with the word 'know' in the breadth and depth column.

All other content must be taught as understanding.

Opportunities to cover mathematical skills and how science works concepts and skills are exemplified in two columns in the unit content tables. Further information about the requirements for mathematical skills and how science works concepts and skills can be found in Appendices C and D.

#### 4.1.2 NEA units (F182-F186)

The NEA units contain a number of topic areas.

For each topic area, we list **teaching content** that must be taught and give **exemplification**. The exemplification shows the teaching expected to equip students to successfully complete their assignments.

#### 4.1.3 Command words

**Appendix B** gives information about the command words that will be used in the external assessments and the NEA assessment criteria.

#### 4.1.4 Performance Objectives (POs):

Each Cambridge Advanced National qualification has four Performance Objectives.

PO1	Show knowledge and understanding
PO2	Apply knowledge and understanding
PO3	Analyse and evaluate knowledge, understanding and performance
PO4	Demonstrate and apply skills and processes relevant to the subject

PO1 is assessed in the externally assessed unit only.

PO4 is assessed in the NEA units only.

The weightings of the Performance Objectives across the units in the **Certificate** qualification are:

Performance Objective	Externally Assessed unit (range)	NEA unit	Overall weighting
PO1	21.4 – 28.6%	n/a	21.4 – 28.6%
PO2	21.4 – 28.6%	12.5%	33.9 – 41.1%
PO3	0.0	12.5%	12.5%
PO4	n/a	25.0%	25.0%
<b>Overall weighting of assessments</b>	50.0%	50.0%	100.0%

The weightings of the Performance Objectives across the units in the **Extended Certificate** qualification are:

Performance Objective	Externally Assessed unit (range)	NEA units	Overall weighting
PO1	13.3 – 20.0%	n/a	13.3 – 20.0%
PO2	15.0 – 21.7%	15.0 – 17.5%	30 – 39.2%
PO3	5.00%	15.8 – 19.2%	20.8 – 24.2%
PO4	n/a	25.0 – 27.5%	25.0 – 27.5%
<b>Overall weighting of assessments</b>	40.0%	60.0%	100%

## 4.2 Externally assessed units

### 4.2.1 Unit F180: Fundamentals of science

#### Unit aim

An understanding of Applied Science is exciting and challenging and essential to appreciate how the world works. Chemicals are in the food we eat, the medicines we take, the clothes we wear and the fuels we use. In addition, a greater insight into biological processes from individual cells to organisms, metabolic reactions and the way we interact with other living things is fascinating. We are also dependent on the physical forces around us and on the energy we harvest and use, whilst seeking to understand more about the world around us.

In this unit you will learn about the structure and composition of substances and how they can combine to form new useful substances. Exploring living systems is equally rewarding, enabling you to find out more about yourself and how you are placed in your environment. You will also explore electrical circuits which will support understanding of applications of Physics, the fundamental theory which supports medical physics, and how we can interpret data about the physical world.

Unit F180: Fundamentals of science		
BIOLOGY		
Topic Area B1: Cell structure and microscopy		
Teaching content	Breadth and Depth	Opportunities to cover:
<b>1.1 Cell structure and function</b>		<b>Maths</b> <b>HSW</b>
<b>1.1.1 Ultrastructure and function of cells and their components</b> <input type="checkbox"/> Features common to all cells  <input type="checkbox"/> Eukaryotic cells <ul style="list-style-type: none"> <li>• Cell surface membrane</li> <li>• Cytoplasm</li> <li>• Nucleus and nucleolus</li> <li>• Mitochondrion</li> <li>• Centriole</li> <li>• Smooth endoplasmic reticulum (SER)</li> </ul>	To include: <ul style="list-style-type: none"> <li><input type="checkbox"/> Why it is essential for living cells to have a cell surface membrane, cytoplasm and nucleic acid</li> <li><input type="checkbox"/> Know the 'cell theory'</li> <li><input type="checkbox"/> Know viruses are not living cells</li>   <li><input type="checkbox"/> How to use the features of a photomicrograph to draw and label a low-power plan of a eukaryotic cell</li> <li><input type="checkbox"/> Features of the cell surface membrane as shown by the fluid mosaic model, including relevance in osmosis, simple and facilitated diffusion and active transport</li> <li><input type="checkbox"/> The functional link between the Golgi apparatus, and vesicles/lysosomes</li> </ul>	<b>M0.1</b> <b>M1.1</b> <b>M1.4</b> <b>HSW1</b>

<ul style="list-style-type: none"> <li>• Rough endoplasmic reticulum (RER)</li> <li>• 70s and 80s ribosomes</li> <li>• Golgi apparatus/body</li> <li>• Vesicles and lysosomes</li> <li>• Flagellum and cilium</li> <li>• Chloroplast</li> <li>• Cell wall</li> </ul> <p><input type="checkbox"/> Plant and animal cells</p> <p><input type="checkbox"/> Prokaryotic cells</p>	<p><input type="checkbox"/> Know the key differences between plant and animal cells</p> <p><input type="checkbox"/> Why a fungal cell could be identified as both a plant cell and an animal cell</p> <p><input type="checkbox"/> How prokaryotic cells differ from eukaryotic cells</p> <p><input type="checkbox"/> The difference between gram-positive and gram-negative bacteria</p> <p><input type="checkbox"/> How the differential response to antibiotics can be used to identify bacteria</p> <p>Does not include:</p> <p><input type="checkbox"/> Details of cell autolysis or apoptosis</p>		
<p><b>1.1.2 Cell specialisation</b></p> <p><input type="checkbox"/> Significance of cell specialisation in living organisms</p> <p><input type="checkbox"/> Structure and function of specialised animal cells:</p> <ul style="list-style-type: none"> <li>• Erythrocytes</li> <li>• Leukocytes</li> <li>• Epithelial cells</li> <li>• Sperm and egg cells</li> <li>• Muscle cells</li> </ul> <p><input type="checkbox"/> Importance of retaining undifferentiated stem cells within the adult animal or plant</p>	<p>To include:</p> <p><input type="checkbox"/> Why cells have different functions in a multi-cellular organism</p> <p><input type="checkbox"/> Know how to interpret photomicrographs to identify the cells found in blood</p> <p><input type="checkbox"/> Differences between the appearance, dimensions and function of the 5 types of leukocytes</p> <p><input type="checkbox"/> The key features of squamous, ciliated and columnar epithelial cells</p> <p><input type="checkbox"/> Why sperm and egg cells are so specialised</p> <p><input type="checkbox"/> The key features of sperm cell and egg cell structures that allow them to carry out their role</p> <p><input type="checkbox"/> Differences between cardiac, smooth and skeletal muscle cells</p> <p><input type="checkbox"/> How animal stem cells can differentiate into a wide range of specialised cells</p>	<b>M1.4</b>	<b>HSW1</b>

<ul style="list-style-type: none"> <li><input type="checkbox"/> Structure and function of specialised cells found in a plant leaf:           <ul style="list-style-type: none"> <li>• Epithelial cells and cuticle</li> <li>• Mesophyll cells</li> <li>• Guard cells</li> <li>• Xylem and phloem</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Know how to identify the key cells found in a leaf TS</li> <li><input type="checkbox"/> Opening and closure of stomata and the significance of chloroplasts in the guard cells</li> <li><input type="checkbox"/> Why water flows along the transpiration stream in a plant leaf</li> <li><input type="checkbox"/> Why nutrients flow along phloem sieve elements in a plant leaf</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Details of other specialised animal/plant cells</li> </ul>		
<p><b>1.1.3 Tissue structure and function</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Definition of a tissue in animals and plants</li> <li><input type="checkbox"/> Tissues found in animals           <ul style="list-style-type: none"> <li>• Epithelial</li> <li>• Blood</li> <li>• Lung</li> <li>• Gastrointestinal</li> <li>• Endocrine</li> </ul> </li> <li><input type="checkbox"/> Tissues found in plants:           <ul style="list-style-type: none"> <li>• Epidermis</li> <li>• Parenchyma</li> <li>• Xylem</li> <li>• Phloem</li> </ul> </li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Know that a tissue is a collection of identical or similar cells sharing a common function</li> <li><input type="checkbox"/> How to extrapolate the function of a tissue, based on its structural features shown in a diagram and photomicrograph</li> <li><input type="checkbox"/> Comparison of lung and gastrointestinal epithelial tissues in the context of molecular movement across a membrane</li> <li><input type="checkbox"/> Why root tissues are usually non-photosynthetic</li> <li><input type="checkbox"/> What is the function of root hairs</li> <li><input type="checkbox"/> Why the retention of roots is essential for successful transplantation</li> <li><input type="checkbox"/> Know differences between the transport of substances in xylem and phloem</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Details of hormonal activity</li> <li><input type="checkbox"/> Biochemical details of photosynthesis</li> <li><input type="checkbox"/> Other plant and animal tissues</li> </ul>	<b>M0.1</b>	<b>HSW1</b>

<b>1.2 Microscopy</b>		<b>Maths</b>	<b>HSW</b>
<b>1.2.1 Light and electron microscopy</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> The stages in producing a temporary, stained mount of an LM specimen</li> <li><input type="checkbox"/> Know advantages and disadvantages of LM and EM</li> <li><input type="checkbox"/> Differences between transmission electron microscopes (TEM) and scanning electron microscopes (SEM)</li> <li><input type="checkbox"/> Know advantages and disadvantages of the TEM and SEM</li> <li><input type="checkbox"/> How to draw a low -power plan of an EM image</li> <li><input type="checkbox"/> Advantages and disadvantages of using a haemocytometer vs a Coulter counter</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Freeze-etching technique for EM</li> <li><input type="checkbox"/> Details of staining of permanent slides</li> <li><input type="checkbox"/> The physics of LM and EM techniques</li> </ul>	<b>M0.1</b> <b>M1.4</b> <b>M4.2</b>	<b>HSW5</b> <b>HSW4</b>
<b>1.2.2 Practical 1: Light microscopy</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> How to prepare and examine microscope slides for use in light microscopy, including the use of an eyepiece graticule and stage micrometer</li> <li><input type="checkbox"/> How to use and interpret the most commonly used stains, including iodine, safranin, methylene blue and Leishman stain</li> <li><input type="checkbox"/> How to draw a low-power plan of an LM image</li> <li><input type="checkbox"/> How to use a haemocytometer and a Coulter counter to count cells in a sample</li> <li><input type="checkbox"/> Know the appropriateness of using the units of mm, <math>\mu\text{m}</math> and nm in microscopy</li> <li><input type="checkbox"/> Use of the equation:  Total magnification = magnification of objective lens <math>\times</math> magnification of eyepiece lens</li> <li><input type="checkbox"/> Use of the equation:  <math display="block">\text{Magnification} = \frac{\text{observed size}}{\text{actual size}}</math></li> </ul> <p><i>Questions relating to this teaching content will be included in Section D: Practicals in the exam</i></p>	<b>M0.1</b> <b>M1.1</b> <b>M1.4</b>	<b>HSW4</b>

<b>Topic Area B2: Bioenergetics</b>			
<b>Teaching content</b>	<b>Breadth and Depth</b>	<b>Opportunities to cover:</b>	
<b>2.1 Photosynthesis</b>		<b>Maths</b>	<b>HSW</b>
<b>2.1.1 Site of photosynthesis</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Structure and function of chloroplast components           <ul style="list-style-type: none"> <li>• Outer membrane</li> <li>• Stroma</li> <li>• Granal and intergranal thylakoids</li> </ul> </li> <li><input type="checkbox"/> Location of chloroplasts           <ul style="list-style-type: none"> <li>• Distribution within individual plant cells</li> <li>• Concentration across a plant leaf</li> </ul> </li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Details of proton pumps located on thylakoids</li> </ul>	<b>M0.1</b> <b>M4.3</b>	<b>HSW2</b>
<b>2.1.2 Biochemistry of photosynthesis</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Balanced chemical and word equations of photosynthesis</li> <li><input type="checkbox"/> Photosynthetic pigments involved in photosynthesis</li> <li><input type="checkbox"/> Importance of CO<sub>2</sub> absorption on climate change</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Details of the biochemical reactions within cyclic and non-cyclic photophosphorylation and the Calvin cycle</li> </ul>	<b>M3.2</b> <b>M3.3</b> <b>M3.4</b> <b>M3.5</b>	<b>HSW6</b>
<b>2.2 Cellular respiration</b>		<b>Maths</b>	<b>HSW</b>
<b>2.2.1 Site of cellular respiration</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Structure of mitochondria           <ul style="list-style-type: none"> <li>• Smooth outer membrane</li> <li>• Matrix</li> <li>• Cristae</li> </ul> </li> </ul>	<b>M0.1</b>	<b>HSW1</b>

<ul style="list-style-type: none"> <li>• 70S ribosomes</li> <li><input type="checkbox"/> Location of mitochondria</li> <li>• Distribution within plant and animal cells</li> <li>• Concentration differences in relation to plant and animal cell specialisation and function</li> </ul>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Benefits of the folded cristae and watery matrix to the aerobic phase of cellular respiration</li> <li><input type="checkbox"/> Why active animal cells have an abundance of mitochondria, including: <ul style="list-style-type: none"> <li>• Sperm cell</li> <li>• Muscle cell/fibre</li> <li>• Renal tubule cell</li> <li>• Synaptic knob of neuron</li> </ul> </li> <li><input type="checkbox"/> Why active plant cells have an abundance of mitochondria, including: <ul style="list-style-type: none"> <li>• Root hair cell</li> <li>• Phloem companion cell</li> </ul> </li> <li><input type="checkbox"/> Why water-logged soils can reduce the active uptake of mineral ions</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Details of proton pumps located on cristae</li> </ul>		
<p><b>2.2.2 Biochemistry of cellular respiration</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Balanced chemical and word equations of aerobic and anaerobic respiration</li> <li><input type="checkbox"/> Net production of ATP</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Similarities and differences between aerobic and anaerobic respiration</li> <li><input type="checkbox"/> Why ATP synthesis is not 100% efficient</li> <li><input type="checkbox"/> When anaerobic respiration can be applied to industrial and agricultural processes</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Details of the biochemical reactions along the phases of glycolysis, link reaction, Krebs cycle and electron transfer chains</li> </ul>	<b>M2.3</b>	<b>HSW10</b>
<b>Topic Area B3: Structure and function of biological molecules</b>			
<p><b>Teaching content</b></p>	<p><b>Breadth and Depth</b></p>	<b>Opportunities to cover:</b>	
<p><b>3.1 Biological molecules</b></p>		<b>Maths</b>	<b>HSW</b>
<p><b>3.1.1 Structure and function of carbohydrates</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Monomers/monosaccharides <ul style="list-style-type: none"> <li>• Alpha (<math>\alpha</math>) and beta (<math>\beta</math>) glucose</li> <li>• Fructose</li> <li>• Galactose</li> </ul> </li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Know how to interpret molecular diagrams of monosaccharides, disaccharides and polysaccharides</li> <li><input type="checkbox"/> Comparison of C1-4 and C1-6 glycosidic bonds</li> <li><input type="checkbox"/> Advantages and disadvantages of starch and glycogen as carbohydrate stores</li> <li><input type="checkbox"/> Know the key features of the iodine test, reducing sugar test and non-reducing sugar test</li> </ul>	<b>M4.2</b>	<b>HSW1</b>

<ul style="list-style-type: none"> <li><input type="checkbox"/> Disaccharides           <ul style="list-style-type: none"> <li>• Maltose</li> <li>• Sucrose</li> <li>• Lactose</li> </ul> </li> <li><input type="checkbox"/> Polysaccharides           <ul style="list-style-type: none"> <li>• Starch</li> <li>• Glycogen</li> <li>• Cellulose</li> </ul> </li> <li><input type="checkbox"/> Condensation and hydrolysis reactions</li> </ul>	<p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Details of monosaccharide isomers</li> </ul>		
<p><b>3.1.2 Structure and function of lipids</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Saturated and unsaturated fatty acids</li> <li><input type="checkbox"/> Mono-, di- and triglycerides</li> <li><input type="checkbox"/> Phospholipids</li> <li><input type="checkbox"/> Condensation and hydrolysis reactions</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> How to interpret molecular diagrams of mono-, di- and triglycerides</li> <li><input type="checkbox"/> The key features of ester bond formation between glycerol and fatty acids</li> <li><input type="checkbox"/> Relevance of phospholipids within the cell surface membrane, including the effect of saturated and unsaturated fatty acids on membrane thickness and fluidity</li> <li><input type="checkbox"/> Why triglycerides are an effective energy source in plants (including seeds) and animals (within adipose tissue)</li> <li><input type="checkbox"/> How lipids in the myelin sheath provide insulation of the neuron axon</li> <li><input type="checkbox"/> Know the key features of the emulsion and Sudan IV tests</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Recognition of fatty acids beyond their saturated or unsaturated properties</li> </ul>	<b>M0.1</b>	<b>HSW1 HSW11</b>
<p><b>3.1.3 Structure and function of proteins</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Amino acid structure</li> <li><input type="checkbox"/> Characteristic features of dipeptides and polysaccharides</li> <li><input type="checkbox"/> Condensation and hydrolysis reactions</li> <li><input type="checkbox"/> Levels of protein organisation</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> How to interpret molecular diagrams of amino acids</li> <li><input type="checkbox"/> How to carry out thin layer chromatography (TLC)</li> <li><input type="checkbox"/> How to interpret chromatograms to identify amino acids</li> <li><input type="checkbox"/> Know the key features of the biuret test</li> <li><input type="checkbox"/> How carboxylic and amino groups form the peptide bond between adjacent amino acids</li> <li><input type="checkbox"/> The differences between primary, secondary, tertiary and quaternary levels of organisation</li> </ul>	<b>M2.1 M3.1 M4.2</b>	<b>HSW3</b>

<ul style="list-style-type: none"> <li><input type="checkbox"/> Enzyme structure and function           <ul style="list-style-type: none"> <li>• Lock and key and induced fit hypotheses</li> <li>• Factors affecting the rate of enzyme-catalysed reactions</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Why there is such a diverse range of proteins, including structural and functional types</li> <li><input type="checkbox"/> Know the key features of the enzyme as a protein</li> <li><input type="checkbox"/> Functions of lipases, proteases and carbohydrases</li> <li><input type="checkbox"/> How to explain the lock and key and induced fit hypotheses</li> <li><input type="checkbox"/> The effect of enzyme concentration, substrate concentration, temperature, pressure and pH on reaction rate</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Inorganic catalysts, cofactors and coenzymes</li> </ul>		
<p><b>3.1.4 Structure and function of nucleic acids</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Key features of a nucleotide</li> <li><input type="checkbox"/> ATP and ADP as mononucleotides</li> <li><input type="checkbox"/> DNA and RNA as polynucleotides</li> <li><input type="checkbox"/> Condensation and hydrolysis reactions</li> <li><input type="checkbox"/> Significance of base pairing</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> How to interpret molecular diagrams of mono- and polynucleotides, including both DNA and RNA</li> <li><input type="checkbox"/> Function of nuclelease enzymes</li> <li><input type="checkbox"/> Relevance of the mononucleotide structure of ATP and ADP</li> <li><input type="checkbox"/> Purpose and function of DNA and RNA in inheritance and protein synthesis</li> <li><input type="checkbox"/> Similarities and differences between DNA and RNA, including mtDNA, rRNA, mRNA and tRNA</li> <li><input type="checkbox"/> Know how base pairing is fundamental to the integrity of DNA and the formation of RNA</li> <li><input type="checkbox"/> Know why alterations in the sequence of bases can lead to mutations</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Details of protein synthesis at the ribosome</li> <li><input type="checkbox"/> Detailed steps of the PCR protocol</li> </ul>	<b>M4.2</b>	<b>HSW1</b>
<p><b>Topic Area B4: Biodiversity and ecosystems</b></p>			
<p><b>Teaching content</b></p>	<p><b>Breadth and Depth</b></p>		<p><b>Opportunities to cover:</b></p>
<p><b>4.1 The distribution of organisms</b></p>		<b>Maths</b>	<b>HSW</b>
<p><b>4.1.1 Distribution of organisms</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> The location and interaction of organisms in the living world           <ul style="list-style-type: none"> <li>• Ecosystem</li> <li>• Community</li> <li>• Population</li> </ul> </li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> The relationship between ecosystem, community, population, habitat and niche</li> <li><input type="checkbox"/> How organisms participate in food chains and food webs, including brown food chains</li> <li><input type="checkbox"/> Know how the percentage efficiency of energy transfer limits the number of trophic levels</li> </ul>	<b>M0.3</b> <b>M1.1</b> <b>M1.2</b> <b>M2.3</b>	<b>HSW12</b>

<ul style="list-style-type: none"> <li>• Habitat</li> <li><input type="checkbox"/> Factors affecting the distribution of organisms in an ecosystem           <ul style="list-style-type: none"> <li>• Abiotic (climatic and edaphic) factors</li> <li>• Biotic factors</li> <li>• Human influences</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Use of the equation:  <math display="block">\text{Percentage efficiency} = \frac{\text{useful energy transferred (J)}}{\text{total energy transferred (J)}} \times 100</math> </li> <li><input type="checkbox"/> The impact of abiotic and biotic factors on the distribution and survival of organisms within an ecosystem</li> <li><input type="checkbox"/> Why climate change has such a profound influence on the distribution and survival of organisms</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Details of energy transfer estimates across an ecosystem</li> <li><input type="checkbox"/> Political issues related to climate change</li> </ul>		
<h3>4.2 Sampling</h3> <h4>4.2.1 Sampling techniques</h4> <ul style="list-style-type: none"> <li><input type="checkbox"/> Influences on the choice of sampling technique           <ul style="list-style-type: none"> <li>• Type of organisms</li> <li>• Density of populations</li> <li>• Environmental characteristics</li> </ul> </li> <li><input type="checkbox"/> Features of random sampling</li> <li><input type="checkbox"/> Measurement of abiotic factors</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Why different sampling techniques are needed for different types of organisms, including:           <ul style="list-style-type: none"> <li>• Plants</li> <li>• Sedentary or mobile animals</li> <li>• Algae and seaweed</li> </ul> </li> <li><input type="checkbox"/> Characteristic features of pitfall traps, sweep nets, quadrats and pooters</li> <li><input type="checkbox"/> Benefits and limitations of random sampling, including bias</li> <li><input type="checkbox"/> Know abiotic factors including light intensity, air, water, substrate or soil, temperature and pH</li> <li><input type="checkbox"/> How to determine soil features of water, humus, and particulate mass</li> <li><input type="checkbox"/> Importance of sampling techniques in agriculture</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Analysis of kite diagrams</li> <li><input type="checkbox"/> Calculation of standard error</li> </ul>	<b>Maths</b> <b>M0.4</b> <b>M0.3</b> <b>M1.7</b>	<b>HSW</b> <b>HSW7</b>
<h4>4.2.2 Practical 2: Sampling</h4> <ul style="list-style-type: none"> <li><input type="checkbox"/> Use of simple and grid quadrats</li> <li><input type="checkbox"/> Line and belt transects</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> How to decide the appropriate type of sampling technique for collecting random and non-random samples in the field</li> <li><input type="checkbox"/> Know how to use a quadrat for sampling in an area and along a transect</li> </ul>	<b>M0.3</b> <b>M1.7</b> <b>M1.8</b>	<b>HSW8</b>

	<ul style="list-style-type: none"> <li><input type="checkbox"/> How to estimate % plant cover within a quadrat</li> <li><input type="checkbox"/> How to measure abiotic factors under field conditions</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Point quadrats</li> </ul> <p><i>Questions relating to this teaching content will be included in Section D: Practicals in the exam</i></p>		
<b>CHEMISTRY</b>			
<b>Topic Area C1: Atomic structure and the Periodic Table</b>			
Teaching content	Breadth and Depth	Opportunities to cover:	
<b>1.1 Atomic structure</b>		<b>Maths</b>	<b>HSW</b>
<b>1.1.1 Atomic structure</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Know definitions of atomic number (Z) and mass number (A)</li> <li><input type="checkbox"/> Know how to represent an atom's structure using the Bohr model of the atom up to Z = 20</li> <li><input type="checkbox"/> The relative charges and relative masses of protons, neutrons and electrons</li> <li><input type="checkbox"/> The existence of isotopes</li> <li><input type="checkbox"/> Use of the equation:</li> </ul> $\text{Relative atomic mass} = \sum \frac{(\text{isotope mass} \times \text{isotope abundance})}{100}$ <ul style="list-style-type: none"> <li><input type="checkbox"/> Know how to interpret simple mass spectra of elements (limited to ions with single charges)</li> <li><input type="checkbox"/> How to work out the electron configuration of atoms in terms of main shells and sub-shells (s, p and d) up to Z = 36</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Electron spin</li> <li><input type="checkbox"/> Orbitals and their shapes</li> <li><input type="checkbox"/> Knowledge of the main principles of the mass spectrometer</li> </ul>	<b>M1.1</b> <b>M2.3</b> <b>M2.4</b>	<b>HSW3</b>

1.2 The Periodic Table		Maths	HSW
<b>Arrangement of elements in the Periodic Table</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Periods</li> <li><input type="checkbox"/> Groups</li> <li><input type="checkbox"/> Blocks</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Know the order of the elements in the Periodic Table in terms of increasing atomic (proton) number</li> <li><input type="checkbox"/> Know the arrangement of elements in periods showing repeating trends in physical and chemical properties (periodicity)</li> <li><input type="checkbox"/> Arrangement of elements in groups having similar chemical properties</li> <li><input type="checkbox"/> The periodic trend in electron configurations of periods 2 and 3</li> <li><input type="checkbox"/> How to classify elements into s-, p- and d-block elements</li> <li><input type="checkbox"/> The relationship between electron configuration and the position of the element in the Periodic Table</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> f-block</li> <li><input type="checkbox"/> The development of the Periodic Law or modern Periodic tables</li> </ul>	M3.1	HSW1
<b>Topic Area C2: Quantitative chemistry</b>			
<b>Teaching content</b>	<b>Breadth and Depth</b>	<b>Opportunities to cover:</b>	
<b>2.1 Amount of substance</b>		<b>Maths</b>	<b>HSW</b>
<b>2.1.1 The mole and molar mass</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> The mole</li> <li><input type="checkbox"/> Molar mass</li> <li><input type="checkbox"/> Calculation of the number of moles from the mass in g and the molar mass</li> <li><input type="checkbox"/> Empirical formula</li> <li><input type="checkbox"/> Molecular formula</li> <li><input type="checkbox"/> Formula unit</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> The terms: <ul style="list-style-type: none"> <li>• Amount of substance</li> <li>• The mole (symbol 'mol'), as the unit for amount of substance</li> <li>• The Avogadro constant, <math>N_A</math>, as the number of particles in one mole (<math>6.02 \times 10^{23} \text{ mol}^{-1}</math>)</li> <li>• Molar mass as the mass of one mole (units <math>\text{g mol}^{-1}</math>)</li> </ul> </li> <li><input type="checkbox"/> Know what is meant by empirical formula, molecular formula for covalent molecules, and formula unit for ionic compounds</li> <li><input type="checkbox"/> Know how to calculate the empirical formula of a compound from the % by mass of its elements</li> <li><input type="checkbox"/> Use of the equation:</li> </ul> $\text{Amount of substance (mol)} = \frac{\text{mass of substance (g)}}{\text{molar mass (g mol}^{-1}\text{)}}$	M0.2 M0.5 M2.2 M2.3	HSW3

	<p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Definitions of the mole</li> <li><input type="checkbox"/> Relative formula mass in terms of Carbon-12</li> </ul>		
<b>2.1.2 Balancing equations and reacting masses</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> How to classify types of reaction to include acid-base, acid-carbonate, acid-metal, thermal decomposition, redox and precipitation</li> <li><input type="checkbox"/> Know how to write balanced chemical equations for the types of reactions listed above, including state symbols</li> <li><input type="checkbox"/> Know how to calculate reacting masses and masses of products based on balanced chemical equations</li> </ul>	<b>M0.3 M2.1</b>	<b>HSW2 HSW5</b>
<b>2.1.3 Number of moles in aqueous solutions and preparation of a standard solution</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Use of the equation:</li> </ul> $\text{Concentration (mol dm}^{-3}\text{)} = \frac{\text{amount of solute (mol)}}{\text{volume (dm}^3\text{)}}$ <ul style="list-style-type: none"> <li><input type="checkbox"/> Use of the equation:</li> </ul> $\text{Concentration (g dm}^{-3}\text{)} = \frac{\text{mass of solute (g)}}{\text{volume (dm}^3\text{)}}$ <ul style="list-style-type: none"> <li><input type="checkbox"/> How to convert between g dm<sup>-3</sup> and mol dm<sup>-3</sup></li> </ul>	<b>M0.3 M2.2 M2.3</b>	<b>HSW5</b>
<b>2.1.4 Neutralisation</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Neutralisation as the reaction between acids and bases, including alkalis and carbonates, to form salts</li> <li><input type="checkbox"/> Formulae of the common acids (HCl, H<sub>2</sub>SO<sub>4</sub>, HNO<sub>3</sub> and CH<sub>3</sub>COOH) and alkalis (NaOH, KOH and NH<sub>3</sub>)</li> <li><input type="checkbox"/> How to determine the formulae and names of salts produced by acids</li> </ul>	<b>M0.3</b>	<b>HSW15</b>
<b>2.1.5 Practical 3: volumetric analysis</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> The use of acid-base titration to determine concentration</li> <li><input type="checkbox"/> The use of appropriate indicators to determine the end point of an acid-base titration, including the colour changes expected</li> <li><input type="checkbox"/> The use of apparatus, techniques and procedures to carry out acid-base titrations</li> <li><input type="checkbox"/> The use of titration curves for acid-base titrations</li> <li><input type="checkbox"/> Structured titration calculations based on experimental results of familiar and non-familiar acids and bases</li> </ul>	<b>M0.3 M1.5</b>	<b>HSW4</b>

	<p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> How and why indicators change colour</li> </ul> <p><i>Questions relating to this teaching content will be included in Section D: Practicals in the exam</i></p>		
<b>2.1.6 Moles and volumes of gases</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Molar gas volume as the volume occupied by one mole of any gas (24 dm<sup>3</sup> at RTP)</li> <li><input type="checkbox"/> Know how to calculate reacting masses and volume of gases from balanced equations, using the concept of amount of substance</li> <li><input type="checkbox"/> Use of the equation:</li> </ul> $\text{Amount of gas (mol)} = \frac{\text{volume of gas (dm}^3\text{)}}{24 \text{ (dm}^3 \text{ mol}^{-1}\text{)}}$ <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> The Ideal Gas Equation, <math>PV = nRT</math></li> </ul>	<b>M0.1 M2.2</b>	<b>HSW11</b>
<b>Topic Area C3: Structure and bonding</b>			
<b>Teaching content</b>	<b>Breadth and Depth</b>	<b>Opportunities to cover:</b>	
<b>3.1 Bonding</b>		<b>Maths</b>	<b>HSW</b>
<b>3.1.1 Bonding</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Ionic Bonding <ul style="list-style-type: none"> <li>• Formation of ionic compounds</li> <li>• Formation of giant ionic lattices</li> </ul> </li> <li><input type="checkbox"/> Covalent Bonding <ul style="list-style-type: none"> <li>• Formation of covalent substances (simple molecular and giant covalent)</li> <li>• Electronegativity and bond polarity</li> <li>• Intermolecular forces</li> </ul> </li> </ul>	<b>M4.2</b>	<b>HSW1</b>

<input type="checkbox"/> Metallic Bonding	<ul style="list-style-type: none"> <li><input type="checkbox"/> Intermolecular forces based on permanent dipole–dipole interactions and induced dipole–dipole (London) interactions</li> <li><input type="checkbox"/> Hydrogen bonding as intermolecular bonding between molecules containing N, O or F and the H atom of –NH, –OH or HF</li> <li><input type="checkbox"/> The solid structures of simple molecular lattices, as covalently bonded molecules attracted by intermolecular forces</li> <li><input type="checkbox"/> The solid giant covalent lattices of carbon (diamond, graphite and graphene) and silicon as networks of atoms bonded by strong covalent bonds</li> <li><input type="checkbox"/> Know metallic bonding as strong electrostatic attraction between cations (positive ions) and delocalised electrons, creating a giant metallic lattice structure</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Shapes of molecules</li> <li><input type="checkbox"/> No details of cubic or hexagonal packing required</li> </ul>		
<b>3.1.2 Formulae of ions and compounds</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Cations and anions</li> <li><input type="checkbox"/> Formulae of ionic compounds and covalent substances</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Know how to write formulae of ionic compounds from ionic charges</li> <li><input type="checkbox"/> How to predict ionic charge from the position of an element in the Periodic Table</li> <li><input type="checkbox"/> Know the names and formulae of the following ions: <math>\text{NO}_3^-</math>, <math>\text{CO}_3^{2-}</math>, <math>\text{SO}_4^{2-}</math>, <math>\text{OH}^-</math>, <math>\text{NH}_4^+</math>, <math>\text{Zn}^{2+}</math> and <math>\text{Ag}^+</math></li> <li><input type="checkbox"/> Know how to use chemical symbols to write the formulae of elements and covalent and ionic compounds</li> </ul>	<b>M0.3</b> <b>M0.5</b>	<b>HSW5</b>
<b>3.2 Structures and properties</b> <b>3.2.1 Physical properties of metals, ionic compounds and covalent substances</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Physical properties of metals, ionic compounds and covalent substances (both simple molecular and giant covalent) to include melting point and electrical conductivity</li> <li><input type="checkbox"/> How to explain the properties in terms of the type of bonding, the particles present and the forces between particles</li> </ul>	<b>Maths</b>	<b>HSW</b>

3.3 Organic chemistry		Maths	HSW
<b>3.3.1 Core concepts of organic chemistry</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Nomenclature</li> <li><input type="checkbox"/> Structure of common organic compounds</li> <li><input type="checkbox"/> Structural isomerism</li> <li><input type="checkbox"/> Combustion equations of alkanes and alcohols</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> How to use IUPAC rules of nomenclature for systematically naming organic compounds, limited to: alkanes; alkenes; alcohols; aldehydes; ketones; carboxylic acids; haloalkanes</li> <li><input type="checkbox"/> Know the definition of structural isomers</li> <li><input type="checkbox"/> How to draw the structural and displayed formulae of the first six members of the alkane series and their corresponding alkyl groups and write their chemical formulas</li> <li><input type="checkbox"/> Know classification of alcohols into primary, secondary and tertiary alcohols</li> <li><input type="checkbox"/> Know how to write balanced equations for the complete combustion of alkanes and alcohols</li> <li><input type="checkbox"/> Advantages and disadvantages of using alkanes and alcohols as fuels</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Use of the general formula of a homologous series to predict the formula of any member of the series</li> <li><input type="checkbox"/> Qualitative tests for different functional groups</li> <li><input type="checkbox"/> Definitions of displayed formula and skeletal formula</li> <li><input type="checkbox"/> Details of reactivity of each homologous series</li> </ul>	M4.2	HSW8

**Topic Area C4: Rates of reaction and enthalpy changes**

Teaching content	Breadth and Depth	Opportunities to cover:	
<b>4.1 Rates of reaction</b>		Maths	HSW
<b>4.1.1 Factors which affect reaction rate</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Collision theory</li> <li><input type="checkbox"/> Boltzmann distribution of molecular energies</li> <li><input type="checkbox"/> Activation energy</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Know rate of reaction as the change in mass or volume of a reactant or product per unit time</li> <li><input type="checkbox"/> Know activation energy as the minimum amount of energy required for a reaction to occur</li> <li><input type="checkbox"/> The effect of concentration of solutions, surface area of solids, pressure of gases, temperature and catalyst on reaction rate</li> <li><input type="checkbox"/> The role of a catalyst <ul style="list-style-type: none"> <li>• in increasing reaction rate without being used up by the overall reaction</li> <li>• in allowing a reaction to proceed via a different route with lower activation energy</li> </ul> </li> <li><input type="checkbox"/> The effect of concentration, surface area and pressure on reaction rate in terms of simple collision theory</li> </ul>	M2.3 M3.1 M3.8 M3.9	HSW6 HSW8

	<ul style="list-style-type: none"> <li><input type="checkbox"/> The Boltzmann distribution and its relationship with activation energy</li> <li><input type="checkbox"/> The qualitative effect of temperature changes and catalysts on the proportion of molecules exceeding the activation energy using Boltzmann distributions</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Homogeneous and heterogeneous catalysts</li> <li><input type="checkbox"/> Detailed knowledge of how catalysts work</li> </ul>		
<b>4.1.2 Practical 4: Investigating reaction rates</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Experimental techniques for measuring rate</li> <li><input type="checkbox"/> Analysis of results</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> The use of continuous monitoring methods to measure changes in mass or gas volume</li> <li><input type="checkbox"/> The use of apparatus, techniques and procedures to investigate reaction rates</li> <li><input type="checkbox"/> Reaction rate from the gradient of a graph or experimental data</li> </ul> <p><i>Questions relating to this teaching content will be included in Section D: Practicals in the exam</i></p>	<b>M3.3</b> <b>M3.5</b> <b>M3.7</b> <b>M3.9</b>	<b>HSW3</b>
<b>4.2 Enthalpy Changes</b>		<b>Maths</b>	<b>HSW</b>
<b>4.2.1 Exothermic and endothermic reactions</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Energy profiles</li> <li><input type="checkbox"/> Examples of exothermic and endothermic reactions</li> <li><input type="checkbox"/> Energy profile diagrams</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Energy profiles for exothermic and endothermic reactions</li> <li><input type="checkbox"/> Know combustion and respiration as examples of exothermic reactions</li> <li><input type="checkbox"/> Know thermal decomposition and cracking as examples of endothermic reactions</li> <li><input type="checkbox"/> The signs and units of <math>\Delta H</math> for exothermic and endothermic reactions</li> </ul>	<b>M2.1</b> <b>M3.9</b>	<b>HSW8</b> <b>HSW11</b>
<b>4.2.2 Enthalpy change of combustion of alcohols</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> The enthalpy change of combustion <math>\Delta_c H</math>, as the enthalpy change when 1 mol of a substance undergoes complete combustion</li> <li><input type="checkbox"/> How to determine the enthalpy change of combustion of fuels directly</li> <li><input type="checkbox"/> Assumptions and limitations of experimentally determined enthalpies</li> <li><input type="checkbox"/> How to use</li> </ul> <p>Thermal energy = mass <math>\times</math> specific heat capacity <math>\times</math> change in temperature  <math display="block">(J) \quad (kg) \quad (J\ kg^{-1}\ ^\circ\text{C}^{-1}) \quad (^{\circ}\text{C})</math></p> <p>to calculate <math>\Delta_c H</math> of fuels (in <math>\text{kJ mol}^{-1}</math>) from experimental results</p> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Any other enthalpy terms</li> </ul>	<b>M1.5</b> <b>M2.3</b> <b>M2.4</b>	<b>HSW5</b> <b>HSW11</b>

<b>PHYSICS</b>			
<b>Topic Area P1: Electricity</b>			
<b>Teaching content</b>	<b>Breadth and Depth</b>	<b>Opportunities to cover:</b>	
<b>1.1 Circuits</b>		<b>Maths</b>	<b>HSW</b>
<b>1.1.1. Charge and current</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Know the definition of electric current in metals and electrolytes</li> <li><input type="checkbox"/> Know the unit of current</li> <li><input type="checkbox"/> Conventional current and electron flow</li> <li><input type="checkbox"/> Direct current</li> <li><input type="checkbox"/> Know the unit of charge</li> <li><input type="checkbox"/> Elementary charge, <math>e</math>, including charge of an electron and proton</li> <li><input type="checkbox"/> Use of the equation: <math display="block">\text{Charge (C)} = \text{current (A)} \times \text{time (s)}</math></li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Mean drift velocity</li> <li><input type="checkbox"/> Alternating current</li> </ul>		<b>HSW8</b>
<b>1.1.2. Potential difference, and resistance</b> <input type="checkbox"/> I-V characteristics	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Know the definition of potential difference</li> <li><input type="checkbox"/> Know the unit of potential difference</li> <li><input type="checkbox"/> How resistance is defined by: <math display="block">\text{Resistance } (\Omega) = \frac{\text{potential difference (V)}}{\text{current (A)}}</math></li> <li><input type="checkbox"/> Know the unit of resistance</li> <li><input type="checkbox"/> I-V characteristics of resistor, light-dependent resistor (LDR), filament lamp, thermistor, diode and light-emitting diode (LED)</li> <li><input type="checkbox"/> Use of the equation: <math display="block">\text{Potential difference (V)} = \text{current (A)} \times \text{resistance } (\Omega)</math></li> </ul>	<b>M2.4</b>	<b>HSW8</b>

	<ul style="list-style-type: none"> <li><input type="checkbox"/> Know Ohm's law</li> <li><input type="checkbox"/> Resistance of NTC thermistors with temperature, and resistance of LDRs with light intensity</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Superconductivity</li> <li><input type="checkbox"/> Semiconductors</li> <li><input type="checkbox"/> Conductance and conductivity</li> <li><input type="checkbox"/> E.M.F. and internal resistance</li> </ul>		
<b>1.1.3 Power and energy in circuits</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Know the definition of power</li> <li><input type="checkbox"/> Know the unit of power</li> <li><input type="checkbox"/> Use of the equations:</li> </ul> $\text{Power (W)} = \text{current (A)} \times \text{potential difference (V)}$ $\text{Power (W)} = (\text{current (A)})^2 \times \text{resistance (\Omega)}$ $\text{Power (W)} = \frac{(\text{potential difference (V)})^2}{\text{resistance (\Omega)}}$ <ul style="list-style-type: none"> <li><input type="checkbox"/> The definition of an electronvolt</li> <li><input type="checkbox"/> Use of the equation:</li> </ul> $\text{Work done (J)} = \text{potential difference (V)} \times \text{current (A)} \times \text{time (s)}$ <ul style="list-style-type: none"> <li><input type="checkbox"/> Use of the equation:</li> </ul> $\text{Work done (J)} = \text{potential different (V)} \times \text{charge (C)}$	<b>M2.2</b> <b>M2.3</b> <b>M2.4</b>	<b>HSW11</b>
<b>1.1.4 Series and parallel circuits</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Circuits</li> <li><input type="checkbox"/> Conservation of charge and energy</li> <li><input type="checkbox"/> Kirchoff's Laws</li> <li><input type="checkbox"/> Solving circuit problems</li> <li><input type="checkbox"/> The circuit symbols as set out in ASE publication Signs, Symbols and Systematics (The ASE Companion to 16–19 Science)</li> <li><input type="checkbox"/> The relationships between currents, voltages and resistances in series and parallel, including how potential difference varies for cells in series and cells in parallel</li> <li><input type="checkbox"/> Know Conservation of charge and Kirchoff's first law</li> <li><input type="checkbox"/> Know Conservation of energy and Kirchoff's second law</li> </ul>	<b>M2.3</b> <b>M3.9</b>	<b>HSW5</b>

	<ul style="list-style-type: none"> <li>□ Use of the equation:  <math display="block">R_T = R_1 + R_2 + \dots</math> <p>for two or more resistors in series where:</p> <p><math>R_T</math> = total resistance in series (<math>\Omega</math>)  <math>R_1</math> = resistance of resistor 1 (<math>\Omega</math>)  <math>R_2</math> = resistance of resistor 2 (<math>\Omega</math>)</p> </li> <li>□ Use of the equation:  <math display="block">\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \dots</math> <p>for two or more resistors in parallel where:</p> <p><math>R_T</math> = total resistance in parallel (<math>\Omega</math>)  <math>R_1</math> = resistance of resistor 1 (<math>\Omega</math>)  <math>R_2</math> = resistance of resistor 2 (<math>\Omega</math>)</p> </li> <li>□ How to solve problems for series and parallel circuits</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li>□ Derivation of equations for calculating total resistances in series and parallel</li> </ul>		
<b>1.1.5 Potential dividers</b>	<p>To include:</p> <ul style="list-style-type: none"> <li>□ The principles of a potential divider circuit</li> <li>□ The use of a potentiometer as a potential divider</li> <li>□ The use of potential divider circuits with LDRs and thermistors</li> <li>□ How to solve problems for potential divider circuits with potentiometers, LDRs and thermistors</li> </ul>	<b>M1.1</b>	<b>HSW5 HSW8</b>
<b>1.1.6 Practical 5: Potential divider circuits</b>	<p>To include:</p> <ul style="list-style-type: none"> <li>□ Use of apparatus, techniques and procedures to investigate potential divider circuits which may include a sensor such as a thermistor or an LDR</li> <li>□ How to identify and fix faults in potential divider circuits</li> </ul>		

Topic Area P2: Motion			
Teaching content	Breadth and Depth	Opportunities to cover:	
2.1 Energy		Maths	HSW
<b>2.1.1 Energy stores and energy transfers</b> <input type="checkbox"/> Energy stores and energy transfers <input type="checkbox"/> Conservation of energy <input type="checkbox"/> Sankey diagrams	To include: <input type="checkbox"/> How energy is stored <input type="checkbox"/> How energy is transferred via energy carriers or pathways <input type="checkbox"/> How diagrams can be used to represent energy transfers		HSW4
<b>2.1.2 Work and energy</b>	To include: <input type="checkbox"/> Know the definition of work done by a force <input type="checkbox"/> Know the unit of work done <input type="checkbox"/> Use of the equations: $\text{Work done (J)} = \text{force (N)} \times \text{displacement (m)}$ $\text{Work done (J)} = \text{force (N)} \times \text{displacement (m)} \times \cos\theta$ <input type="checkbox"/> Law of conservation of energy <input type="checkbox"/> The relationship between work done and energy transferred  Does not include: <input type="checkbox"/> Radians	M0.6 M2.4 M4.1	HSW11
<b>2.1.3 Kinetic and potential energy</b>	To include: <input type="checkbox"/> Use of the equations: $\text{Kinetic energy (J)} = \frac{1}{2} \times \text{mass (kg)} \times (\text{velocity (m s}^{-1}\text{)})^2$ $\text{Gravitational potential energy} = \text{mass} \times \text{acceleration} \times \text{height of free fall}$ $(\text{J}) \qquad \qquad (\text{kg}) \qquad (\text{m s}^{-2}) \qquad (\text{m})$ $\text{Elastic potential energy (J)} = \frac{1}{2} \times \text{force (N)} \times \text{extension (m)}$ $\text{Elastic potential energy (J)} = \frac{1}{2} \times \text{spring constant (N m}^{-1}\text{)} \times (\text{extension (m)})^2$ <input type="checkbox"/> How to apply conservation of energy to examples involving gravitational potential energy, elastic potential energy, and kinetic energy	M2.2 M2.3 M2.4	HSW6

	Does not include: <input type="checkbox"/> Gravitational potential energy between two point masses		
<b>2.1.4 Power and Efficiency</b>	To include: <input type="checkbox"/> Use of the equation: $\text{Power (W)} = \frac{\text{work done (J)}}{\text{time (s)}}$ <input type="checkbox"/> Use of the equation: $\text{Efficiency} = \frac{\text{useful energy transferred (J)}}{\text{total energy transferred (J)}}$	<b>M2.2</b> <b>M2.3</b>	
<b>2.1.5 Force</b> <input type="checkbox"/> Newton's first and third laws of motion <input type="checkbox"/> Newton's second law of motion for constant mass <input type="checkbox"/> Scalar and vector quantities <input type="checkbox"/> SUVAT	To include: <input type="checkbox"/> Use of the equation: $\text{Net force (N)} = \text{mass (kg)} \times \text{acceleration (m s}^{-2}\text{)}$ <input type="checkbox"/> Use of Newton's three laws of motion including how to use free-body force diagrams to solve problems <input type="checkbox"/> The terms tension, normal contact force, weight and friction <input type="checkbox"/> The vector–scalar distinction as it applies to displacement and distance, velocity and speed <input type="checkbox"/> Use of average velocity equation: $\text{Average velocity (m s}^{-1}\text{)} = \frac{\text{displacement (m)}}{\text{time taken (s)}}$ <input type="checkbox"/> Use of constant acceleration equation: $\text{Acceleration (m s}^{-2}\text{)} = \frac{\text{final velocity (m s}^{-1}\text{)} - \text{initial velocity (m s}^{-1}\text{)}}{\text{time taken (s)}}$	<b>M2.2</b> <b>M2.4</b> <b>M3.7</b> <b>M3.8</b>	<b>HSW8</b>

	<ul style="list-style-type: none"> <li><input type="checkbox"/> Use of SUVAT equations to solve constant acceleration problems:           <math display="block">v = u + at</math> <math display="block">s = \frac{1}{2}(u + v)t</math> <math display="block">s = ut + \frac{1}{2}at^2</math> <math display="block">v^2 = u^2 + 2as</math> </li> </ul> <p>where:</p> <p><math>v</math> = final velocity (<math>\text{m s}^{-1}</math>)  <math>u</math> = initial velocity (<math>\text{m s}^{-1}</math>)  <math>a</math> = acceleration (<math>\text{m s}^{-2}</math>)  <math>t</math> = time taken (s)  <math>s</math> = displacement (m)</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Use of velocity–time and displacement–time graphs to solve problems</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Resolving forces using vector triangles</li> <li><input type="checkbox"/> Terminal velocity</li> </ul>		
<b>2.1.6 Practical 6: Investigating motion</b>	To include: <ul style="list-style-type: none"> <li><input type="checkbox"/> Use of apparatus, techniques and procedures to accurately determine the acceleration of free fall using trapdoor and electromagnet arrangement; light gates and timer</li> </ul>		<b>HSW4</b> <b>HSW5</b>
<b>Topic Area P3: Medical physics</b>			
<b>Teaching content</b>	<b>Breadth and Depth</b>	<b>Opportunities to cover:</b>	
<b>3.1 X-rays and ultrasound</b>		<b>Maths</b>	<b>HSW</b>
<b>3.1.1 The atom</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> The Rutherford–Bohr model</li> <li><input type="checkbox"/> Energy levels in atoms</li> </ul>	To include: <ul style="list-style-type: none"> <li><input type="checkbox"/> Electron transitions</li> <li><input type="checkbox"/> Ground state, excited state, and ionised state</li> </ul>	<b>M0.5</b>	<b>HSW11</b>

	<p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Alpha particle scattering</li> <li><input type="checkbox"/> Electric force and strong nuclear force</li> <li><input type="checkbox"/> Electron stationary waves in atoms</li> <li><input type="checkbox"/> Nuclear radius – Radius of nuclei <math>R = r_o A^{1/3}</math></li> </ul>		
<b>3.1.2 Electromagnetic radiation</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> The similarities and differences between the types of electromagnetic (EM) radiation, including in terms of production, penetration, uses, frequency and wavelength</li> <li><input type="checkbox"/> Know the definition of a quantum and a photon</li> <li><input type="checkbox"/> Use of the equations:</li> </ul> <p>Energy of a photon (J) = Planck constant (J s) × frequency (Hz)</p> $\text{Energy of a photon (J)} = \frac{\text{Planck constant (J s)} \times \text{speed of light in a vacuum (m s}^{-1})}{\text{wavelength (m)}}$ <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Investigating the photoelectric effect experimentally</li> <li><input type="checkbox"/> Stopping potential difference</li> <li><input type="checkbox"/> Spectral lines</li> <li><input type="checkbox"/> Wave-particle duality</li> </ul>	<b>M2.4</b>	<b>HSW7</b>
<b>3.1.3 X-rays</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Basic structure of an X-ray tube including: heater (cathode), anode, target metal and high voltage supply</li> <li><input type="checkbox"/> How X-rays are produced in an X-ray tube, including thermionic emission and energy transfers</li> <li><input type="checkbox"/> How tube current and voltage affects the X-ray beam</li> <li><input type="checkbox"/> Attenuation of X-rays by absorption and scattering</li> <li><input type="checkbox"/> Use of the attenuation of X-rays equation to calculate intensity:</li> </ul> $I = I_0 e^{-\mu x} \quad \text{with } e = 2.718$ <p>where:</p> <p><math>I</math> = intensity of emergent beam (<math>\text{W m}^{-2}</math>)</p> <p><math>I_0</math> = intensity of incident beam (<math>\text{W m}^{-2}</math>)</p> <p><math>\mu</math> = linear attenuation coefficient (<math>\text{m}^{-1}</math>)</p> <p><math>x</math> = distance travelled through the medium (m)</p>	<b>M0.5 M1.3 M2.2 M2.3</b>	<b>HSW9</b>

	<ul style="list-style-type: none"> <li><input type="checkbox"/> Know mass attenuation coefficient</li> <li><input type="checkbox"/> Use of the equation:           <math display="block">\text{Mass attenuation coefficient (m}^2\text{ kg}^{-1}\text{)} = \frac{\text{linear attenuation coefficient (m}^{-3}\text{)}}{\text{density of medium (kg m}^{-3}\text{)}}</math> </li> <li><input type="checkbox"/> Use of the equation:           <math display="block">\text{Density (kg m}^{-3}\text{)} = \frac{\text{mass (kg)}}{\text{volume (m}^3\text{)}}</math> </li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Logarithms</li> <li><input type="checkbox"/> Calculus</li> <li><input type="checkbox"/> X-ray attenuation mechanisms</li> <li><input type="checkbox"/> Types of X-ray, e.g. Bremsstrahlung</li> <li><input type="checkbox"/> Formation of an X-ray image</li> <li><input type="checkbox"/> Photographic film</li> <li><input type="checkbox"/> Charge-coupled device</li> <li><input type="checkbox"/> X-ray spectra graphs</li> </ul>		
<b>3.1.4 Wave motion</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Progressive Waves</li> <li><input type="checkbox"/> Longitudinal and transverse waves</li> <li><input type="checkbox"/> Wave motion in terms of displacement, amplitude, wavelength, time period, frequency and wave speed</li> <li><input type="checkbox"/> Graphical representations of longitudinal and transverse waves</li> <li><input type="checkbox"/> Intensity of a progressive wave</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Examples of longitudinal and transverse waves including sound waves and electromagnetic waves</li> <li><input type="checkbox"/> Use of the equation:           <math display="block">\text{Frequency (Hz)} = \frac{1}{\text{time period (s)}}</math> </li> <li><input type="checkbox"/> Use of the equation for wave speed:           <math display="block">\text{Wave speed (m s}^{-1}\text{)} = \text{frequency (Hz)} \times \text{wavelength (m)}</math> </li> <li><input type="checkbox"/> Use of the equation for intensity:           <math display="block">\text{Intensity (W m}^{-2}\text{)} = \frac{\text{power (W)}}{\text{area (m}^2\text{)}}</math> </li> <li><input type="checkbox"/> The relationship between intensity and amplitude</li> </ul>	<b>M2.4</b> <b>M3.4</b> <b>M3.6</b>	<b>HSW1</b>

	<p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Phase difference</li> </ul>		
<b>3.1.5 Ultrasound</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Know definition of ultrasound, including in medical contexts</li> <li><input type="checkbox"/> Reflection, and transmission of ultrasound</li> <li><input type="checkbox"/> Know that a transducer can both transmit pulses and receive reflected pulses</li> <li><input type="checkbox"/> Use of the acoustic impedance equation:  Acoustic impedance = density of medium × speed of sound in the medium <math display="block">\alpha = \frac{I_r}{I_0} = \left( \frac{Z_2 - Z_1}{Z_2 + Z_1} \right)^2</math>where: <math>\alpha</math> = intensity reflection coefficient <math>I_r</math> = intensity of reflected wave (<math>\text{W m}^{-2}</math>) <math>I_0</math> = intensity of incident wave (<math>\text{W m}^{-2}</math>) <math>Z_1</math> = acoustic impedance of initial medium (<math>\text{kg m}^{-2} \text{s}^{-1}</math>) <math>Z_2</math> = acoustic impedance of second medium (<math>\text{kg m}^{-2} \text{s}^{-1}</math>)</li> <li><input type="checkbox"/> Use of the intensity reflection coefficient equation:</li> </ul> <p><input type="checkbox"/> Attenuation of ultrasound by absorption and scattering</p> <p><input type="checkbox"/> Impedance matching and coupling mediums</p> <p><input type="checkbox"/> How to interpret and use A-scans to solve problems</p> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Know the details of the piezoelectric effect</li> <li><input type="checkbox"/> Advantages and disadvantages of A scans and B scans</li> <li><input type="checkbox"/> How to produce clear images using ultrasound</li> <li><input type="checkbox"/> Advantages and disadvantages of ultrasound imaging</li> <li><input type="checkbox"/> Destructive ultrasound</li> <li><input type="checkbox"/> Doppler effect in ultrasound</li> <li><input type="checkbox"/> Determining the speed of blood</li> </ul>	<b>M2.1</b> <b>M2.3</b>	<b>HSW9</b>

<b>3.2 Radioactivity</b>		<b>Maths</b>	<b>HSW</b>
<b>3.2.1 Fundamentals of radioactivity</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Radioactive decay</li> <li><input type="checkbox"/> Properties of nuclear radiation (alpha, beta and gamma)</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> The spontaneous and random nature of nuclear radioactive decay</li> <li><input type="checkbox"/> Know types of decay</li> <li><input type="checkbox"/> Nuclear decay equations</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Electron capture and transmutation</li> <li><input type="checkbox"/> How to use a G–M tube to measure half-life</li> <li><input type="checkbox"/> Detecting alpha, beta and gamma emissions</li> <li><input type="checkbox"/> Beta plus decay</li> <li><input type="checkbox"/> Graph of N against Z for stable nuclei</li> <li><input type="checkbox"/> Effect of magnetic field on alpha, beta and gamma</li> <li><input type="checkbox"/> Big Bang Theory and Cosmic Microwave Background Radiation</li> </ul>	<b>M2.4</b>	<b>HSW11</b>
<b>3.2.2 Mathematical analysis of radioactivity</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Activity of a source</li> <li><input type="checkbox"/> Decay Law</li> <li><input type="checkbox"/> Half-life</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Use of the activity equation:</li> </ul> <p style="margin-left: 20px;">Activity = radioactive decay constant <math>\times</math> number of undecayed nuclei</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Use of the equations to determine <math>N/N_0/A/A_0</math>:</li> </ul> $N = N_0 e^{-\lambda t}$ $A = A_0 e^{-\lambda t}$ <p style="margin-left: 20px;">with <math>e = 2.718</math></p> <p>where:</p> <p style="margin-left: 20px;"><math>N</math> = number of undecayed nuclei</p> <p style="margin-left: 20px;"><math>N_0</math> = initial number of undecayed nuclei</p> <p style="margin-left: 20px;"><math>e</math> = Euler's number</p> <p style="margin-left: 20px;"><math>\lambda</math> = radioactive decay constant (<math>s^{-1}</math>)</p> <p style="margin-left: 20px;"><math>t</math> = time (s)</p> <p style="margin-left: 20px;"><math>A</math> = activity (Bq)</p> <p style="margin-left: 20px;"><math>A_0</math> = initial activity (Bq)</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Biological, physical and effective half-lives</li> </ul>	<b>M1.4 M1.6</b>	<b>HSW11</b>

	<ul style="list-style-type: none"> <li><input type="checkbox"/> Use of the effective half-life equation:  <math display="block">\frac{1}{\text{effective half-life}} = \frac{1}{\text{physical half-life}} + \frac{1}{\text{biological half-life}}</math> </li> <li><input type="checkbox"/> Know how to graphically determine the physical half-life of an isotope</li> <li><input type="checkbox"/> Use of the equation:  <math display="block">\text{Physical half-life} = \frac{0.693}{\text{radioactive decay constant (s}^{-1}\text{)}}</math> </li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Logarithms</li> <li><input type="checkbox"/> Differential rate of decay equation: <math>-dN/dt = \lambda N</math></li> <li><input type="checkbox"/> Calculus</li> <li><input type="checkbox"/> Use of the equation:  <math display="block">N = \text{mass of radioactive sample} \times \frac{\text{Avogadro constant}}{\text{relative atomic mass}}</math> </li> </ul>		
<b>3.2.3 Radiation hazards</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Effects of radiation</li> <li><input type="checkbox"/> Ionisation</li> <li><input type="checkbox"/> Absorbed and effective dose</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Irradiation and contamination</li> <li><input type="checkbox"/> Physiological effects of radiation</li> <li><input type="checkbox"/> Mechanism of direct and indirect ionisation of biological molecules</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Measuring radiation exposure</li> </ul>		<b>HSW10</b>
<b>3.2.4 Using radionuclides</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Radiopharmaceuticals</li> <li><input type="checkbox"/> Radionuclides</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Know the definition of radiopharmaceuticals</li> <li><input type="checkbox"/> Use of radionuclides in sterilisation, cancer treatments and medical tracers</li> <li><input type="checkbox"/> How to select a radionuclide for an appropriate use</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Uses of radioactive nuclides in testing for cracks, carbon dating, dating rocks, smoke detectors</li> <li><input type="checkbox"/> Know the use and function of gamma cameras</li> <li><input type="checkbox"/> Know the components of a gamma camera</li> <li><input type="checkbox"/> Know the use and function of PET scans</li> </ul>		<b>HSW10</b>

	<ul style="list-style-type: none"><li><input type="checkbox"/> Know the components of a PET scanner</li><li><input type="checkbox"/> Artificial radioactive nuclides</li><li><input type="checkbox"/> Manufacture of radionuclides</li></ul>		
--	--	--	--

### Assessment guidance

This unit is assessed by an exam. The exam is 1 hour and 30 minutes and has **70** marks in total. All questions in the exam should be answered.

The exam has four Sections:

- Section A has 20 marks.
- Section B has 20 marks.
- Section C has 20 marks.
- Section D has 10 marks.

Content in Section A will be sampled from topic areas B1-B4, with at least one question or part question relating to each topic area.

Content in Section B will be sampled from topic areas C1-C4, with at least one question or part question relating to each topic area.

Content in Section C will be sampled from topic areas P1-P3, with at least one question or part question relating to each topic area.

Content in Section D will be sampled from Practicals 1-6.

Content in this exam will have links to the 'How Science Works Concepts and Skills' and 'Mathematical skills for Applied Science'.

Sections A-C **do not** explicitly assess knowledge of practicals 1-6. However, knowledge of the practicals may help to answer the questions in these sections.

Section D **does** explicitly assess knowledge of practicals 1-6. Knowledge from B1-B4, C1-C4, and P1-P3 will help to answer the questions in Section D.

This will be conducted under examination conditions. For more details refer to the **Administration area**.

A range of question types will be used in the exam including:

- Forced choice/controlled response questions – including MCQ
- Short answer, closed response questions (with or without diagrams)
- Short answer with calculation/working
- Extended constructed response with points-based mark scheme

The Applied Science **Guide to our Sample Assessment Material** gives more information about the layout and expectations of the exam.

The exam for this unit assesses the following Performance Objectives:

- PO1 – Show knowledge and understanding
- PO2 – Apply knowledge and understanding

### **Synoptic assessment**

This unit allows students to gain underpinning knowledge and understanding relevant to the qualification and sector. The NEA units draw on and strengthen this learning with students applying their learning in an applied or practical way.

The following NEA units have synoptic links with this unit. The synoptic grids at the end of these NEA units show these synoptic links.

- Unit F182: Investigating science
- Unit F183: Analytical techniques in chemistry
- Unit F184: Environmental studies
- Unit F185: Forensic biology
- Unit F186: Medical physics

More information about synoptic assessment in these qualifications can be found in [\*\*Section 5.2 Synoptic Assessment\*\*](#).

## 4.2.2 Unit F181: Science in society

**Unit aim**

Science has transformed the world we live in and brought about many benefits to society, raising living standards and improving peoples' health and life expectancy. Scientific knowledge enables new technologies to be developed, practical problems to be solved and informed decisions to be made. The challenges facing modern society, such as the emergence of new diseases, climate change and sustainability of natural resources, are being addressed by scientists across the world. This unit explores the work of scientists to collect, analyse and present data, using a process called the Scientific Method, to increase knowledge and address these challenges. Communication in science helps inform, educate, and raise awareness of science-related topics within society, inspiring future scientists like you so that scientific technologies continue to progress.

In this unit you will learn about the skills scientists use and the roles they perform in an international scientific community. You will examine different types of scientific data and learn how scientists use them to draw conclusions that can contribute to scientific advancement. You will investigate what makes a scientific theory different to a scientific law by reviewing past scientific discoveries. You will explore current scientific developments and future challenges facing society that science will need to solve. You will consider ways that science is communicated in the scientific and wider communities, the implications of miscommunication and the importance of communication in driving future scientific advances.

<b>Unit F181: Science in society</b>			
<b>Topic Area 1: What scientists do</b>			
<b>Teaching content</b>	<b>Breadth and Depth</b>	<b>Opportunities to cover:</b>	
<b>1.1 The skills of scientists</b>		<b>Maths</b>	<b>HSW</b>
<b>1.1.1 The skills scientists use to carry out research into the natural world and developing new technologies:</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Analysis</li> <li><input type="checkbox"/> Communication</li> <li><input type="checkbox"/> Problem-solving</li> <li><input type="checkbox"/> Creativity</li> <li><input type="checkbox"/> Open-mindedness</li> <li><input type="checkbox"/> Scepticism</li> <li><input type="checkbox"/> Logic</li> <li><input type="checkbox"/> Observation</li> <li><input type="checkbox"/> Objectivity</li> <li><input type="checkbox"/> Pragmatism</li> <li><input type="checkbox"/> Curiosity</li> </ul>	To include: <ul style="list-style-type: none"> <li><input type="checkbox"/> Know what each skill involves</li> <li><input type="checkbox"/> How these skills are used by scientists</li> <li><input type="checkbox"/> Know reasons why these skills are important in science</li> <li><input type="checkbox"/> How to recognise when scientists are employing these skills in their work</li> </ul>		<b>HSW3</b>

<b>1.2 The Scientific Method</b>		<b>Maths</b>	<b>HSW</b>
<b>1.2.1 Steps in the Scientific Method:</b> <input type="checkbox"/> Defining the problem <input type="checkbox"/> Research <input type="checkbox"/> Formulating a hypothesis and making predictions <input type="checkbox"/> Undertaking experiments <input type="checkbox"/> Analysing the data <input type="checkbox"/> Drawing conclusions <input type="checkbox"/> Communicating results to others	To include: <input type="checkbox"/> Key features of each step <input type="checkbox"/> Know the importance of each step <input type="checkbox"/> The reasons for the order of the steps <input type="checkbox"/> The role of inductive and deductive reasoning in the scientific method <input type="checkbox"/> How the approach to the scientific method varies in different disciplines of science		<b>HSW3</b>
<b>1.2.2 The scientific method is a non-linear process:</b> <input type="checkbox"/> Iterative and cyclical nature of science research <input type="checkbox"/> The role of serendipity and intuition in discovery <input type="checkbox"/> Cross-disciplinary approaches <input type="checkbox"/> Inductive reasoning that leads to hypotheses	To include: <input type="checkbox"/> How scientific inquiry can be cyclical and continuous <input type="checkbox"/> The importance of flexibility and adaptability in scientific research <input type="checkbox"/> Accidental scientific discoveries occur occasionally in comparison to planned research <input type="checkbox"/> Scientific research often involves colleagues from multiple disciplines <input type="checkbox"/> Observations and patterns can lead to theories that explain them and conclusions that are likely		<b>HSW5</b>
<b>1.3 The Scientific Community</b>		<b>Maths</b>	<b>HSW</b>
<b>1.3.1 Scientists can work:</b> <input type="checkbox"/> Alone <input type="checkbox"/> In a team <input type="checkbox"/> Collaboratively in an international community	To include: <input type="checkbox"/> Advantages and disadvantages of each type of working <input type="checkbox"/> Reasons why collaboration is important in scientific research <input type="checkbox"/> Know ways that scientists collaborate <input type="checkbox"/> The importance of diversity and inclusivity in a team		<b>HSW5</b>
<b>1.3.2 Successful collaborations in science</b>	To include: <input type="checkbox"/> What was accomplished and how <input type="checkbox"/> The necessity for collaboration in these successes <input type="checkbox"/> Why it is important to have scientists from different disciplines working together  Examples of <b>successful collaborations in science</b> may include: <input type="checkbox"/> Human Genome Project <input type="checkbox"/> ATLAS Project <input type="checkbox"/> International Space Station		<b>HSW11</b>

	<input type="checkbox"/> Global Climate Observing System <input type="checkbox"/> Collaborative Partnership on Sustainable Wildlife Management		
<b>1.3.3 International Scientific Organisations</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Role of international organisations in developments in science</li> <li><input type="checkbox"/> Know why it is an advantage to have these organisations</li> </ul> <p>Examples of <b>international scientific organisations</b> may include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> WHO</li> <li><input type="checkbox"/> UNESCO</li> <li><input type="checkbox"/> IUCN</li> <li><input type="checkbox"/> WWF</li> <li><input type="checkbox"/> CERN</li> <li><input type="checkbox"/> IPCC</li> </ul>		<b>HSW12</b>
<b>1.4 The role of scientists</b>			<b>Maths</b> <b>HSW</b>
<ul style="list-style-type: none"> <li><input type="checkbox"/> Scientists have many varied roles across different disciplines of natural sciences</li> <li><input type="checkbox"/> Applied science uses scientific knowledge to achieve practical goals           <ul style="list-style-type: none"> <li>• Solve real-world problems</li> <li>• Develop useful technologies</li> </ul> </li> </ul>			
<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> How to recognise the different disciplines of science and the roles of scientists in them</li> <li><input type="checkbox"/> Know why it is useful to think of science as different disciplines</li> <li><input type="checkbox"/> Why it is important to consider the interconnectivity and overlap between the disciplines</li> <li><input type="checkbox"/> The role of 'pure' and applied science and their dependence on each other</li> </ul>			<b>HSW11</b>
<b>Topic Area 2: Handling scientific data</b>			
<b>Teaching content</b>	<b>Breadth and Depth</b>		<b>Opportunities to cover:</b>
<b>2.1 Types of scientific data</b>			<b>Maths</b> <b>HSW</b>
<ul style="list-style-type: none"> <li><input type="checkbox"/> Qualitative and quantitative data</li> <li><input type="checkbox"/> Continuous and discrete data</li> <li><input type="checkbox"/> Data from observations and measurements</li> <li><input type="checkbox"/> Primary and secondary data</li> </ul>		<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Know what each type of data looks like</li> <li><input type="checkbox"/> How to classify data into these types</li> <li><input type="checkbox"/> How to represent these different types of data appropriately</li> </ul>	<b>M1.6</b> <b>HSW6</b>

<b>2.2 Collecting scientific data</b>		<b>Maths</b>	<b>HSW</b>
<b>Scientific data can be collected using:</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Observation and measurement from experiments</li> <li><input type="checkbox"/> Surveys</li> <li><input type="checkbox"/> Sampling <ul style="list-style-type: none"> <li>• Random</li> <li>• Systematic</li> </ul> </li> <li><input type="checkbox"/> Estimation</li> <li><input type="checkbox"/> Cohort studies</li> <li><input type="checkbox"/> Meta-studies</li> <li><input type="checkbox"/> Computer modelling</li> </ul>	<b>M1.7</b>	<b>HSW3</b>
<b>2.3 Storage and presentation of scientific data</b>		<b>Maths</b>	<b>HSW</b>
<b>2.3.1 Scientific data can be stored on a:</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Personal database</li> <li><input type="checkbox"/> National database</li> <li><input type="checkbox"/> International database</li> </ul>	<b>M1.2</b>	<b>HSW9</b>
<b>2.3.2 Scientific data can be represented in different graphical forms:</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Scatter and line graph</li> <li><input type="checkbox"/> Bar chart</li> <li><input type="checkbox"/> Histogram</li> <li><input type="checkbox"/> Pie chart</li> <li><input type="checkbox"/> Kite diagram</li> <li><input type="checkbox"/> Cumulative graph</li> <li><input type="checkbox"/> Box and whisker plots</li> </ul>	<b>M1.6</b>	<b>HSW11</b>
<b>2.4 Interpreting data</b>		<b>Maths</b>	<b>HSW</b>
<b>2.4.1 Identifying patterns and relationships to:</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Draw conclusions</li> <li><input type="checkbox"/> Accept or reject a hypothesis</li> </ul>	<b>M3.1</b>	<b>HSW8</b>

<input type="checkbox"/> Inform further scientific investigation			
<b>Topic Area 3: Scientific developments</b>			
<b>Teaching content</b>	<b>Breadth and Depth</b>	<b>Opportunities to cover:</b>	
<b>3.1 Hypothesis, theory, and law</b>		<b>Maths</b>	<b>HSW</b>
<b>3.1.1 Scientific use of terms:</b> <input type="checkbox"/> Hypothesis <input type="checkbox"/> Prediction <input type="checkbox"/> Theory <input type="checkbox"/> Law	To include: <input type="checkbox"/> Know definitions of the terms <input type="checkbox"/> Know how to write a hypothesis and predictions <input type="checkbox"/> How a hypothesis may become a theory <input type="checkbox"/> How the term theory is used in science and in everyday language <input type="checkbox"/> The role of assumptions, estimations and approximations in science	<b>M0.4</b>	<b>HSW6</b>
<b>3.1.2 Scientific theory vs scientific law</b>	To include: <input type="checkbox"/> Know how a law is different from a theory <input type="checkbox"/> Both theories and laws require evidence and can be open to change and revision  Examples of <b>scientific theories</b> may include: <input type="checkbox"/> Theory of evolution <input type="checkbox"/> Theory of relativity <input type="checkbox"/> Atomic theory  Examples of <b>scientific laws</b> may include: <input type="checkbox"/> Newton's Laws of motion <input type="checkbox"/> Periodic Law <input type="checkbox"/> Laws of thermodynamics  Does not include: <input type="checkbox"/> Detailed information on each law or theory		<b>HSW11</b>
<b>3.2 Using new technologies in science</b>		<b>Maths</b>	<b>HSW</b>
<b>3.2.1 New technologies play an important part in continuing scientific development:</b> <input type="checkbox"/> Robotics and automation <input type="checkbox"/> Computer aided design (CAD)	To include: <input type="checkbox"/> Key concepts of each type of new technology <input type="checkbox"/> Advantages of the new technologies to further scientific development <input type="checkbox"/> How scientific disciplines might be supported by these technologies		<b>HSW9</b> <b>HSW10</b>

<ul style="list-style-type: none"> <li><input type="checkbox"/> Artificial intelligence and machine learning</li> <li><input type="checkbox"/> Quantum computing</li> <li><input type="checkbox"/> Big data analytics</li> <li><input type="checkbox"/> Smart technologies</li> <li><input type="checkbox"/> Advanced imaging technologies</li> <li><input type="checkbox"/> Augmented and virtual reality</li> </ul>	<p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Detailed descriptions of how each technology works</li> </ul>		
<b>3.2.2 Limitations and risks of new technologies in society</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Impacts on people, money, security and the environment</li> <li><input type="checkbox"/> How to identify the limitations and risks</li> <li><input type="checkbox"/> How judgements are made about the use of these new technologies</li> </ul>		<b>HSW9 HSW10</b>
<b>3.3 Implications and limitations of scientific developments</b>		<b>Maths</b>	<b>HSW</b>
<p><b>3.3.1 Considerations for scientific developments:</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Monetary costs and funding</li> <li><input type="checkbox"/> Social, ethical, and moral issues</li> <li><input type="checkbox"/> Environmental issues</li> <li><input type="checkbox"/> Benefits and limitations to society</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Know the importance of funding in science</li> <li><input type="checkbox"/> The role of private companies, charitable foundations or governments in scientific research</li> <li><input type="checkbox"/> Factors that affect research that is carried out</li> <li><input type="checkbox"/> How scientists receive funding for research</li> <li><input type="checkbox"/> What issues might arise and how they are classified as social, ethical or moral issues</li> </ul> <p>Examples of <b>scientific developments</b> may include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Stem cell therapies</li> <li><input type="checkbox"/> Proton beam therapy</li> <li><input type="checkbox"/> Electric vehicles</li> <li><input type="checkbox"/> GM crops</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Detailed understanding of research grant applications</li> <li><input type="checkbox"/> Detailed information on examples of scientific developments</li> </ul>		<b>HSW10 HSW11 HSW12</b>
<p><b>3.3.2 Contemporary issues that science will need to solve in the future:</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Climate change</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Know key concepts of these main issues</li> <li><input type="checkbox"/> What scientific disciplines will be necessary to solve these issues</li> <li><input type="checkbox"/> Social, ethical, and moral issues arising</li> <li><input type="checkbox"/> Economic and environmental considerations</li> </ul>		<b>HSW7 HSW9</b>

<input type="checkbox"/> Sustainability of natural resources <input type="checkbox"/> Conservation <input type="checkbox"/> Public health <input type="checkbox"/> Energy sources <input type="checkbox"/> Transport <input type="checkbox"/> Manufactured products	Examples of <b>contemporary issues</b> may include: <input type="checkbox"/> Antibiotic resistance <input type="checkbox"/> Self-driving electric vehicles <input type="checkbox"/> Use of palm oil <input type="checkbox"/> Nanotechnology		
<b>Topic Area 4: Communicating science</b>			
<b>Teaching content</b>	<b>Breadth and Depth</b>		<b>Opportunities to cover:</b>
<b>4.1 Methods of communication</b>		<b>Maths</b>	<b>HSW</b>
<b>4.1.1 Communicating science to the public using the media:</b> <input type="checkbox"/> Popular science books <input type="checkbox"/> TV documentaries <input type="checkbox"/> Blogs and vlogs <input type="checkbox"/> Podcasts <input type="checkbox"/> Social media <input type="checkbox"/> Websites <input type="checkbox"/> National newspapers <input type="checkbox"/> Science magazines	To include: <input type="checkbox"/> Know key features of each media <input type="checkbox"/> Advantages and disadvantages of communicating using each media <input type="checkbox"/> Know target audiences of each media <input type="checkbox"/> Language, structure, and images used for engagement of target audience <input type="checkbox"/> How to assess the effectiveness of a source of information in providing accurate information and being engaging <input type="checkbox"/> Know how to assess the validity of a source of information		<b>HSW11</b>
<b>4.1.2 Communicating science between experts:</b> <input type="checkbox"/> Journals <input type="checkbox"/> Meetings and seminars <input type="checkbox"/> Conferences and symposia <input type="checkbox"/> Online platforms and forums  <input type="checkbox"/> The process of peer review	To include: <input type="checkbox"/> Know why it is important for experts within scientific disciplines to engage with each other <input type="checkbox"/> Know why it is important for experts across scientific disciplines to engage with each other <input type="checkbox"/> Key features of each type of communication  <input type="checkbox"/> Know steps in the process of peer review <input type="checkbox"/> Why peer review is important <input type="checkbox"/> How the process of peer review increases reliability and validity of published information		<b>HSW8</b> <b>HSW11</b>

<b>4.2 Plagiarism</b>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Complete</li> <li><input type="checkbox"/> Direct</li> <li><input type="checkbox"/> Self</li> <li><input type="checkbox"/> Source-based</li> <li><input type="checkbox"/> Accidental</li> </ul> <p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Know definition of each type of plagiarism</li> <li><input type="checkbox"/> When each type of plagiarism could occur</li> <li><input type="checkbox"/> Why people plagiarise and why it matters</li> <li><input type="checkbox"/> How to avoid plagiarism</li> <li><input type="checkbox"/> Potential consequences of plagiarism</li> </ul>	<b>Maths</b>	<b>HSW</b>
<b>4.3 Using science to inform decision making</b>	<p><b>Different organisations that use science to inform their decision making:</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Government organisations</li> <li><input type="checkbox"/> Non-governmental organisations</li> <li><input type="checkbox"/> Private and commercial organisations</li> <li><input type="checkbox"/> Pressure, voluntary and charitable groups</li> </ul> <p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Know how organisations use scientific information and data</li> <li><input type="checkbox"/> Aims and objectives of these types of organisations</li> <li><input type="checkbox"/> The importance of these organisations in influencing public opinion</li> <li><input type="checkbox"/> The importance of these organisations in future scientific advancement</li> </ul> <p>Examples of different organisations may include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Environment Agency (EA)</li> <li><input type="checkbox"/> Health and Safety Executive (HSE)</li> <li><input type="checkbox"/> European Union (EU)</li> <li><input type="checkbox"/> United Nations (UN)</li> <li><input type="checkbox"/> Worldwide Fund for Nature (WWF)</li> <li><input type="checkbox"/> Greenpeace</li> </ul>	<b>Maths</b>	<b>HSW</b>
<b>4.4 Problems with communicating science</b>	<p><b>4.4.1 Public trust in the scientific community and developments</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Misinformation in science</li> <li><input type="checkbox"/> Misinformation vs disinformation</li> <li><input type="checkbox"/> Ways of improving public trust in the scientific community and developments</li> </ul> <p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Know how to differentiate between misinformation and disinformation</li> <li><input type="checkbox"/> How to identify potential misinformation and disinformation in science</li> <li><input type="checkbox"/> Why science might be misrepresented</li> <li><input type="checkbox"/> Different ways science can be misrepresented</li> <li><input type="checkbox"/> Possible causes of misinformation</li> <li><input type="checkbox"/> Sources of misinformation</li> <li><input type="checkbox"/> Know definition of scientific literacy</li> <li><input type="checkbox"/> Why it is important for all citizens in society to be scientifically literate</li> <li><input type="checkbox"/> How scientists can improve communication with citizens about developments and research</li> </ul>	<b>Maths</b>	<b>HSW</b>

<b>4.4.2 Bias in science communication</b> <ul style="list-style-type: none"><li><input type="checkbox"/> Confirmation bias</li><li><input type="checkbox"/> Publication bias</li><li><input type="checkbox"/> Reporting bias</li><li><input type="checkbox"/> Biased language</li><li><input type="checkbox"/> Conclusions influenced by other factors</li></ul>	To include: <ul style="list-style-type: none"><li><input type="checkbox"/> Contrast in how the term bias is used in science and in everyday language</li><li><input type="checkbox"/> Key ideas about each type of bias in science communication</li><li><input type="checkbox"/> Possible consequences of bias in science communication</li><li><input type="checkbox"/> Know how to avoid bias in science communication</li></ul>		<b>HSW11</b>
---	---	--	--------------

### Assessment guidance

This unit is assessed by an exam which contains pre-release material. The exam is 1 hours and 15 minutes and has 50 marks in total. All questions in the exam should be answered.

The exam has two sections:

- Section A has a range of 23-27 marks. Questions in Section A are specifically based on the pre-release material and can come from anywhere in the unit content.
- Section B has a range of 23-27 marks. Questions in Section B are not based on the pre-release material and can come from anywhere in the unit content.

The combined total of Section A and Section B will be 50 marks.

Content will be sampled from all topic areas of F181: Science in Society, with at least one question or part question relating to each topic area.

Content in this exam will have links to the 'How Science Works Concepts and Skills' and 'Mathematical skills for Applied Science'.

The pre-release material will be used to introduce novel contexts. This will provide opportunities for students to develop the skills of scientific literacy, research and scientific enquiry, and to engage more in self-directed learning. A wider understanding of the topics and issues raised in the pre-release material would be beneficial for the assessment.

Students are not required to understand any detailed scientific explanations beyond that outlined in the pre-release material, and in the mandatory units of the specification (Units F180, F181, F182).

It is recommended that students spend approximately 3-4 hours detailed study on this pre-release material.

The pre-release material will be issued electronically via OCR's secure website six weeks prior to the examination date. This will ensure that it is available at the same time for everyone. A clean hard copy of the pre-release material will be provided with the question paper in the examination.

This will be conducted under examination conditions. For more details refer to the **Administration area**.

A range of question types will be used in the exam including:

- Forced choice/controlled response questions – including MCQs
- Short answer, closed response questions (with or without diagrams)
- Short answer with calculation/working
- Extended constructed response with points-based mark scheme
- Extended constructed response with levels of response mark scheme

The Applied Science **Guide to our Sample Assessment Material** gives more information about the layout and expectations of the exam.

The exam for this unit assesses the following Performance Objectives:

- PO1 – Show knowledge and understanding
- PO2 – Apply knowledge and understanding
- PO3 – Analyse and evaluate knowledge, understanding and performance.

### **Synoptic assessment**

This unit allows students to gain underpinning knowledge and understanding relevant to the qualification and sector. The NEA units draw on and strengthen this learning as students will apply their learning to practical or applied tasks.

The following NEA units have synoptic links with this unit. The synoptic grids at the end of these NEA units show these synoptic links.

- Unit F182: Investigating science
- Unit F184: Environmental studies
- Unit F185: Forensic biology
- Unit F186: Medical physics

More information about synoptic assessment in these qualifications can be found in **Section 5.2 Synoptic Assessment**.

## 4.3 NEA Units

### 4.3.1 Unit F182: Investigating science

#### Unit Aim

Scientific research and investigation happen continuously. Scientific investigation is a series of steps of research that scientists take to solve problems by asking questions and testing possible answers. Research scientists conduct scientific investigations to test out new ideas, find explanations, build knowledge, and develop new technologies.

In this unit you will learn about the role of a research scientist in industry by learning how to conduct your own scientific investigation. You will develop the skills to research, plan and risk assess your investigation before safely undertaking the practical tasks. You will learn how to collect and analyse data and communicate your findings in a scientific report and a presentation. Finally, you will develop the skills to evaluate your investigation, including assessing the effectiveness of the methods used and suggesting improvements that could be made. You will be able to assess the relevance of your investigation to environmental, commercial and industrial processes.

<b>F182: Investigating science</b>			
<b>Topic Area 1: Planning a scientific investigation</b>			
<b>Teaching content</b>	<b>Exemplification</b>	<b>Opportunities to cover:</b>	
<b>1.1 Researching the topic</b>		<b>Maths</b>	<b>HSW</b>
<b>1.1.1</b> <input type="checkbox"/> How to undertake research: <ul style="list-style-type: none"> <li>• Selecting appropriate sources of primary and secondary information</li> <li>• Selecting methodologies to answer a question</li> <li>• Providing background information for putting an investigation in context</li> <li>• Risks and hazards associated with materials and methods</li> <li>• Limitations and sources of error</li> </ul>	To include: <ul style="list-style-type: none"> <li>□ How to identify relevant sources for an investigation</li> <li>□ How to evaluate sources of information using the Currency, Relevance, Authority, Accuracy and Purpose (CRAAP) test</li> <li>□ The importance of exploring multiple sources</li> <li>□ How to use research to relate an investigation to an environmental, commercial or industrial process</li> <li>□ Why there are limits to the amount and type of research that are achievable</li> </ul>	<b>M1.6</b>	<b>HSW2</b>

<ul style="list-style-type: none"> <li><input type="checkbox"/> Developing a research question for an investigation</li> <li><input type="checkbox"/> Creating a hypothesis and prediction</li> <li><input type="checkbox"/> Identifying relevant variables for an investigation</li> </ul>	<ul style="list-style-type: none"> <li><input type="checkbox"/> How to create an appropriate research question from a set title</li> <li><input type="checkbox"/> What makes a good research question, for example, that is SMART</li> <li><input type="checkbox"/> Understand the constraints of carrying out an investigation in schools</li> <li><input type="checkbox"/> The difference between a research question, hypothesis and prediction</li> <li><input type="checkbox"/> How to construct a hypothesis and prediction from a research question</li> <li><input type="checkbox"/> The importance of explaining the scientific principles behind an investigation</li> <li><input type="checkbox"/> How to explain the scientific principles that support a hypothesis and prediction</li> <li><input type="checkbox"/> Why a null hypothesis may also be useful and when they are appropriate</li> <li><input type="checkbox"/> How to accept or reject a hypothesis</li> <li><input type="checkbox"/> The difference between independent, dependent and control variables</li> <li><input type="checkbox"/> How to identify all relevant variables that might affect the outcome of an investigation</li> <li><input type="checkbox"/> How to decide if a variable is qualitative or quantitative</li> <li><input type="checkbox"/> How to evaluate significant variables to control in an investigation</li> </ul>		
<p><b>1.1.2</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Referencing using standard methods:           <ul style="list-style-type: none"> <li>• In-text citation</li> <li>• End-text citation</li> <li>• Creating a bibliography</li> </ul> </li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> How to reference citations in-text and end-text</li> <li><input type="checkbox"/> Why referencing is important</li> <li><input type="checkbox"/> The existence of different referencing systems</li> <li><input type="checkbox"/> The importance of consistency and clarity in referencing</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Specific details of any one referencing system</li> </ul>		<b>HSW2</b>
<p><b>1.2 Designing a scientific investigation</b></p> <p><b>1.2.1</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> A plan should include decisions about:           <ul style="list-style-type: none"> <li>• Variables</li> <li>• Method</li> <li>• Equipment</li> <li>• Measurements</li> <li>• Preliminary testing</li> </ul> </li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> How to select an investigation method that will answer the research question</li> <li><input type="checkbox"/> Making modifications to methods to answer a research question</li> <li><input type="checkbox"/> How to decide what values to select for the relevant variables in the investigation</li> <li><input type="checkbox"/> How to ensure a method is valid</li> <li><input type="checkbox"/> How to decide what preliminary tests are necessary for the success of the investigation</li> <li><input type="checkbox"/> How to modify a method to reduce errors</li> <li><input type="checkbox"/> What is meant by data of sufficient quality</li> <li><input type="checkbox"/> How to select equipment that produces data of sufficient quality</li> </ul>	<b>Maths</b> <b>M1.5</b> <b>M1.8</b>	<b>HSW</b> <b>HSW3</b>

	<input type="checkbox"/> The use of online databases, simulations and models as alternatives to practical investigations <input type="checkbox"/> Why there are limitations for the types of investigations that can be carried out in schools		
<b>1.2.2</b> <input type="checkbox"/> Risk assessment: <ul style="list-style-type: none"><li>• Identifying hazardous equipment, chemicals, biological hazards and procedures</li><li>• Risks</li><li>• Control measures</li><li>• Emergency measures</li></ul>	To include: <input type="checkbox"/> How to complete a risk assessment <input type="checkbox"/> How to differentiate between a hazard and risk <input type="checkbox"/> How to identify appropriate risks and hazards for an investigation <input type="checkbox"/> Hazard symbols and what they represent <input type="checkbox"/> How to select and interpret relevant information from chemical safety data sheets <input type="checkbox"/> How to explain control measures using scientific principles <input type="checkbox"/> Why it is important to be aware of emergency measures before carrying out an investigation		<b>HSW9</b>
<b>1.3 Conducting preliminary experiments</b>		<b>Maths</b>	<b>HSW</b>
<b>1.3.1</b> <input type="checkbox"/> Conducting preliminary experiments for making decisions about: <ul style="list-style-type: none"><li>• Techniques</li><li>• Equipment</li></ul> <input type="checkbox"/> Modifying a plan in response to preliminary testing	To include: <input type="checkbox"/> Why preliminary experiments are important <input type="checkbox"/> What information can be gained by conducting preliminary experiments <input type="checkbox"/> How to record and present outcomes of preliminary testing <input type="checkbox"/> How to evaluate the data from preliminary testing to decide if modifications are necessary <input type="checkbox"/> How to justify a plan using the data from the preliminary testing  Examples of <b>conducting preliminary experiments for making decisions</b> may include: <input type="checkbox"/> Techniques – length of time required, repeats required, values for variables <input type="checkbox"/> Equipment – sizes of equipment, quantities, concentrations of chemicals	<b>M1.2</b>	<b>HSW3</b>

<b>Topic Area 2: Performing a scientific investigation</b>			
<b>Teaching content</b>	<b>Exemplification</b>	<b>Opportunities to cover:</b>	
<b>2.1 Practical skills and apparatus</b>		<b>Maths</b>	<b>HSW</b>
<b>2.1.1</b> <input type="checkbox"/> Practical techniques <ul style="list-style-type: none"> <li>• Common practical methods available in schools               <ul style="list-style-type: none"> <li>◦ Types of variable that can be altered and measured</li> <li>◦ Risks and hazards</li> </ul> </li> <li>• Equipment               <ul style="list-style-type: none"> <li>◦ Common equipment available in schools</li> <li>◦ Calibration</li> <li>◦ Data collection of sufficient quality</li> <li>◦ Uncertainties</li> <li>◦ Common errors</li> </ul> </li> <li>• Databases and simulations</li> </ul>	To include: <ul style="list-style-type: none"> <li>◦ How the practical techniques in Unit F180: Fundamentals of science can be modified for use in an investigation</li> <li>◦ Why it is important to develop competency in practical techniques and how this can be achieved</li> <li>◦ How to access and use databases and simulations to produce data</li> <li>◦ Why it is important to work safely and with due care and attention in a scientific practical investigation</li> <li>◦ How to demonstrate skilful use of practical apparatus</li> <li>◦ How to identify and mitigate sources of error</li> <li>◦ How data of sufficient quality can be collected</li> <li>◦ How to determine the uncertainty associated with different measuring equipment and reduce uncertainty</li> <li>◦ How to calibrate equipment to reduce errors</li> <li>◦ How to assess the cleanliness and proper function of equipment</li> </ul>	<b>M1.5</b>	<b>HSW3 HSW4</b>
<b>2.2 Recording data from experiments</b>		<b>Maths</b>	<b>HSW</b>
<b>2.2.1</b> <input type="checkbox"/> Types of data available in practical investigations: <ul style="list-style-type: none"> <li>• Qualitative and quantitative data</li> <li>• Continuous and discrete data</li> <li>• Data from observations and measurements (including repeats)</li> </ul>	To include: <ul style="list-style-type: none"> <li>◦ Key features of each type of data</li> <li>◦ Advantages of each type of data in practical investigations</li> <li>◦ Appropriate units and conventions for each type of data</li> <li>◦ The importance of recording all relevant forms of data</li> </ul>	<b>M1.6</b>	<b>HSW6</b>

<ul style="list-style-type: none"> <li><input type="checkbox"/> Recording data in:           <ul style="list-style-type: none"> <li>• Diagrams, images, and video</li> <li>• Results tables</li> <li>• Spreadsheets</li> <li>• Dataloggers</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Advantages and disadvantages of different ways of recording data</li> <li><input type="checkbox"/> How to select a format for recording data that suits the data being collected</li> <li><input type="checkbox"/> Use of appropriate column headings and units</li> <li><input type="checkbox"/> Use of appropriate levels of precision</li> </ul>		
<b>Topic Area 3: Analysing and communicating results</b>			
Teaching content	Exemplification	Opportunities to cover:	
<b>3.1 Analysing data</b>		<b>Maths</b>	<b>HSW</b>
<b>3.1.1</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Using mathematical skills from Mathematical Skills for Applied Science (Appendix D) to analyse data in investigations           <ul style="list-style-type: none"> <li>• Processing data</li> <li>• Using graphical techniques to analyse data</li> </ul> </li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> How to select which mathematical skills are appropriate</li> <li><input type="checkbox"/> The value of processing raw data for analysis</li> <li><input type="checkbox"/> How to use appropriate mathematical skills</li> <li><input type="checkbox"/> How to propagate uncertainties to determine total uncertainty</li> <li><input type="checkbox"/> How to determine when and which statistical analysis is appropriate</li> <li><input type="checkbox"/> How to use spreadsheets to process data</li> <li><input type="checkbox"/> How to draw each type of graph, including error bars and lines and curves of best fit</li> <li><input type="checkbox"/> How to select appropriate graph(s) to suit the data recorded</li> <li><input type="checkbox"/> How to use spreadsheets to draw graphs, error bars, and lines and curves of best fit</li> </ul>	<b>M1.6</b> <b>M3.1</b>	<b>HSW6</b>
<b>3.1.2</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Types of errors           <ul style="list-style-type: none"> <li>• Random</li> <li>• Systematic</li> </ul> </li> <li><input type="checkbox"/> Outliers and anomalous data</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Definitions of random and systematic error</li> <li><input type="checkbox"/> How to identify each type of error in an investigation</li> <li><input type="checkbox"/> How to explain reasons for errors</li> <li><input type="checkbox"/> The difference between an outlier and an anomalous result</li> <li><input type="checkbox"/> How to identify outliers and anomalous data in tables and graphs</li> <li><input type="checkbox"/> Causes and effects of outliers and anomalous data</li> <li><input type="checkbox"/> How to account for outliers and anomalous data</li> </ul>	<b>M1.8</b>	<b>HSW6</b>
<b>3.2 Writing conclusions</b>		<b>Maths</b>	<b>HSW</b>
<b>3.2.1</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Using mathematical skills from Mathematical Skills for Applied Science (Appendix D) to interpret data from graphs:</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> How to mathematically interpret data from graphs and when it is necessary</li> <li><input type="checkbox"/> How to find values by interpolation and extrapolation</li> </ul>	<b>M3.3</b> <b>M3.4</b>	<b>HSW5</b>

<ul style="list-style-type: none"> <li><input type="checkbox"/> Using patterns and relationships from graphs to make conclusions.</li> </ul>	<ul style="list-style-type: none"> <li><input type="checkbox"/> How to interpret patterns of data from different types of graphs</li> <li><input type="checkbox"/> How to describe relationships shown by patterns in graphs</li> <li><input type="checkbox"/> The difference between a correlation and causation</li> <li><input type="checkbox"/> Examples of patterns and relationships from graphs to include: <ul style="list-style-type: none"> <li>• Overlapping error bars between plotted points</li> <li>• Slope of lines of best fit</li> <li>• Inflection points</li> </ul> </li> </ul>		
<b>3.2.2</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Conclusions from data <ul style="list-style-type: none"> <li>• Comparing results to secondary data</li> <li>• Confidence in conclusions</li> <li>• Relating the investigation and data to environmental, commercial and industrial processes</li> <li>• Answering the research question</li> </ul> </li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> How to write a concise conclusion(s) from primary and secondary data</li> <li><input type="checkbox"/> How to select appropriate data from secondary sources to compare results to</li> <li><input type="checkbox"/> How to make valid comparisons between primary and secondary data</li> <li><input type="checkbox"/> What is meant by confidence in conclusions for an investigation</li> <li><input type="checkbox"/> How to explain the impact of limitations on a conclusion</li> <li><input type="checkbox"/> How the conclusion(s) is/are relevant to environmental, commercial and industrial processes</li> <li><input type="checkbox"/> How to address the extent to which the research question was answered</li> </ul>		<b>HSW11</b>
<b>3.3 Communicating results</b>	<p><b>3.3.1</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Writing a scientific report of the investigation</li> </ul> <p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> What should be included in a scientific report</li> <li><input type="checkbox"/> The importance of each section of the report</li> <li><input type="checkbox"/> Use of appropriate scientific terminology and the level of detail required in scientific reports</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Writing abstracts</li> </ul>	<b>Maths</b>	<b>HSW</b>
<b>3.3.2</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Defending conclusions</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> What is meant by a defence of conclusions</li> <li><input type="checkbox"/> How scientists defend their research to peers</li> <li><input type="checkbox"/> How to present a brief summary of the investigation</li> <li><input type="checkbox"/> How to communicate clearly</li> <li><input type="checkbox"/> How to prepare for challenges to the conclusions of an investigation</li> <li><input type="checkbox"/> How to form relevant questions to challenge the investigation of peers</li> </ul>		<b>HSW6</b>

Topic Area 4: Evaluating a scientific investigation			
Teaching content	Exemplification	Opportunities to cover:	
4.1 Evaluating the investigation		Maths	HSW
4.1.1 <ul style="list-style-type: none"> <li><input type="checkbox"/> Evaluating the investigation <ul style="list-style-type: none"> <li>• Equipment</li> <li>• Methods</li> <li>• Outcomes</li> <li>• Sources of information and secondary data</li> </ul> </li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Why it is important to evaluate an investigation</li> <li><input type="checkbox"/> How to assess the effectiveness of the equipment and methods used</li> <li><input type="checkbox"/> How to assess the methods used to process and display the data</li> <li><input type="checkbox"/> How to explain the limitations and sources of error in collected data</li> <li><input type="checkbox"/> How to decide the reliability of sources of information and secondary data used in the investigation</li> <li><input type="checkbox"/> How to suggest improvements for an investigation, limited to those available in schools</li> <li><input type="checkbox"/> How to decide if the improvements are appropriate and what impact they will have</li> </ul>	M1.8	HSW4

### Assessment criteria

Section 6.4 provides full information on how to assess the NEA units and apply the assessment criteria.

These are the assessment criteria for the tasks for this unit. The assessment criteria indicate what is required in each task. Students' work must show that all aspects of a criterion have been met in sufficient detail for it to be **successfully achieved** (see Section 6.4.1). If a student's work does not fully meet a criterion, you must not award that criterion.

The command words used in the assessment criteria are defined in **Appendix B**.

Pass	Merit	Distinction
<b>P1:</b> Use research to <b>create</b> an appropriate research question from <b>one</b> of the given investigation titles.	<b>M1:</b> <b>Explain</b> the scientific principles behind the investigation.	<b>D1:</b> Use research to <b>explain</b> how the scientific principles behind the investigation relate to environmental, commercial, and industrial processes.
<b>P2:</b> <b>Construct</b> a hypothesis, and a prediction.		
<b>P3:</b> <b>Produce</b> a plan for the full investigation which includes a method for the preliminary testing.	<b>M2:</b> <b>Explain</b> the choice of equipment and variables for the full investigation.	<b>D2:</b> <b>Justify</b> the plan using the data from the preliminary testing.
<b>P4:</b> Use research to <b>complete</b> a risk assessment for your investigation.	<b>M3:</b> <b>Explain</b> the choices for the preliminary testing aspect of your method.	

<b>P5:</b> Present the outcomes of your preliminary testing.		
<b>P6:</b> Complete the investigation by following your plan safely.	<b>M4:</b> Collect data of sufficient quality to help answer the research question.	
<b>P7:</b> Collect valid data following your plan.		
<b>P8:</b> Record the data obtained in appropriate ways using correct conventions and units.		
<b>P9:</b> Use standard mathematical skills to process data.	<b>M5:</b> Use spreadsheets to appropriately process the data.	<b>D3:</b> Justify the methods used to process and display data.
<b>P10:</b> Use appropriate graphical representation(s) to display data.		
	<b>M6:</b> Calculate percentage uncertainties for the investigation.	<b>D4:</b> Explain the sources of error.
<b>P11:</b> Write appropriate conclusions from the data obtained.	<b>M7:</b> Make valid qualitative comparisons between primary and secondary data.	
<b>P12:</b> Explain the limitations of the data collected, including the method used to collect the data.	<b>M8:</b> Evaluate the sources of information and secondary data.	<b>D5:</b> Justify suggestions for any improvements that could be made.
		<b>D6:</b> Assess the relevance of your investigation and data to environmental, commercial and industrial processes.
<b>P13:</b> Present your conclusions.		
<b>P14:</b> Defend your conclusions.		

## Assessment guidance

This assessment guidance gives you information relating to the assessment criteria. There might not be additional assessment guidance for each assessment criterion. It is included only where it is needed.

Assessment Criteria	Assessment guidance
P1	<ul style="list-style-type: none"> <li>Teachers must discuss with students the research they completed independently to inform their research question, giving students the opportunity to say: <ul style="list-style-type: none"> <li>What research they completed</li> <li>How they completed it</li> <li>Why they used the research methods they did.</li> </ul> </li> <li>The research question must include one independent and one dependent variable, and an indication of how investigation will be performed (e.g. via titration, using gas syringe, colorimetry).</li> <li>The data collected for both variables will need to be quantitative.</li> <li>The research should include data that the student can use to help them create their research question, and to allow them to then make a comparison later on between this data and their collected data in <b>M7</b>.</li> <li>The research element of this criterion does not need to be completed under supervised conditions.</li> </ul>
M1	<ul style="list-style-type: none"> <li>Students must apply knowledge and understanding from Unit F180 to explain the scientific principles behind the investigation.</li> </ul>
D1	<ul style="list-style-type: none"> <li>Students must explain how the scientific principles in <b>M1</b> and their research question in <b>P1</b> can relate to real world understanding or applications. Students must explain how the scientific principles behind the investigation relate to environmental, commercial, and industrial processes.</li> <li>If any of environmental, commercial and/or industrial processes are not appropriate, students must explain why.</li> <li>The research element of this criterion does not need to be completed under supervised conditions.</li> </ul>
P3	<ul style="list-style-type: none"> <li>Students must provide a step-by-step method that includes all of the equipment they wish to use, including sizes and quantities, personal protective equipment (PPE) as appropriate, and includes the number of repeats they will do.</li> <li>There must be a separate section describing how the preliminary tests will be carried out.</li> <li>They must state the control variables and account for how they will be controlled throughout the investigation. This could be in the form of a table.</li> </ul>
P4	<ul style="list-style-type: none"> <li>The research element of this criterion does not need to be completed under supervised conditions.</li> </ul>
P5	<ul style="list-style-type: none"> <li>A results table may be appropriate for most investigations, but qualitative descriptions are also suitable.</li> <li>The teacher observation record form should comment on the independent collection of data from preliminary testing.</li> </ul>
M2	<ul style="list-style-type: none"> <li>Students must consider how the equipment chosen will help with the collection of valid and high-quality data.</li> <li>Students must explain why each variable (independent, dependent and control) was chosen for this investigation, and explain the range of value(s) they have decided to test.</li> </ul>
M3	<ul style="list-style-type: none"> <li>Students must give reasons for the method and range of variables to be tested in the preliminary testing, and what information they expect to be useful for carrying out the full investigation.</li> </ul>

D2	<ul style="list-style-type: none"> <li>Students must explain any decisions made about modifications to the original plan in relation to the preliminary testing. They must also account for any absence of modifications.</li> </ul>
P6	<ul style="list-style-type: none"> <li>Students must follow their plan safely, including consideration of the control measures outlined in their risk assessment.</li> <li>The teacher observation record form should comment on the safe carrying out of the procedures.</li> </ul>
P7	<ul style="list-style-type: none"> <li>Students must collect data about all of the variables discussed in the plan, i.e. also the control variables.</li> </ul>
M4	<ul style="list-style-type: none"> <li>The teacher observation record form should comment on the skilful use of apparatus and the accuracy and precision of data collected.</li> </ul>
P9	<ul style="list-style-type: none"> <li>Students must use mathematical skills identified in the specification to process their data appropriately.</li> <li>They must show at least one example of their full working out in the written evidence.</li> </ul>
P10	<ul style="list-style-type: none"> <li>Appropriate trendlines and error bars should be included.</li> </ul>
P11	<ul style="list-style-type: none"> <li>An analysis of the data is required to write appropriate conclusions.</li> <li>A limited scientific explanation is required.</li> </ul>
M5	<ul style="list-style-type: none"> <li>Students must use spreadsheet packages (e.g. Microsoft Excel) to calculate, for example, standard deviation.</li> <li>Students can also use spreadsheets to help them process and represent data in <b>P9</b> and <b>P10</b>.</li> </ul>
M6	<ul style="list-style-type: none"> <li>Students must calculate the percentage uncertainty on each piece of equipment used and the combined uncertainty for each repeat.</li> <li>They must show their full working out in the written evidence.</li> </ul>
M7	<ul style="list-style-type: none"> <li>Students must make a qualitative comparison between their collected data and one source of appropriate secondary data.</li> <li>The secondary data should come from the research completed in <b>P1</b>.</li> </ul>
D3	<ul style="list-style-type: none"> <li>Students must justify their methods for processing and displaying the data in their report. E.g. the type of graph used, any data they had identified as anomalous, positioning of lines of best fit, etc.</li> </ul>
D4	<ul style="list-style-type: none"> <li>Students must account for any anomalous results or patterns in the data that do not appear to fit the hypothesis.</li> <li>If there are no anomalous results, students must explain how they arrived at this decision.</li> <li>This should be done qualitatively only.</li> </ul>
P12	<ul style="list-style-type: none"> <li>Students should also explain how well they were able to collect good quality data with the techniques and equipment chosen.</li> <li>This should be supported by evidence collected during the investigation.</li> </ul>
P13	<ul style="list-style-type: none"> <li>The research question should be presented, a brief explanation of the methods followed, and the data summarised. The extent to which the research question was answered should be justified.</li> <li>This can be delivered to the assessor and/or peers.</li> </ul>
P14	<ul style="list-style-type: none"> <li>The assessor should ask appropriate questions to enable the student to defend their investigation adequately. For example: <ul style="list-style-type: none"> <li>Were there any limitations that prevented the research question being answered in full?</li> <li>Are you confident errors had little impact on your results?</li> <li>Are your conclusions justified sufficiently by the data you collected?</li> </ul> </li> <li>The teacher observation record form should include the questions posed and comment on how well they were answered following the student's presentation in <b>P13</b>.</li> </ul>

M8	<ul style="list-style-type: none"> <li>Students should include judgements on their confidence in the sources used throughout the investigation, e.g. those used to design the method, create the risk assessment, and the secondary data, with reference to reliability and validity.</li> </ul>
D5	<ul style="list-style-type: none"> <li>Students should give valid reasons for improvements to the investigation that would improve the conclusion(s) or help answer the research question.</li> <li>Processed data should be used to support any recommendations.</li> <li>If no improvements can be recommended then this needs to be explained using evidence from the investigation.</li> </ul>
D6	<ul style="list-style-type: none"> <li>Students should provide reasons, based on the evidence collected during the investigation, about the relevance of conclusions made to environmental, commercial and industrial processes.</li> <li>If any of environmental, commercial and/or industrial processes are not relevant, students must explain why.</li> </ul>

### Synoptic assessment

Some of the knowledge, understanding and skills needed to complete this unit will draw on the learning in Units F180 and F181.

This table details these synoptic links.

Unit F182: Investigating science		Unit F180: Fundamentals of science	
Topic Area		Topic Area	
2	Performing a scientific investigation	B1	Cell structure and microscopy
		B4	Biodiversity and ecosystems
		C2	Quantitative chemistry
		C4	Rates of reaction and enthalpy changes
		P1	Electricity
		P2	Motion

Unit F182: Investigating science		Unit F181: Science in society	
Topic Area		Topic Area	
1	Planning a scientific investigation	4	Communicating science
3	Analysing and communicating results	1	What scientists do

More information about synoptic assessment in these qualifications can be found in **Section 5.2 Synoptic assessment**.

## 4.3.2 Unit F183: Analytical techniques in chemistry

**Unit Aim**

Science is ever evolving. Improving our understanding of substances and how they are composed and interact is key to driving innovation in areas such as chemical sciences, forensic science, biochemical science and environmental science. This unit explores how to identify chemical substances and determine quantities present by using a wide range of techniques to separate and analyse the composition. The knowledge and skills developed will give you a solid basis for further progression in a range of scientific fields.

In this unit you will learn how to plan and perform practical investigations to separate substances and purify them. You will also learn how to categorise different types of substance according to their physical properties and determine amounts present in a substance or solution. You will develop the skills to use chemical tests to identify the presence of specific ions and molecules and interpret spectra to provide information about the structure of molecules. Studying this unit will help you develop analytical skills, make logical deductions and conclusions from observations and interpret results and data. You will gain planning and problem-solving skills by selecting and applying techniques as well as understanding the principles behind the tests and equipment used.

<b>Unit F183: Analytical techniques in chemistry</b>			
<b>Topic Area 1: Techniques to categorise and separate chemical substances</b>			
<b>Teaching content</b>	<b>Exemplification</b>	<b>Opportunities to cover:</b>	
<b>1.1 Chemical substances and their properties</b>		<b>Maths</b>	<b>HSW</b>
<b>1.1.1 Distinguishing between different types of chemical substance</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Elements           <ul style="list-style-type: none"> <li>• Metal</li> <li>• Metalloid</li> <li>• Non-metal</li> </ul> </li> <li><input type="checkbox"/> Mixtures</li> <li><input type="checkbox"/> Compounds</li> <li><input type="checkbox"/> Structure types           <ul style="list-style-type: none"> <li>• Lattices</li> <li>• Giant</li> <li>• Simple</li> </ul> </li> <li><input type="checkbox"/> Physical properties of substances           <ul style="list-style-type: none"> <li>• Electrical and thermal conductivity</li> </ul> </li> </ul>	To include: <ul style="list-style-type: none"> <li><input type="checkbox"/> The difference between a pure substance and a mixture</li> <li><input type="checkbox"/> Methods to determine the physical properties of a substance to support identification</li> <li><input type="checkbox"/> How to compare physical properties of materials with data books/tables to support identification</li> <li><input type="checkbox"/> The limitations of data from books and tables</li> <li><input type="checkbox"/> How to distinguish between a pure substance and a mixture via physical properties and other observations</li> <li><input type="checkbox"/> The limitations of using physical properties to predict the identity of a material</li> <li><input type="checkbox"/> How physical properties of mixtures can be altered, for example, melting point</li> <li><input type="checkbox"/> Determining and comparing the cooling curves of pure and impure compounds</li> <li><input type="checkbox"/> The use of IT to create cooling curves</li> </ul> Does not include: <ul style="list-style-type: none"> <li><input type="checkbox"/> Atomic structure, isotopes, periodicity, reactivity</li> </ul>	<b>M3.1</b> <b>M3.2</b>	<b>HSW1</b>

<ul style="list-style-type: none"> <li>• Melting and boiling point</li> <li>• Density</li> <li>• Malleability</li> <li>• Ductility</li> <li>• Brittleness</li> <li>• Hardness</li> <li>• Solubility</li> </ul>			
<b>1.2 Separating chemical substances</b>		<b>Maths</b>	<b>HSW</b>
<b>1.2.1 Techniques to separate substances</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Filtration <ul style="list-style-type: none"> <li>• Gravity</li> <li>• Reduced pressure</li> </ul> </li> <li><input type="checkbox"/> Centrifugation</li> <li><input type="checkbox"/> Solvent extraction</li> <li><input type="checkbox"/> Recrystallisation</li> <li><input type="checkbox"/> Drying</li> <li><input type="checkbox"/> Sublimation</li> <li><input type="checkbox"/> Distillation <ul style="list-style-type: none"> <li>• Simple</li> <li>• Steam</li> <li>• Reduced pressure</li> </ul> </li> <li><input type="checkbox"/> Fractional distillation</li> <li><input type="checkbox"/> Chromatography <ul style="list-style-type: none"> <li>• Paper</li> <li>• Thin Layer Chromatography (TLC)</li> <li>• Column</li> <li>• Ion-exchange</li> <li>• Gel-permeation</li> <li>• Gas-Liquid Chromatography (GLC)</li> <li>• High Performance Liquid Chromatography (HPLC)</li> </ul> </li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Why all substances can be considered to be mixtures</li> <li><input type="checkbox"/> The principles of each separation technique and their use</li> <li><input type="checkbox"/> The appropriateness of each separation technique for different types of mixtures</li> <li><input type="checkbox"/> How to carry out those separation techniques available to schools</li> <li><input type="checkbox"/> The risks and hazards associated with the techniques that can be performed in schools</li> <li><input type="checkbox"/> The advantages and disadvantages of each separation technique <ul style="list-style-type: none"> <li>• Examples to include decomposition, flammability and reactivity</li> </ul> </li> <li><input type="checkbox"/> Why some techniques are combined or repeated to increase the purity of a substance</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Synthesis of compounds</li> </ul>	<b>HSW4</b>	

<b>1.2.2 Testing the purity of a substance</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> The principles and use of techniques to determine purity of a substance, including the instrumental techniques mentioned within this unit</li> <li><input type="checkbox"/> How to choose appropriate tests for purity</li> <li><input type="checkbox"/> The advantages and disadvantages of each test</li> <li><input type="checkbox"/> How to perform tests for purity available to schools</li> <li><input type="checkbox"/> The risks and hazards associated with the tests that can be performed in schools</li> <li><input type="checkbox"/> Suitability of different types of equipment for each test to produce accurate results, and their uncertainties</li> <li><input type="checkbox"/> Analysing chromatograms to determine percentage purity and identities of components</li> <li><input type="checkbox"/> Calculating R<sub>f</sub> values and using these to identify a substance</li> <li><input type="checkbox"/> Use the equation:  <math display="block">R_f = \frac{\text{distance of component from base line (cm)}}{\text{distance of solvent front from base line (cm)}}</math> </li> <li><input type="checkbox"/> Using data books or tables to identify substances by their R<sub>f</sub> values</li> <li><input type="checkbox"/> The limitations of data from books and tables</li> <li><input type="checkbox"/> Analysing cooling curves to determine melting or boiling points and purity of substances</li> </ul>	<b>M0.3 M2.3</b>	<b>HSW2 HSW10</b>
--	--	----------------------	-----------------------

### Topic Area 2: Quantitative and qualitative analytical techniques to quantify and identify substances

Teaching content	Exemplification	Opportunities to cover:	
2.1 Quantitative analysis		Maths	HSW
<b>2.1.1 Quantitative analysis of solids</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> How amount, mass and volume of substances produced in reactions can be used to determine the identity of a substance</li> <li><input type="checkbox"/> How to select the appropriate quantitative analysis technique, including the instrumental techniques mentioned within this unit</li> <li><input type="checkbox"/> The advantages and disadvantages of each method of quantitative analysis</li> <li><input type="checkbox"/> How to carry out the analysis techniques available to schools</li> <li><input type="checkbox"/> The risks and hazards associated with the techniques that can be performed in schools</li> <li><input type="checkbox"/> Suitability of different types of equipment for each technique to produce accurate results, and their uncertainties</li> </ul>	<b>M0.3 M1.5 M1.8</b>	<b>HSW3</b>
<b>2.1.2 Qualitative analysis of substances</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> How to identify substances using qualitative analysis techniques, including the instrumental techniques mentioned within this unit</li> <li><input type="checkbox"/> The advantages and disadvantages of each technique</li> <li><input type="checkbox"/> How to carry out the analysis techniques available to schools</li> <li><input type="checkbox"/> The risks and hazards associated with the techniques that can be performed in schools</li> <li><input type="checkbox"/> Suitability of different types of equipment for each technique to produce accurate results, and their uncertainties</li> </ul>	<b>M0.3 M1.5 M1.8</b>	<b>HSW3</b>

	<ul style="list-style-type: none"> <li><input type="checkbox"/> Examples:           <ul style="list-style-type: none"> <li>• Determine chemical formulae of metal oxides</li> <li>• Determine stoichiometric equation and chemical formulae of products of thermal decomposition</li> <li>• Identify unknown metals / metal carbonates from their reaction with an acid</li> <li>• Identify ions using precipitation reaction</li> </ul> </li> </ul>		
<b>2.1.2 Quantitative analysis of solutions</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> How to select the appropriate quantitative analysis technique, including the instrumental techniques mentioned within this unit</li> <li><input type="checkbox"/> How to identify the appropriate standard solution to use in a titration</li> <li><input type="checkbox"/> How to select the correct indicator for a titration</li> <li><input type="checkbox"/> Preparation of and importance of serial dilutions</li> <li><input type="checkbox"/> How to carry out different types of titration to determine concentration, including acid-base, redox, complexometric and back titrations</li> <li><input type="checkbox"/> Suitability of different types of equipment in a titration to produce accurate results, and their uncertainties</li> <li><input type="checkbox"/> Common errors, risks and hazards associated with techniques available in schools</li> <li><input type="checkbox"/> How to use a colorimeter, produce calibration curves and use IT in colorimetry</li> <li><input type="checkbox"/> How to use instrumentation in titration:           <ul style="list-style-type: none"> <li>• Thermometer for thermometric titration</li> <li>• pH meter for monitoring pH change</li> <li>• Autotitrators</li> </ul> </li> <li><input type="checkbox"/> The advantages and disadvantages of each method of quantitative analysis</li> </ul>	<b>M0.3 M1.5</b>	<b>HSW3</b>
<b>2.2 Qualitative analysis</b>		<b>Maths</b>	<b>HSW</b>
<b>2.2.1 Identification of inorganic substances</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> How to perform qualitative analysis for the presence (and absence) of the listed anions, cations and gases to determine the identity of an inorganic substance</li> <li><input type="checkbox"/> How to use these tests to confirm purity of a substance</li> <li><input type="checkbox"/> Common errors, risks and hazards associated with tests available in schools</li> <li><input type="checkbox"/> How to select the appropriate qualitative analysis technique, including the instrumental techniques</li> <li><input type="checkbox"/> The principles of each instrumental technique and their use to identify ions and gases</li> <li><input type="checkbox"/> The advantages and disadvantages of each method of qualitative analysis</li> </ul>		<b>HSW4</b>

<ul style="list-style-type: none"> <li><input type="checkbox"/> Chemical tests for cations           <ul style="list-style-type: none"> <li>• <math>\text{Li}^+</math></li> <li>• <math>\text{Na}^+</math></li> <li>• <math>\text{K}^+</math></li> <li>• <math>\text{Mg}^{2+}</math></li> <li>• <math>\text{Ca}^{2+}</math></li> <li>• <math>\text{Ba}^{2+}</math></li> <li>• <math>\text{Al}^{3+}</math></li> <li>• <math>\text{Fe}^{2+}</math></li> <li>• <math>\text{Fe}^{3+}</math></li> <li>• <math>\text{Cu}^{2+}</math></li> <li>• <math>\text{H}^+</math></li> <li>• <math>\text{NH}_4^+</math></li> </ul> </li> <li><input type="checkbox"/> Chemical tests for anions           <ul style="list-style-type: none"> <li>• Hydroxide (<math>\text{OH}^-</math>)</li> <li>• Carbonate (<math>\text{CO}_3^{2-}</math>)</li> <li>• Sulfate (<math>\text{SO}_4^{2-}</math>)</li> <li>• Chloride (<math>\text{Cl}^-</math>)</li> <li>• Bromide (<math>\text{Br}^-</math>)</li> <li>• Iodide (<math>\text{I}^-</math>)</li> </ul> </li> <li><input type="checkbox"/> Combined chemical tests to identify inorganic compounds</li> <li><input type="checkbox"/> Alternative techniques using instrumentation           <ul style="list-style-type: none"> <li>• Atomic emission spectroscopy (AES)</li> <li>• Colorimetry</li> </ul> </li> </ul>			
<p><b>2.2.2 Identification of organic compounds</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Chemical tests for functional groups of organic compounds           <ul style="list-style-type: none"> <li>• Alkenes</li> <li>• Alcohols</li> <li>• Halogenoalkanes</li> <li>• Carbonyl compounds</li> </ul> </li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> How to perform chemical tests to identify the functional group of these organic compounds</li> <li><input type="checkbox"/> How to use these tests to confirm purity of a substance</li> <li><input type="checkbox"/> Common errors, risks and hazards associated with tests available in schools</li> </ul>		<b>HSW6</b>

<ul style="list-style-type: none"> <li>• Carboxylic acids</li> </ul> <p><input type="checkbox"/> Alternative techniques using instrumentation           <ul style="list-style-type: none"> <li>• Infrared spectroscopy</li> <li>• UV-visible spectroscopy</li> <li>• Fluorescence spectroscopy</li> <li>• Colorimetry</li> </ul> </p>	<ul style="list-style-type: none"> <li><input type="checkbox"/> How to select the appropriate qualitative analysis technique, including the instrumental techniques</li> <li><input type="checkbox"/> The principles of each instrumental technique and their use to confirm the organic compounds</li> <li><input type="checkbox"/> The advantages and disadvantages of each method of qualitative analysis</li> </ul>		
---	---	--	--

**Topic Area 3: The principles of spectroscopic techniques and interpreting spectra for chemical substances**

Teaching content	Exemplification	Opportunities to cover:	
3.1 Spectroscopic techniques		Maths	HSW
<b>3.1.1 Mass spectrometry</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Principles</li> <li><input type="checkbox"/> Spectrum interpretation</li> <li><input type="checkbox"/> Relative Atomic Mass (RAM) and Relative Formula Mass (RFM) determination</li> <li><input type="checkbox"/> Molecular ion</li> <li><input type="checkbox"/> Fragmentation patterns</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> An introduction to the principles of mass spectrometry and its applications</li> <li><input type="checkbox"/> Interpreting mass spectra to determine the RFM of molecules, limited to those encountered in this specification.</li> <li><input type="checkbox"/> How to interpret fragmentation patterns to deduce structural features for molecules</li> <li><input type="checkbox"/> How to use mass spectrometry in conjunction with percentage mass data, qualitative tests and chromatography (GC-MS)</li> </ul> <p>Does not include</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Ions with charges greater than 1</li> <li><input type="checkbox"/> Detailed features of mass spectroscopy and the equipment involved</li> </ul>	<b>M0.1</b> <b>M0.4</b>	<b>HSW5</b>
<b>3.1.2 Infrared spectroscopy</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Principles</li> <li><input type="checkbox"/> Spectrum interpretation</li> <li><input type="checkbox"/> Use of data reference table of covalent bonds</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> An introduction to the principles of infrared spectroscopy and its applications</li> <li><input type="checkbox"/> How to interpret infrared spectra to determine the types of covalent bonds and functional groups present in molecules, limited to those given in this specification</li> <li><input type="checkbox"/> How to determine the purity or concentration of compounds</li> <li><input type="checkbox"/> How to use infrared spectrometry in conjunction with percentage mass data, qualitative tests and mass spectrometry to identify an unknown organic compound</li> </ul>		<b>HSW8</b>

<p><b>3.1.3 Carbon-13 Nuclear magnetic resonance (<math>^{13}\text{C}</math>-NMR) spectroscopy</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Principles</li> <li><input type="checkbox"/> Spectrum interpretation using data reference table of chemical shifts</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> An introduction to the principles of NMR spectroscopy and its applications</li> <li><input type="checkbox"/> How to interpret <math>^{13}\text{C}</math>-NMR spectrums to determine the structure of molecules, limited to those given in this specification</li> <li><input type="checkbox"/> How to use NMR spectrometry in conjunction with percentage mass data, qualitative tests, mass spectrometry and infrared spectrometry to confirm the identity of an organic compound</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Details about the use of TMS or magnetic fields</li> <li><input type="checkbox"/> Detailed knowledge about magnetic nuclear spin</li> </ul>	M3.1	HSW8
--	---	------	------

### Assessment criteria

[Section 6.4](#) provides full information on how to assess the NEA units and apply the assessment criteria.

These are the assessment criteria for the tasks for this unit. The assessment criteria indicate what is required in each task. Students' work must show that all aspects of a criterion have been met in sufficient detail for it to be **successfully achieved** (see [Section 6.4.1](#)). If a student's work does not fully meet a criterion, you must not award that criterion.

The command words used in the assessment criteria are defined in [Appendix B](#).

Pass	Merit	Distinction
<b>P1:</b> Identify appropriate tests and techniques to investigate the unknown compounds in a logically sequenced order.		
<b>P2:</b> Identify appropriate equipment, reagents and quantities to investigate the unknown compounds.		
<b>P3:</b> Use research to <b>complete</b> a risk assessment for your investigation.		
<b>P4:</b> Perform separating techniques identified in the plan for the unknown organic compound safely and skilfully.	<b>M1:</b> Use appropriate techniques to confirm the purity of the isolated compound.	<b>D1:</b> Justify the identity of the organic compound.

Pass	Merit	Distinction
<b>P5: Perform</b> qualitative tests identified in the plan to determine the functional group of the organic compound safely.	<b>M2: Interpret</b> spectra to confirm the identity of the organic compound.	
<b>P6: Perform</b> appropriate separating techniques for the unknown inorganic compound.	<b>M3: Use</b> appropriate techniques to confirm the purity of the isolated compound.	<b>D2: Evaluate</b> the accuracy of the percentage purity of the inorganic compound.
<b>P7: Perform</b> qualitative tests identified in the plan to confirm the identity of the inorganic compound.	<b>M4: Explain</b> the identity of the inorganic compound.	
<b>P8: Use</b> research to <b>identify</b> appropriate techniques and reagent(s) to determine concentration.		
<b>P9: Prepare</b> appropriate standard solution(s).		
<b>P10: Use</b> appropriate technique(s) to determine reacting volumes safely and skilfully.	<b>M5: Calculate</b> the concentration of the solution and the combined uncertainty in this result.	<b>D3: Evaluate</b> concentration of the solution in comparison with the actual concentration that is suggested in the scenario.
<b>P11: Explain</b> other tests or techniques that could be used to help confirm the identity of the compounds and the concentration of the solution.	<b>M6: Assess</b> the quality of the data collected.	<b>D4: Evaluate</b> the tests and techniques used to confirm the identity and concentrations of the compounds.
		<b>D5: Justify</b> suggestions for improvements that could be made.

## Assessment guidance

This assessment guidance gives you information relating to the assessment criteria. There might not be additional assessment guidance for each assessment criterion. It is included only where it is needed.

Assessment Criteria	Assessment guidance
P1	<ul style="list-style-type: none"> <li>• <b>P1</b> does not require research from students, it should be from taught Unit F183 knowledge.</li> <li>• <b>P1</b> should not be a standalone list, it should form part of a written, logically sequenced plan for the investigation.</li> </ul>
P2	<ul style="list-style-type: none"> <li>• The size, quantity and type of equipment (e.g. size and type of pipettes/beakers etc.) will need to be specified by the student to achieve <b>P2</b>.</li> <li>• <b>P2</b> should not be a standalone list, it should form part of the written, logically sequenced plan for the investigation.</li> </ul>
P3	<ul style="list-style-type: none"> <li>• Students will need to complete some basic research to help them identify the risks associated with the reagents and techniques chosen.</li> <li>• References should be included at the end of the risk assessment template.</li> <li>• The research element of this criterion does not need to be completed under supervised conditions.</li> </ul>
P4	<ul style="list-style-type: none"> <li>• Students should use annotated photographic evidence to help them describe qualitative observations.</li> <li>• The teacher observation record form should comment on the safe carrying out of the separating techniques and the skilful use of apparatus by the student to collect data of sufficient quality.</li> </ul>
P5	<ul style="list-style-type: none"> <li>• Students should use annotated photographic evidence to help them describe qualitative observations.</li> <li>• The teacher observation record form should comment on the safe carrying out of the qualitative tests by the student.</li> </ul>
M2	<ul style="list-style-type: none"> <li>• Students should match the evidence collected from <b>P4</b>, <b>P5</b> and <b>M1</b> to the spectroscopic data provided, to identify the type of organic compound.</li> <li>• Students should then use calculations to confirm the identity of the organic compound.</li> <li>• The name of the organic compound should be provided using IUPAC nomenclature, as well as the displayed or structural formula of the organic compound.</li> </ul>
D1	<ul style="list-style-type: none"> <li>• Students should explain how they matched the evidence from <b>P4</b>, <b>P5</b> and <b>M1</b> to the spectroscopic data. Students should also explain why they rejected the other spectroscopic data.</li> <li>• Annotations to the spectroscopic data should be made to help students form their explanation.</li> </ul>
P6	<ul style="list-style-type: none"> <li>• Students should use annotated photographic evidence to help them describe qualitative observations.</li> </ul>
P7	<ul style="list-style-type: none"> <li>• Students should use annotated photographic evidence to help them describe qualitative observations.</li> </ul>
M4	<ul style="list-style-type: none"> <li>• Students should explain how they collated evidence from <b>P6</b>, <b>P7</b> and <b>M3</b> to identify the ions in the inorganic compound. Students should explain why they rejected the presence of other ions in the inorganic compound.</li> <li>• The name of the inorganic compound should be provided using IUPAC nomenclature, as well as the chemical formula.</li> </ul>

D2	<ul style="list-style-type: none"> <li>Students should use appropriate techniques (including gravimetric analysis) to calculate the percentage purity of the inorganic compound.</li> <li>Students should then consider how accurate this value is considering the techniques used in <b>P6</b> and <b>M3</b>.</li> </ul>
P8	<ul style="list-style-type: none"> <li>Research is required to select appropriate reagents to determine the concentration of the unknown inorganic compound.</li> <li>The research element of this criterion does not need to be completed under supervised conditions.</li> </ul>
P9	<ul style="list-style-type: none"> <li>The teacher observation record form should comment on the skilful preparation of standard solutions.</li> </ul>
P10	<ul style="list-style-type: none"> <li>Students should use annotated photographic evidence to help them indicate that they have collected data of sufficient quality.</li> <li>The teacher observation record form should comment on the safe carrying out of the quantitative tests by the student.</li> </ul>
M5	<ul style="list-style-type: none"> <li>Students should process raw data appropriately and indicate their decisions in their written evidence. All working out should be included in the written evidence, with appropriate units.</li> </ul>
P11	<ul style="list-style-type: none"> <li>Students should not be restricted to the tests or techniques available in their school.</li> </ul>
M6	<ul style="list-style-type: none"> <li>Students should use their understanding of quality data to offer a reasoned judgment of the data collected.</li> <li>Students should consider the purity of the final compounds they isolated, potential losses during separation techniques, and any other errors that may have been introduced during the investigation.</li> <li>They should not attribute errors in the data to the materials provided by the centre or that provided in the scenario.</li> </ul>
D4	<ul style="list-style-type: none"> <li>Students should consider the strengths and limitations of the apparatus, tests, and techniques that were used.</li> <li>Combined uncertainty calculated in M5 should form part of this judgment.</li> </ul>
D5	<ul style="list-style-type: none"> <li>Students should consider all techniques explored in Unit F183 when making their decisions about improvements.</li> <li>The justification should be restricted to the tests or techniques available in their school.</li> </ul>

### Synoptic assessment

Some of the knowledge, understanding and skills needed to complete this unit will draw on the learning in Unit F180.

This table details these synoptic links.

Unit F183: Analytical techniques in chemistry		Unit F180: Fundamentals of science	
Topic Area		Topic Area	
1	Techniques to categorise and separate chemical substances	C3	Structure and bonding
2	Quantitative and qualitative analytical techniques to quantify and identify substances	C2	Quantitative chemistry
3	The principles of spectroscopic techniques and interpreting spectra for chemical substances	C1	Atomic structure and the Periodic Table

More information about synoptic assessment in these qualifications can be found in **Section 5.2 Synoptic assessment**.

## 4.3.3 Unit F184: Environmental studies

**Unit Aim**

Human activity has significant impact on the environment and the species living within it. This unit explores ecosystems and biodiversity, how ecosystems are managed and the conservation strategies used in their management. The unit also considers the strategies for managing domestic and industrial waste.

In this unit you will learn to use primary and secondary data to study ecosystems. You will develop the skills to carry out *in situ* fieldwork investigations to survey an area using different sampling techniques. You will learn about the different surveys available for studying the environment and how *in situ* and *ex situ* conservation strategies are used to protect species and their environments. You will also learn how to use online information to learn about biodiversity and compare different ecosystems. Finally, you will be able to research some of the strategies used to monitor and treat waste products in places such as landfill sites and water courses.

<b>Unit F184: Environmental studies</b>			
<b>Topic Area 1: Ecosystems and biodiversity</b>			
<b>Teaching content</b>	<b>Exemplification</b>	<b>Opportunities to cover:</b>	
<b>1.1 Ecosystems</b>		<b>Maths</b>	<b>HSW</b>
<b>1.1.1 What an ecosystem is</b> <input type="checkbox"/> Abiotic factors <input type="checkbox"/> Biotic factors	To include: <input type="checkbox"/> Ecosystems range in size and are dynamic <input type="checkbox"/> Organisms engage in complex interactions with their environment <input type="checkbox"/> The composition of an ecosystem is affected by abiotic factors and biotic factors <input type="checkbox"/> The role of interdependence in an ecosystem		<b>HSW11</b>
<b>1.1.2 Types of ecosystem</b> <input type="checkbox"/> Terrestrial ecosystems <input type="checkbox"/> Aquatic ecosystems	To include: <input type="checkbox"/> Different terrestrial ecosystems <input type="checkbox"/> Different aquatic ecosystems <input type="checkbox"/> Abiotic and biotic factors common to these ecosystems <input type="checkbox"/> How adaptations of different species enable them to live and survive in different ecosystems  Examples of <b>ecosystems</b> may include: <input type="checkbox"/> Pond, tree, local park, local woodland, school playing field		<b>HSW11</b>
<b>1.2 Biodiversity</b>		<b>Maths</b>	<b>HSW</b>
<b>1.2.1 Levels of biodiversity</b> <input type="checkbox"/> Species diversity <input type="checkbox"/> Ecosystem diversity	To include: <input type="checkbox"/> Species diversity as a measure of species richness and species evenness <input type="checkbox"/> Ecosystem diversity as a measure of the range of ecosystems in a specific area	<b>M2.3</b>	<b>HSW1</b>

<input type="checkbox"/> Genetic biodiversity	<input type="checkbox"/> Genetic diversity as the biological variation within a species <input type="checkbox"/> The interactions and influences of each level on the others  Does not include: <input type="checkbox"/> Calculations of genetic diversity		
<b>1.3 Importance of conserving ecosystems and maintaining biodiversity</b>		<b>Maths</b>	<b>HSW</b>
<b>1.3.1 Importance of ecosystems</b> <input type="checkbox"/> Ecological reasons <input type="checkbox"/> Life support functions <input type="checkbox"/> Ecosystem-support functions <input type="checkbox"/> Endemic species <input type="checkbox"/> Economic reasons <input type="checkbox"/> Aesthetic reasons	To include: <input type="checkbox"/> Provision of specific habitats and niches for different species <input type="checkbox"/> Why ecosystem conservation is particularly important to endemic species <input type="checkbox"/> How sustainable habitat management can secure future supplies of natural resources, such as wood and food <input type="checkbox"/> The role of biomimetics in design and manufacture		<b>HSW11</b>
<b>1.3.2 Importance of maintaining biodiversity</b> <input type="checkbox"/> Importance of ecosystems with high biodiversity (species-rich areas) <input type="checkbox"/> Keystone species <input type="checkbox"/> Foundation species	To include: <input type="checkbox"/> Why healthy, biodiverse ecosystems are important <input type="checkbox"/> The use of wildlife and plant life as pest control or sources of new medicines <input type="checkbox"/> The role of genetic diversity as a source for improving agricultural crops <input type="checkbox"/> How to identify keystone and foundation species  Examples may include: <input type="checkbox"/> Improve air and water quality <input type="checkbox"/> Prevent soil erosion <input type="checkbox"/> Seed dispersal and pollination <input type="checkbox"/> Recycle nutrients <input type="checkbox"/> Provide food and raw materials	<b>M1.7</b>	<b>HSW10</b>
<b>1.4 Understanding case studies</b>		<b>Maths</b>	<b>HSW</b>
<b>1.4.1 Case studies as a unique source of information</b>	<input type="checkbox"/> The advantages of a case study over other forms of scientific research in informing developments <input type="checkbox"/> How to select appropriate case studies to support research and decision making <input type="checkbox"/> How to evaluate the relevance, limitations, and methodologies used by a case study about an ecosystem or development		<b>HSW2</b>

Topic Area 2: Impact of human activity and natural events			
Teaching content	Exemplification	Opportunities to cover:	
2.1 Impact of human activities		Maths	HSW
<b>2.1.1 Change of land use</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Farming practices</li> <li><input type="checkbox"/> Industrial practices</li> <li><input type="checkbox"/> Housing and commercial</li> <li><input type="checkbox"/> Recreation and tourism</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> How the need for more food and more housing due to increasing human population leads to change of land use</li> <li><input type="checkbox"/> How change of land use has impacts on biodiversity and the environment</li> </ul> <p>Examples of <b>impacts of human activities</b> may include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Use of large agricultural machinery results in need for bigger fields so removal of hedgerows as natural boundaries</li> <li><input type="checkbox"/> Removal of grasslands and deforestation for building industrial units and housing developments</li> <li><input type="checkbox"/> Changing natural lakes into parcouse fishing lake</li> </ul>	M3.1	HSW10
<b>2.1.2 Species exploitation and eradication</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> For resources</li> <li><input type="checkbox"/> For sport</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Historical, cultural and economical reasons for direct and deliberate destruction of populations of animal and plant life</li> </ul> <p>Examples of <b>species exploitation for resources</b> may include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Food, fashion, furniture and traditional medicines</li> </ul>		HSW10
<b>2.1.3 Introduction of alien species</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Invasive species</li> <li><input type="checkbox"/> Impact of pets</li> <li><input type="checkbox"/> Trade in exotic species</li> <li><input type="checkbox"/> Impact of farm animals</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> The difference between native and invasive species</li> <li><input type="checkbox"/> How invasive species are introduced into the environment and how they impact native species</li> <li><input type="checkbox"/> Why the introduction of domestic pets impacts biodiversity, including food webs and predator-prey relationships</li> <li><input type="checkbox"/> How trade in exotic species causes imbalance in the food webs and reduces biodiversity</li> <li><input type="checkbox"/> How intensive farming impacts the environment</li> </ul>		HSW11

<b>2.1.4 Pollution</b> <input type="checkbox"/> Air pollution <input type="checkbox"/> Water pollution <input type="checkbox"/> Soil pollution <input type="checkbox"/> Noise pollution	To include: <input type="checkbox"/> Origins and effects of different types of pollution on ecosystems and biodiversity <input type="checkbox"/> Wider impacts on society <input type="checkbox"/> The difference between point source and non-point source pollution <input type="checkbox"/> General ways to mitigate pollution and the reasons why pollution continues  Examples of origins of <b>pollution</b> may include: <input type="checkbox"/> Transport <input type="checkbox"/> Mining <input type="checkbox"/> Energy generation <input type="checkbox"/> Manufacture of goods		<b>HSW11</b>
<b>2.2 Impact of natural events</b>		<b>Maths</b>	<b>HSW</b>
<b>2.2.1 Disease</b> <input type="checkbox"/> Genetic disease <input type="checkbox"/> Infectious disease	To include: <input type="checkbox"/> How disease affects population numbers and ecosystems <input type="checkbox"/> Why species with small gene pools or small populations are more at risk	<b>M3.1</b> <b>M3.2</b>	<b>HSW10</b>
<b>2.2.2 Earth events</b> <input type="checkbox"/> Effects of natural disasters and events	To include: <input type="checkbox"/> How natural disasters affect biodiversity and the environment  Examples of <b>earth events</b> may include: <input type="checkbox"/> Earthquakes <input type="checkbox"/> Wildfires <input type="checkbox"/> Flooding <input type="checkbox"/> Drought <input type="checkbox"/> Volcanic activity		<b>HSW11</b>
<b>Topic Area 3: Waste management</b>			
<b>Teaching content</b>	<b>Exemplification</b>	<b>Opportunities to cover:</b>	
<b>3.1 Dealing with domestic waste</b>		<b>Maths</b>	<b>HSW</b>
<b>3.1.1 Processing domestic waste in the UK</b> <input type="checkbox"/> Landfill	To include: <input type="checkbox"/> Different types of solid domestic waste and how it is collected and distributed <input type="checkbox"/> What happens to waste in landfill sites including: <ul style="list-style-type: none"> <li>• Different routes for different types of waste</li> <li>• Possible environmental damage</li> <li>• Monitoring waste gases produced</li> </ul>	<b>M3.1</b>	<b>HSW7</b> <b>HSW10</b>

<input type="checkbox"/> Recycling  <input type="checkbox"/> Exporting waste	<ul style="list-style-type: none"> <li><input type="checkbox"/> What happens to items recycled by households including:           <ul style="list-style-type: none"> <li>• Methods for sorting different recyclable materials</li> <li>• Routes taken by different materials</li> <li>• How new products are made</li> </ul> </li>   <li><input type="checkbox"/> What happens to exported waste including:           <ul style="list-style-type: none"> <li>• Waste shipped to other countries in containers</li> </ul> </li>   <li><input type="checkbox"/> Advantages and disadvantages of different methods of dealing with domestic waste</li> </ul>		
<b>3.1.2 Processing sewage</b> <input type="checkbox"/> Sewage treatment plants <input type="checkbox"/> Septic tanks	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> What happens to domestic wastewater once it leaves homes and businesses</li> <li><input type="checkbox"/> What happens to wastewater from treatment plants</li> <li><input type="checkbox"/> What happens to waste water from septic tanks</li> </ul> <p>Examples of <b>processing sewage</b> may include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> How solid waste can be made into biofuels</li> <li><input type="checkbox"/> Impact of large environmental footprints</li> </ul>	<b>M1.2</b>	<b>HSW7</b>
<b>3.2 Dealing with industrial waste</b> <b>3.2.1 Waste from industry</b> <input type="checkbox"/> Categories of industrial waste <input type="checkbox"/> Strategies used for dealing with industrial waste	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> How different types of industrial waste need specific disposal to prevent environmental damage and impact on biodiversity</li> <li><input type="checkbox"/> Advantages and disadvantages of:           <ul style="list-style-type: none"> <li>• Reduce, reuse, recycle strategy</li> <li>• Financial incentives</li> </ul> </li> </ul>	<b>M1.2</b>	<b>HSW10</b> <b>HSW11</b>
<b>Topic Area 4: Environmental management and conservation</b>			
<b>Teaching content</b>	<b>Exemplification</b>	<b>Opportunities to cover:</b>	
<b>4.1 Environmental surveying</b>		<b>Maths</b>	<b>HSW</b>
<b>4.1.1 Types of environmental survey</b> <input type="checkbox"/> Ecological surveys <input type="checkbox"/> Water quality surveys <input type="checkbox"/> Noise surveys <input type="checkbox"/> Dust in air surveys <input type="checkbox"/> Temperature surveys	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Why environmental surveys are needed</li> <li><input type="checkbox"/> The importance of ecological monitoring in conservation planning</li> <li><input type="checkbox"/> How different types of surveys can be carried out</li> <li><input type="checkbox"/> Which survey to use depending on nature of development and location in the country</li> <li><input type="checkbox"/> Which methods are used for obtaining qualitative and quantitative data</li> </ul>	<b>M2.1</b> <b>M2.3</b>	<b>HSW12</b>

<input type="checkbox"/> Carbon dioxide surveys <input type="checkbox"/> Peat core surveys	<input type="checkbox"/> Data analysis and calculations, including to show correlation such as Spearman's rank correlation coefficient  <b>Examples of ecological surveys</b> may include: <input type="checkbox"/> Bog restoration surveys to determine the success of habitat management measures. <input type="checkbox"/> Tree planting success for the establishment of new areas of woodland.		
<b>4.2 Environmental management</b>		<b>Maths</b>	<b>HSW</b>
<b>4.2.1 Environmental management methods</b> <input type="checkbox"/> Manage resources <input type="checkbox"/> Manage waste and pollution <input type="checkbox"/> Develop sustainably <input type="checkbox"/> Preserve and improve biodiversity <input type="checkbox"/> Maintain and develop ecosystems	To include: <input type="checkbox"/> Role of education and social responsibility in protecting the environment <input type="checkbox"/> Role of laws and legislation in protecting the environment <input type="checkbox"/> Role of governments in managing environments <input type="checkbox"/> Role of businesses in managing environments		<b>HSW11</b>
<b>4.2.2 Role of governments in managing environments</b> <input type="checkbox"/> Setting environmental policy, legislation and regulations <input type="checkbox"/> Raising public awareness <input type="checkbox"/> Establishing agencies, authorities, policies and legislation designed to protect and manage the environment <input type="checkbox"/> Providing funding for environmental protection	To include: <input type="checkbox"/> How environmental regulations are enforced <input type="checkbox"/> How public awareness is raised, including through the use of education <input type="checkbox"/> How agencies, authorities, policies and legislation can be used to ensure human needs are met sustainably  <b>Examples of agencies and authorities</b> with responsibility in creating policies and enforcing them may include: <input type="checkbox"/> Office for Environmental Protection (OEP) <input type="checkbox"/> The Environment Agency <input type="checkbox"/> Local Planning Authority <input type="checkbox"/> Environmental Investigation Agency  <b>Examples of policies and legislation</b> may include: <input type="checkbox"/> The Town and Country Planning (Environmental Impact Assessment) Regulations 2017 <input type="checkbox"/> The wildlife and countryside act (1981) <input type="checkbox"/> The Environment Act 2021		<b>HSW7</b>

	Does not include: <input type="checkbox"/> Specific details of the work of international agencies		
<b>4.2.3 Role of businesses in managing environments</b> <input type="checkbox"/> Environmental management systems (EMSs) <input type="checkbox"/> Environmental impact assessments (EIAs)	To include: <input type="checkbox"/> How to create EMSs and EIAs <input type="checkbox"/> Who is required to have EMSs and EIAs <input type="checkbox"/> The role of case studies and stakeholders in writing EIAs <input type="checkbox"/> Why EMSs and EIAs are important to managing an environment and protecting an ecosystem <input type="checkbox"/> Advantages to organisations and business in creating, implementing and monitoring EMSs and EIAs <input type="checkbox"/> Impacts on businesses from failing to comply with legislations and industry standards to protect the environment <input type="checkbox"/> The importance of sustainability and sustainable development		<b>HSW11</b>
<b>4.2.4 Barriers to effective environmental management</b> <input type="checkbox"/> Issues that can prevent effective management of an environment	To include: <input type="checkbox"/> Barriers that impact the rate of habitat and biodiversity loss <input type="checkbox"/> Why different barriers for managing an environment exist and how these barriers prevent effective management of that environment or ecosystem <input type="checkbox"/> How to identify these barriers from a case study or other information <input type="checkbox"/> Ways in which these barriers may be addressed in the sustainable management of an environment  Examples of <b>barriers</b> may include: <input type="checkbox"/> Religious or cultural <input type="checkbox"/> Education <input type="checkbox"/> Economical		<b>HSW8</b>
<b>4.3 Conservation strategies</b>		<b>Maths</b>	<b>HSW</b>
<b>4.3.1 <i>in situ</i> conservation</b> <input type="checkbox"/> Methods to conserve species <i>in situ</i>	To include: <input type="checkbox"/> How to select appropriate <i>in situ</i> conservation methods <input type="checkbox"/> Advantages and disadvantages of <i>in situ</i> conservation methods  Examples of <b><i>in situ</i> conservation</b> may include: <input type="checkbox"/> Marine conservation zones and wildlife reserves	<b>M1.5</b>	<b>HSW10</b> <b>HSW11</b>

<b>4.3.2 <i>ex situ</i> conservation</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Methods to conserve species <i>ex situ</i></li> <li><input type="checkbox"/> How to select appropriate <i>ex situ</i> conservation methods</li> <li><input type="checkbox"/> Advantages and disadvantages of <i>ex situ</i> conservation methods</li> </ul> <p>Examples of <b><i>ex situ</i> conservation methods</b> may include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Seed banks, botanic gardens and zoos</li> </ul>	<b>M1.5</b>	<b>HSW10 HSW11</b>
<b>Topic Area 5: Fieldwork</b>			
<b>Teaching content</b>	<b>Exemplification</b>	<b>Opportunities to cover:</b>	
<b>5.1 Location analysis</b>		<b>Maths</b>	<b>HSW</b>
<b>5.1.1 Location Analysis</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Physical characteristics</li> <li><input type="checkbox"/> Human uses</li> <li><input type="checkbox"/> Important environmental features</li> <li><input type="checkbox"/> History of location</li> <li><input type="checkbox"/> Biodiversity</li> <li><input type="checkbox"/> Use of maps</li> <li><input type="checkbox"/> Use of databases</li> </ul> <p>Examples of <b>physical characteristics</b> may include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Climate, soil type, roads and rivers</li> </ul> <p>Examples of <b>human uses</b> may include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Current and planned, agriculture and industry</li> </ul> <p>Examples of <b>important environmental features</b> may include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Protected areas and rare species</li> </ul> <p>Examples of <b>history of location</b> may include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Past land uses and environmental accidents</li> </ul> <p>Examples of <b>biodiversity</b> sources may include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Office for National Statistics</li> <li><input type="checkbox"/> National Biodiversity Network</li> <li><input type="checkbox"/> Local wildlife trusts</li> <li><input type="checkbox"/> Local biodiversity action plans</li> </ul>	<b>M0.4 M1.6 M3.1</b>	<b>HSW8 HSW11</b>

<b>5.2 Suitability of the environment</b>		<b>Maths</b>	<b>HSW</b>
<b>Measuring abiotic factors</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Light intensity</li> <li><input type="checkbox"/> Temperature</li> <li><input type="checkbox"/> Wind velocity</li> <li><input type="checkbox"/> Humidity</li> <li><input type="checkbox"/> Water analysis</li> <li><input type="checkbox"/> Soil analysis</li> </ul> <ul style="list-style-type: none"> <li><input type="checkbox"/> Techniques and apparatus to collect data <i>in situ</i> and samples for testing in a laboratory</li> <li><input type="checkbox"/> When to use each technique and the information it will provide about an ecosystem</li> <li><input type="checkbox"/> How each technique is performed to collect data of sufficient quality and have minimal impact on the local environment</li> <li><input type="checkbox"/> The limitations of techniques that can be performed in schools compared with those that are performed professionally</li> </ul>	<b>M0.1</b>	<b>HSW11</b>
<b>5.3 Sampling techniques</b>		<b>Maths</b>	<b>HSW</b>
<b>5.3.1 Population sampling</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Representative sampling <ul style="list-style-type: none"> <li>• Random sampling</li> <li>• Stratified sampling</li> <li>• Systematic sampling</li> </ul> </li> <li><input type="checkbox"/> Species lists</li> <li><input type="checkbox"/> Abundant Common Frequent Occasional Rare (ACFOR) scale</li> <li><input type="checkbox"/> Dominant Abundant Frequent Occasional Rare (DAFOR) scale</li> <li><input type="checkbox"/> Sample timing, size and number</li> <li><input type="checkbox"/> Species identification</li> </ul>	<b>M1.2</b> <b>M1.7</b>	<b>HSW3</b>
<b>5.3.2 Vegetation sampling</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Use of quadrats</li> <li><input type="checkbox"/> Transects</li> <li><input type="checkbox"/> Qualitative sampling</li> <li><input type="checkbox"/> Tree height</li> <li><input type="checkbox"/> Satellite and drone imagery</li> </ul> <ul style="list-style-type: none"> <li><input type="checkbox"/> Techniques available to schools and conservationists for sampling vegetation</li> <li><input type="checkbox"/> How to carry out different types of transects</li> <li><input type="checkbox"/> How to select quadrat size and type</li> <li><input type="checkbox"/> Use of density/coverage vs frequency</li> <li><input type="checkbox"/> How to measure tree height using a clinometer</li> <li><input type="checkbox"/> Advantages and disadvantages of each technique</li> </ul>	<b>M1.7</b>	<b>HSW8</b>

<b>5.3.3 Sampling mobile organisms</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Freshwater invertebrates</li> <li><input type="checkbox"/> Soil invertebrates</li> <li><input type="checkbox"/> Invertebrates on trees and bushes</li> <li><input type="checkbox"/> Signs of presence</li> <li><input type="checkbox"/> Direct counts</li> <li><input type="checkbox"/> Mark, release and recapture</li> <li><input type="checkbox"/> Telemetry</li> <li><input type="checkbox"/> Satellite and drone imagery</li> <li><input type="checkbox"/> Genetic sampling</li> <li><input type="checkbox"/> Camera trapping and acoustic monitoring</li> </ul>	<b>M1.7</b>	<b>HSW8</b>
<b>5.4 Risk assessment</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Identifying hazardous equipment, chemicals and locations</li> <li><input type="checkbox"/> Risks involved</li> <li><input type="checkbox"/> Control measures required</li> <li><input type="checkbox"/> Emergency measures considered</li> </ul>	<b>Maths</b>	<b>HSW</b>
	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Importance of a risk assessment when carrying out fieldwork</li> <li><input type="checkbox"/> Use of a well-designed risk assessment template</li> <li><input type="checkbox"/> Differentiation between hazard and risk</li> <li><input type="checkbox"/> Appreciation of hazard symbols and their meanings</li> <li><input type="checkbox"/> How to select and interpret relevant information about hazardous chemicals</li> <li><input type="checkbox"/> Appreciation of external factors that need to be considered, such as the public, traffic, location choice</li> <li><input type="checkbox"/> How to explain control measures using scientific principles</li> </ul>	<b>HSW6</b>	
<b>5.5 Data processing and analysis</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Averages and ranges</li> <li><input type="checkbox"/> Percentage frequency</li> <li><input type="checkbox"/> Local frequency</li> <li><input type="checkbox"/> Percentage abundance</li> <li><input type="checkbox"/> Calculating tree height</li> <li><input type="checkbox"/> Species richness</li> <li><input type="checkbox"/> Species evenness</li> <li><input type="checkbox"/> Simpson's index of diversity</li> <li><input type="checkbox"/> Chi-squared test</li> <li><input type="checkbox"/> Spearman's rank correlation coefficient</li> </ul>	<b>Maths</b>	<b>HSW</b>
	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> How to carry out the calculations</li> <li><input type="checkbox"/> How to decide the appropriate calculations and statistical analysis to use</li> <li><input type="checkbox"/> How to design the fieldwork to ensure data of sufficient quality for statistical analysis is collected</li> <li><input type="checkbox"/> How to interpret the results</li> <li><input type="checkbox"/> The strengths and weakness of each statistical test</li> </ul>	<b>M1.2</b>	<b>HSW3</b>

## Assessment criteria

Section 6.4 provides full information on how to assess the NEA units and apply the assessment criteria.

These are the assessment criteria for the tasks for this unit. The assessment criteria indicate what is required in each task. Students' work must show that all aspects of a criterion have been met in sufficient detail for it to be **successfully achieved** (see Section 6.4.1). If a student's work does not fully meet a criterion, you must not award that criterion.

The command words used in the assessment criteria are defined in **Appendix B**.

Pass	Merit	Distinction
<b>P1:</b> Use research to help <b>summarise</b> information from the chosen case study.	<b>M1:</b> <b>Discuss</b> the sustainability of the environmental management and conservation methods used.	
<b>P2:</b> <b>Describe</b> how surveys were used to inform the environmental management and conservation methods used.		
<b>P3:</b> Use research to <b>describe</b> the characteristics of the environment and the ecosystem of the chosen area.		
<b>P4:</b> <b>Create</b> a plan to carry out appropriate surveys.	<b>M2:</b> <b>Explain</b> how the methodology of your surveys will enable data of sufficient quality to be gathered.	<b>D1:</b> <b>Discuss</b> how the proposed surveys are appropriate to inform planning and environmental management.
		<b>D2:</b> <b>Evaluate</b> the usefulness of the case study to inform your planning.
<b>P5:</b> <b>Complete</b> a risk assessment for your surveys.		
<b>P6:</b> Use your planned surveys to <b>collect</b> sufficient raw data.		
<b>P7:</b> <b>Present</b> your raw data in appropriate ways.	<b>M3:</b> Use appropriate calculations to <b>process</b> your raw data.	<b>D3:</b> <b>Analyse</b> the raw and processed data collected from your surveys.

Pass	Merit	Distinction
<b>P8: Write</b> appropriate conclusions from the data obtained.	<b>M4:</b> Use research to <b>identify</b> appropriate methods for conserving and managing the chosen area.	<b>D4: Justify</b> suggested methods for conserving and managing the area in a sustainable way.
<b>P9: Describe</b> how the development could affect the chosen area.		
<b>P10: Summarise</b> the strengths and weaknesses of your plan.	<b>M5: Suggest</b> appropriate improvements to your plan.	<b>D5: Justify</b> improvements that could increase your confidence in your report.
<b>P11: Assess</b> the quality of the data collected.	<b>M6: Suggest</b> how to improve the quality of the data collected.	

### Assessment guidance

This assessment guidance gives you information relating to the assessment criteria. There might not be additional assessment guidance for each assessment criterion. It is included only where it is needed.

Assessment Criteria	Assessment guidance
P1	<ul style="list-style-type: none"> <li>Students should research the case study selected to help them interpret the information. Students may use an alternative case study from that in the scenario but should ensure that it is easily accessible and referenced.</li> <li>Students should summarise relevant information about how the impact of human activity has affected the ecosystem in the chosen case study, and methods of environmental management and conservation used.</li> <li>The research element of this criterion does not need to be completed under supervised conditions.</li> </ul>
P3	<ul style="list-style-type: none"> <li>Students should research the area chosen for the development.</li> <li>Students must do a location analysis to be able to describe the characteristics of the area chosen for their development.</li> <li>They must provide information on both <b>abiotic</b> and <b>biotic</b> factors of the ecosystem in the chosen area.</li> <li>The research element of this criterion does not need to be completed under supervised conditions.</li> </ul>
P4	<ul style="list-style-type: none"> <li>Students must create a plan for at least <b>two</b> appropriate surveys which they will carry out in the chosen area.</li> <li>Within their plan, students must include details of methodology and appropriate equipment required.</li> </ul>
P5	<ul style="list-style-type: none"> <li>Students must consider the environmental impact of the fieldwork as part of the risk assessment, including how any damage can be minimised.</li> </ul>

D1	<ul style="list-style-type: none"> <li>Students must discuss the appropriateness of the survey(s) planned in <b>P4</b> and how results from these survey(s) will help to inform planning for the development in the chosen area.</li> </ul>
D2	<ul style="list-style-type: none"> <li>Students should make a reasoned qualitative judgment about the usefulness of the case study to their plan.</li> </ul>
P6	<ul style="list-style-type: none"> <li>Students should collect photographic evidence while performing the surveys they have planned. This should be annotated to describe to the assessor what the photographs are showing.</li> <li>The teacher observation record form should be used to detail students following their plan safely, according to their risk assessment.</li> </ul>
P7	<ul style="list-style-type: none"> <li>The teacher observation record form should also confirm that students collected all of the data recorded.</li> </ul>
M3	<ul style="list-style-type: none"> <li>Students must show their detailed working of the calculations used to process the data.</li> </ul>
D3	<ul style="list-style-type: none"> <li>Students must analyse their data quantitatively and qualitatively.</li> <li>Students should comment on the characteristics of the data.</li> </ul>
P8	<ul style="list-style-type: none"> <li>Students should use their analysis of the data from <b>D3</b> to help them make reasoned conclusions about the chosen area.</li> </ul>
P9	<ul style="list-style-type: none"> <li>Students must write about the potential impact of the development on the chosen area, using conclusions from <b>P8</b> where appropriate.</li> </ul>
M4	<ul style="list-style-type: none"> <li>The appropriateness of the methods must be linked to <b>P9</b>.</li> </ul>
P10	<ul style="list-style-type: none"> <li>If changes were made to the original plans created in Task 2, these should be reflected upon when summarising the strengths and weaknesses of the methodology.</li> </ul>
M6	<ul style="list-style-type: none"> <li>Improvements to the data collected should be linked to the assessment of the quality of the data collected in <b>P11</b>.</li> </ul>
D5	<ul style="list-style-type: none"> <li>This should focus on improvements that would increase your confidence in your report to the organisation.</li> </ul>

## Synoptic assessment

Some of the knowledge, understanding and skills needed to complete this unit will draw on the learning in Units F180 and F181.

This table details these synoptic links.

Unit F184: Environmental studies		Unit F180: Fundamentals of science	
Topic Area		Topic Area	
5	Fieldwork	4	Biodiversity and ecosystems
1	Ecosystems and biodiversity		

Unit F184: Environmental studies		Unit F181: Science in society	
Topic Area		Topic Area	
5	Fieldwork	2	Handling scientific data
2	Impact of human activity and natural events	3	Scientific developments

## 4.3.4 Unit F185: Forensic biology

**Unit Aim**

Forensic biology skills may be used in a number of situations, whether in the field collecting evidence or analysing such evidence in the laboratory. Forensic biologists are employed by government agencies as well as in the private sector. This unit explores how forensic biologists collect and analyse biological evidence that is relevant to a legal investigation in order to match evidence from a crime scene to individuals or organisations. Such investigations include robberies, environmental contamination and wildlife crime. This unit explores the disciplines of forensic biology and associated evidence: the types of cells, tissues and body fluids that may be collected, how the investigation involves biological evidence collection and analysis, and how it is recorded and reported.

In this unit you will learn how to perform investigations of the macro- and ultrastructure of cells and tissues from fresh and prepared material, using optical microscope techniques and electron micrographs. You will develop the skills to complete the safe culturing of bacteria and to perform practical investigations to collect, log and analyse biological evidence using standard procedures. You will learn how to carry out risk assessments, following current guidance, before completing any practical work. You will develop confidence in using laboratory equipment and microscopes.

<b>Unit F185: Forensic biology</b>			
<b>Topic Area 1: Forensic biology disciplines and evidence</b>			
<b>Teaching content</b>	<b>Exemplification</b>	<b>Opportunities to cover:</b>	
<b>1.1 The nature and origins of forensic science</b>		<b>Maths</b>	<b>HSW</b>
<b>1.1.1 Features of forensic science and forensic biology</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> The difference between criminal and civil law</li> <li><input type="checkbox"/> The principle that every contact leaves a trace</li> <li><input type="checkbox"/> The differences between forensic biology and forensic science</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Historical backgrounds of forensic science</li> </ul>		<b>HSW11</b>
<b>1.2 Forensic biology disciplines</b>		<b>Maths</b>	<b>HSW</b>
<b>1.2.1 Disciplines associated with forensic biology</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> The area of study involved in each discipline</li> <li><input type="checkbox"/> How each discipline could be used as a tool that supports an investigation</li> <li><input type="checkbox"/> The type of evidence each discipline can contribute to an investigation</li> </ul>		<b>HSW11</b>

<input type="checkbox"/> Odontology <input type="checkbox"/> Botany <input type="checkbox"/> Microbiology <input type="checkbox"/> Ornithology <input type="checkbox"/> Entomology	Does not include: <input type="checkbox"/> Forensic chemistry or toxicology		
<b>1.3 Types of evidence in forensic biology</b>		<b>Maths</b>	<b>HSW</b>
<b>1.3.1 Evidence available from crime scenes and individuals, relevant to forensic biology</b> <input type="checkbox"/> Biological evidence <input type="checkbox"/> Physical evidence <input type="checkbox"/> Trace evidence	To include: <input type="checkbox"/> The relative importance of each type of evidence in securing particular convictions <input type="checkbox"/> How each type of evidence may be used for generic (class evidence) or unique identification (individual evidence) purposes <input type="checkbox"/> The role evidence plays in supporting time of death in an investigation <input type="checkbox"/> How blood patterns can be used to indicate how blood was shed <input type="checkbox"/> The limitations of techniques available in schools for a full forensic analysis of evidence  Examples of each <b>type of evidence</b> may include: <input type="checkbox"/> <b>Biological</b> : hair, tissues, microorganisms in soil <input type="checkbox"/> <b>Physical</b> : fingerprints, footprints <input type="checkbox"/> <b>Trace</b> : fibres, hair, soil		<b>HSW7</b>
<b>Topic Area 2: Cells, tissues and organs in forensic biology</b>			
<b>Teaching content</b>	<b>Exemplification</b>	<b>Opportunities to cover:</b>	
<b>2.1 Microscopy in forensic biology</b>		<b>Maths</b>	<b>HSW</b>
<b>2.1.1 Key features of microscopy</b> <input type="checkbox"/> Light microscopes (LM) <input type="checkbox"/> Stereo microscopes <input type="checkbox"/> Electron microscopes (EM)	To include: <input type="checkbox"/> How to select the appropriate type of microscopy to use for different forensic evidence <input type="checkbox"/> Limitations of each type of microscopy to observe forensic evidence	<b>M0.2</b> <b>M1.1</b>	<b>HSW4</b>
<b>2.1.2 Use of light microscopes (LM) and stereomicroscopes to observe forensic evidence</b>	To include: <input type="checkbox"/> How to measure evidence using an eyepiece graticule in eyepiece units (EPUs) and calibrating the units into $\mu\text{m}$ using a stage micrometer <input type="checkbox"/> How to provide actual sizes of forensic evidence observed	<b>M0.1</b> <b>M0.4</b>	<b>HSW4</b>
<b>2.1.3 Preparing forensic evidence for microscopy</b>	To include: <input type="checkbox"/> The difference between wet and dry mounts of specimens and when to use them <input type="checkbox"/> How to produce a temporary, stained mount of an LM specimen, for example, for cheek cells		<b>HSW4</b>

	<input type="checkbox"/> How to produce a temporary, dry mount of a LM specimen, for example, for pollen <input type="checkbox"/> Staining and lifting techniques for tissues, for example, skin and hair		
<b>2.2 Observing biological evidence</b>		<b>Maths</b>	<b>HSW</b>
<b>2.2.1 Cellular evidence in Forensic Biology</b>	To include: <input type="checkbox"/> Cell and tissue structure as observed and measured from: <ul style="list-style-type: none"> <li>• Temporary slides</li> <li>• Microscope drawings/photographs</li> <li>• Electron micrographs</li> <li>• Generalised diagrams/photographs</li> </ul> <input type="checkbox"/> The type of information that cell, tissue, and organ evidence can reveal as forensic proof <input type="checkbox"/> How to record quantitative and qualitative information about biological evidence <input type="checkbox"/> The limitations from observing this evidence alone when trying to match to an individual	<b>M0.1</b> <b>M1.1</b>	<b>HSW9</b>
<b>2.2.2 Tissue evidence in Forensic Biology</b>			
<input type="checkbox"/> Hair <input type="checkbox"/> Skin <input type="checkbox"/> Blood <input type="checkbox"/> Bodily fluids			
<b>2.2.3 Organ evidence in Forensic Biology</b>			
<input type="checkbox"/> Teeth <input type="checkbox"/> Bone <input type="checkbox"/> Leaves <input type="checkbox"/> Seeds <input type="checkbox"/> Fruits <input type="checkbox"/> Flowers <input type="checkbox"/> Roots			

<b>2.3 Microbiology in Forensic Science</b>		<b>Maths</b>	<b>HSW</b>
<b>2.3.1 Contributions of microbiology to forensics</b> <input type="checkbox"/> Bioterrorism <input type="checkbox"/> Cause of death <input type="checkbox"/> Time of death <input type="checkbox"/> Place of death <input type="checkbox"/> Outbreaks of foodborne disease <input type="checkbox"/> Biosecurity <input type="checkbox"/> Identification of individuals	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> How microorganisms isolated, identified and genetically sequenced from microbiomes may contribute to forensic investigations</li> </ul>		<b>HSW7</b> <b>HSW12</b>
<b>2.3.2 Culturing microorganisms effectively and safely</b> <input type="checkbox"/> Preparation of work area <input type="checkbox"/> Aseptic technique <input type="checkbox"/> Preparation of sterile agar plates and nutrient media <input type="checkbox"/> Preparation of sterilized equipment <input type="checkbox"/> Disposal	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> The importance of aseptic technique in culturing microorganisms and for forensic proof</li> <li><input type="checkbox"/> Use of alcohol and other sterilisation procedures</li> <li><input type="checkbox"/> Consideration of airflow around workspace</li> <li><input type="checkbox"/> Use of PPE and biosafety cabinets</li> <li><input type="checkbox"/> How to safely culture microorganisms: <ul style="list-style-type: none"> <li>• Implications of temperature</li> <li>• Contamination and sealing Petri dishes</li> <li>• Incubation time</li> <li>• Importance of keeping Petri dishes closed after incubation</li> </ul> </li> <li><input type="checkbox"/> Sterilisation, disinfection and safe disposal after exposure</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Preparation of specialised growth media</li> <li><input type="checkbox"/> Culturing viruses or parasites</li> </ul>		<b>HSW4</b>
<b>2.3.3 The culture of microorganisms by the inoculation of agar plates</b> <input type="checkbox"/> Streak plates <input type="checkbox"/> Lawn plates <input type="checkbox"/> Pour plates	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> The culture of bacteria and fungi obtained from non-pathogenic, approved sources</li> <li><input type="checkbox"/> How to culture bacteria and fungi using the three inoculation techniques, where appropriate <ul style="list-style-type: none"> <li><input type="checkbox"/> How to culture microorganisms found at a crime scene</li> <li><input type="checkbox"/> The advantages and disadvantages of culturing microorganisms in forensic proof</li> </ul> </li> </ul>		<b>HSW4</b>

<p><b>2.3.4 The identification of bacteria and fungi through:</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Appropriate staining</li> <li><input type="checkbox"/> Microscopy</li> <li><input type="checkbox"/> Colony morphology</li> <li><input type="checkbox"/> Selective and differential media</li> <li><input type="checkbox"/> Serology</li> <li><input type="checkbox"/> DNA analysis</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> How to identify colony types and match to reference samples</li> <li><input type="checkbox"/> How to carry out testing for gram-negative and gram-positive bacteria</li> <li><input type="checkbox"/> The role of different types of growth media in the culturing and identification of microorganisms</li> <li><input type="checkbox"/> How to compare bacterial and fungal cultures from the scene with those provided from individuals</li> <li><input type="checkbox"/> The advantages and disadvantages of each technique for forensic proof</li> <li><input type="checkbox"/> The limitations of techniques available in schools to safely identify microorganisms</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Detailed knowledge of how to carry out DNA analysis</li> </ul>	<p><b>M0.3 M1.7</b></p>	<p><b>HSW7</b></p>
<p><b>Topic Area 3: Investigation and evidence collection</b></p>			
<p><b>Teaching content</b></p>	<p><b>Exemplification</b></p>	<p><b>Opportunities to cover:</b></p>	
<p><b>3.1 Scene investigation and preservation of site</b></p>		<p><b>Maths</b></p>	<p><b>HSW</b></p>
<p><b>3.1.1 Restriction of the scene and access to the scene</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Police tape</li> <li><input type="checkbox"/> Scenes of Crime Officers (SOCO)</li> <li><input type="checkbox"/> Forensic tents/work areas</li> <li><input type="checkbox"/> Cordon log</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> The purpose of crime scene preservation and initial documentation</li> <li><input type="checkbox"/> How to carry out appropriate scene preservation in schools</li> </ul>		<p><b>HSW11</b></p>
<p><b>3.1.2 Recording and documenting the scene</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Crime scene notes and visual evidence</li> <li><input type="checkbox"/> Search patterns <ul style="list-style-type: none"> <li>• Quadrant</li> <li>• Lane</li> <li>• Grid</li> <li>• Spiral</li> <li>• Wheel</li> </ul> </li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> The importance of recording detailed observations at the crime scene</li> <li><input type="checkbox"/> How to select suitable search patterns</li> </ul>	<p><b>M0.4 M1.7 M3.1</b></p>	<p><b>HSW11</b></p>

<input type="checkbox"/> Documenting trace materials <ul style="list-style-type: none"> <li>• Scene of crime documentation</li> <li>• Crime scene notes</li> <li>• Sketches and photographs</li> <li>• Video</li> <li>• Evidence labels</li> </ul>	<input type="checkbox"/> How to document trace materials from a crime scene <input type="checkbox"/> How to record and document crime scenes and evidence appropriately		
<b>3.2 Collection of evidence</b>		<b>Maths</b>	<b>HSW</b>
<b>3.2.1 Hazards associated with forensic work</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> At the crime scene</li> <li><input type="checkbox"/> In the laboratory</li> </ul>	To include: <ul style="list-style-type: none"> <li><input type="checkbox"/> How unfamiliar environments may pose physical, chemical and biological risk</li> <li><input type="checkbox"/> Biological hazards associated with the collection and analysis of the biological evidence</li> <li><input type="checkbox"/> The need for suitable personal protective equipment (PPE) and other appropriate control measures to reduce risk</li> <li><input type="checkbox"/> How to complete a risk assessment for a crime scene investigation and laboratory analysis of samples</li> </ul>		<b>HSW5</b>
<b>3.2.2 Collection of evidence</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Evidence recognition</li> <li><input type="checkbox"/> Recovery of trace materials               <ul style="list-style-type: none"> <li>• Swabbing</li> <li>• Forceps</li> <li>• Taping</li> <li>• Shaking, brushing and vacuuming</li> <li>• Marks and impressions</li> <li>• Print lifting</li> </ul> </li> </ul>	To include: <ul style="list-style-type: none"> <li><input type="checkbox"/> How to identify probative evidence at the crime scene</li> <li><input type="checkbox"/> How to recover trace evidence in the correct order to prevent damage and loss of evidence</li> <li><input type="checkbox"/> How to recover trace materials appropriately</li> <li><input type="checkbox"/> The importance of correct methods for individual recovery methods to avoid cross-contamination</li> <li><input type="checkbox"/> The usefulness of the method of recovery for each sample of biological evidence</li> <li><input type="checkbox"/> The use of the double swab technique for recovering DNA evidence</li> </ul>		<b>HSW9</b>
<b>3.2.3 Storing evidence</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Packaging and labelling</li> <li><input type="checkbox"/> Storage and transport of a variety of forensic evidence</li> <li><input type="checkbox"/> Chain of evidence</li> </ul>	To include: <ul style="list-style-type: none"> <li><input type="checkbox"/> How packaging, labelling and storage are selected for the recovered materials by forensic biologists</li> <li><input type="checkbox"/> How to ensure effective preservation and storage of evidence to prevent contamination and degradation</li> <li><input type="checkbox"/> The importance of storage and preservation for recovered trace materials</li> <li><input type="checkbox"/> The stages in the chain of evidence and how they preserve the integrity of the evidence</li> <li><input type="checkbox"/> How to package, label and store evidence in schools and the differences from techniques available to forensic biologists</li> </ul>		<b>HSW8</b>

Topic Area 4: Analytical techniques and evidence interpretation			
Teaching content	Exemplification	Opportunities to cover:	
4.1 Observational analytical techniques		Maths	HSW
<b>4.1.1 Types of observational evidence</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Bodily fluids</li> <li><input type="checkbox"/> Fingerprints</li> <li><input type="checkbox"/> Footprints</li> <li><input type="checkbox"/> Other forms of print</li> <li><input type="checkbox"/> Hair identification</li> <li><input type="checkbox"/> Bone, teeth and skeletal anatomy</li> <li><input type="checkbox"/> Plant material</li> <li><input type="checkbox"/> Fingernail clippings and scrapings</li> <li><input type="checkbox"/> Skin</li> <li><input type="checkbox"/> Insects <ul style="list-style-type: none"> <li>• Flies (Diptera)</li> <li>• Beetles (Coleoptera)</li> </ul> </li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> The components of bodily fluids and their role in matching to individuals</li> <li><input type="checkbox"/> How forensic biologists make use of bodily fluids to support an investigation</li> </ul> <p>Examples of <b>bodily fluids</b> may include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Blood</li> <li><input type="checkbox"/> Saliva</li> <li><input type="checkbox"/> Urine</li> <li><input type="checkbox"/> Fingerprint patterns, ridge characteristics and ridge counting</li> <li><input type="checkbox"/> The types of information available from finger, foot and shoe prints and how to use them for identification</li> <li><input type="checkbox"/> How lip and ear prints, among others, can also be used to confirm identity</li> <li><input type="checkbox"/> The types of information that can be observed by comparing trace and hair samples</li> <li><input type="checkbox"/> How human and animal hair differ</li> <li><input type="checkbox"/> The types of evidence bones and skeletons can reveal</li> <li><input type="checkbox"/> The advantages and disadvantages of using teeth to identify individuals</li> <li><input type="checkbox"/> Combining evidence collected from different plant regions, including roots, stems, leaves, flowers and seeds</li> <li><input type="checkbox"/> Using microscopy to detect the presence of cells and tissues in recovered evidence</li> <li><input type="checkbox"/> Ways insect identification and life cycle can be used to estimate the post-mortem interval</li> </ul>	M1.3	HSW11

<input type="checkbox"/> Fibres	<input type="checkbox"/> Fibres as important sources of forensic evidence <input type="checkbox"/> Limitations of observational evidence techniques and when each technique is appropriate to use		
<b>4.1.2 Analysing observational evidence</b> <input type="checkbox"/> Microscopy <input type="checkbox"/> Observing <input type="checkbox"/> Measuring <input type="checkbox"/> Drawing <input type="checkbox"/> Photography <input type="checkbox"/> Electron micrographs <input type="checkbox"/> DNA identification <input type="checkbox"/> X-rays <input type="checkbox"/> CT scans <input type="checkbox"/> Presumptive tests <ul style="list-style-type: none"><li>• Luminol</li><li>• Leucomalachite green (LMG)</li></ul> <input type="checkbox"/> Blood groups and Rhesus system <input type="checkbox"/> Blood splatter identification	To include: <input type="checkbox"/> The difference between DNA sequencing and profiling <input type="checkbox"/> Principles and application of restriction enzyme analysis <input type="checkbox"/> Principles and application of gel electrophoresis <input type="checkbox"/> Why polymerase chain reaction (PCR) is important to DNA profiling material <input type="checkbox"/> The value of presumptive tests in identification of blood <input type="checkbox"/> The limitations of blood group analysis alone for identification <input type="checkbox"/> How blood patterns can provide indications about how blood was shed <input type="checkbox"/> When the use of X-rays and CT scans is appropriate and their value for forensic biology <input type="checkbox"/> How to perform observational analysis safely and skilfully  Does not include: <input type="checkbox"/> Presumptive tests other than those used for blood	<b>M0.2</b>	<b>HSW7 HSW9</b>
<b>4.2 Microbiological analytical techniques</b> <b>4.2.1</b> <input type="checkbox"/> Microbes (bacteria, fungi, algae and diatoms) and viruses  <input type="checkbox"/> Culturing microbiological evidence samples on agar plates for identification	To include <input type="checkbox"/> Using microscopy to detect the presence of microbes in recovered evidence <input type="checkbox"/> The role of microbiological evidence in forensic biology and identification <input type="checkbox"/> The importance of diatoms in forensic investigations <input type="checkbox"/> The limitations of techniques available in schools <input type="checkbox"/> How to perform microbiological analysis safely and skilfully  <input type="checkbox"/> How to analyse colony morphology using: <ul style="list-style-type: none"><li>• Size</li><li>• Shape</li><li>• Colour</li><li>• Surface appearance</li></ul>	<b>Maths</b>	<b>HSW</b>

	<ul style="list-style-type: none"> <li><input type="checkbox"/> The limitations of using agar plates in schools and the impact of following safety protocols for microbial identification</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Haemolysis</li> </ul>		
<b>4.3 Reviewing evidence</b>		<b>Maths</b>	<b>HSW</b>
<b>4.3.1 Interpreting results of analyses</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> The limitations of individual pieces of evidence</li> <li><input type="checkbox"/> Ways that evidence can be tampered with or destroyed deliberately</li> <li><input type="checkbox"/> How to evaluate how effective the chain of evidence has been throughout the investigation</li> <li><input type="checkbox"/> How well the preservation methods prevented contamination and/or destruction of the evidence from the point of recovery</li> <li><input type="checkbox"/> The existence of false positives and negatives in forensic tests</li> <li><input type="checkbox"/> How the identification of individuals from false positive evidence can be avoided</li> <li><input type="checkbox"/> How to assess the quality of the data collected in terms of accuracy, validity, and precision</li> </ul>	<b>M1.8</b>	<b>HSW6</b>
<b>4.3.2 Communicating results of analysis</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> How a forensic biologist communicates the results of the analyses and for whom</li> <li><input type="checkbox"/> How a forensic biologist makes judgments</li> <li><input type="checkbox"/> What a forensic biologist does not make judgments on</li> </ul>		<b>HSW11</b>

### Assessment criteria

Section 6.4 provides full information on how to assess the NEA units and apply the assessment criteria.

These are the assessment criteria for the tasks for this unit. The assessment criteria indicate what is required in each task. Students' work must show that all aspects of a criterion have been met in sufficient detail for it to be **successfully achieved** (see Section 6.4.1). If a student's work does not fully meet a criterion, you must not award that criterion.

The command words used in the assessment criteria are defined in **Appendix B**.

Pass	Merit	Distinction
<b>P1:</b> Explain which potential forensic biology disciplines could aid the investigation.		
<b>P2:</b> Create a plan to preserve the crime scene and collect the evidence.	<b>M1:</b> Explain the choice of preservation and collection methods.	
<b>P3:</b> Create a plan to analyse the evidence from the scenario.	<b>M2:</b> Explain the choice of analytical techniques.	
<b>P4:</b> Complete a risk assessment for the crime scene investigation and evidence analysis.		
<b>P5:</b> Preserve the crime scene.	<b>M3:</b> Explain the suitability of the preservation, and collection methods performed.	
<b>P6:</b> Use appropriate techniques to collect evidence from the crime scene.		
<b>P7:</b> Select appropriate techniques for the evidence.	<b>M4:</b> Explain how the integrity of the evidence is maintained.	<b>D1:</b> Justify the choice of techniques for the evidence.
<b>P8:</b> Perform observational analysis safely and skilfully.		<b>D2:</b> Evaluate the effectiveness of the risk assessment.
<b>P9:</b> Perform microbiological analysis safely and skilfully.		
<b>P10:</b> Record results of the analysis in suitable formats.		
<b>P11:</b> Assess which individual(s) most closely matches each piece of evidence from the crime scene.	<b>M5:</b> Discuss the validity and the limitations of the analytical techniques conducted.	<b>D3:</b> Assess the relative importance of the results from the analytical techniques to the investigation.

Pass	Merit	Distinction
	<b>M6: Suggest</b> appropriate improvements to the investigation.	<b>D4: Discuss</b> the effectiveness of the collection of evidence.
		<b>D5: Justify</b> improvements to increase confidence in the conclusions.

### Assessment guidance

This assessment guidance gives you information relating to the assessment criteria. There might not be additional assessment guidance for each assessment criterion. It is included only where it is needed.

Assessment Criteria	Assessment guidance
P1	<ul style="list-style-type: none"> <li>Students must recognise the potential evidence likely to be obtained from the crime scene, and the evidence collected from the individuals, identify the forensic biology disciplines required for the investigation, and then explain how each of the disciplines could aid the investigation.</li> </ul>
P2	<ul style="list-style-type: none"> <li>Students must show how they intend to preserve the crime scene through site restriction, notes and visual evidence and a suitable search pattern.</li> <li>Students must show how they will collect the evidence from the crime scene through the recovery of trace materials, together with the ways the evidence is packaged, labelled, stored, and transported.</li> </ul>
P3	<ul style="list-style-type: none"> <li>The evidence from the scenario is the evidence collected by the police from the individuals in the scenario.</li> </ul>
M1	<ul style="list-style-type: none"> <li>The focus of the explanation should only be on why the particular preservation and collection methods chosen <b>are</b> appropriate based on the initial photographic or video evidence provided by the centre.</li> </ul>
M2	<ul style="list-style-type: none"> <li>The focus of the explanation should only be on why the particular analytical methods chosen <b>are</b> appropriate based on the initial photographic or video evidence provided by the centre.</li> </ul>
P5	<ul style="list-style-type: none"> <li>Students should follow their plan created in P2 to preserve the crime scene.</li> <li>Students should also record and document the crime scene to provide evidence of the preservation, including the location and condition of the biological evidence.</li> </ul>
P6	<ul style="list-style-type: none"> <li>Students should follow their plan created in P2 to collect evidence from the crime scene.</li> <li>The teacher observation record should indicate how safely students preserved and collected evidence from the crime scene.</li> <li>The appropriate techniques include recovering, recording, packaging, labelling, and storing evidence from the crime scene.</li> </ul>

M3	<ul style="list-style-type: none"> <li>• This is an extension of <b>P5</b>.</li> <li>• Students must explain how suitable their methods of crime scene preservation and evidence collection were from their plan in <b>P2</b> in achieving minimal contamination and disturbance of all the physical evidence.</li> <li>• Students must also include any adaptations that were required to their plan to preserve the crime scene and collect the evidence.</li> </ul>
P7	<ul style="list-style-type: none"> <li>• Students must select appropriate observational and microbiological analytical techniques for the evidence obtained from the crime scene and for the evidence collected from the individuals.</li> </ul>
P8	<ul style="list-style-type: none"> <li>• The teacher observation record form should comment on the safe and skilful use of observational analytical techniques performed by the student.</li> </ul>
P9	<ul style="list-style-type: none"> <li>• The teacher observation record form should comment on the safe and skilful use of microbiological analytical techniques performed by the student.</li> </ul>
P10	<ul style="list-style-type: none"> <li>• Formats could include tables and written descriptions with annotated sketches and photographs.</li> </ul>
M4	<ul style="list-style-type: none"> <li>• Students must explain how the integrity of the evidence is maintained through the chain of evidence.</li> </ul>
D1	<ul style="list-style-type: none"> <li>• This is an extension of <b>P7</b>.</li> <li>• Students should use their understanding of the unit content to provide valid scientific reasoning for the choice of tests. Additional research is not required.</li> </ul>
D2	<ul style="list-style-type: none"> <li>• Students must evaluate the effectiveness of the risk assessment in terms of how well the risk assessment protected them from physical, biological and chemical hazards.</li> </ul>
M5	<ul style="list-style-type: none"> <li>• Consideration should be given to the likelihood of false positives, the size and condition of each piece of evidence, the quality of preservation and storage methods prior to testing, and equipment used.</li> </ul>
M6	<ul style="list-style-type: none"> <li>• They should reflect on their approaches to <b>Tasks 2</b> and <b>3</b> and consider the way contamination risks could be reduced, chain of evidence correctly maintained, and analysis of evidence improved.</li> </ul>
D3	<ul style="list-style-type: none"> <li>• This is an extension of <b>P11</b>.</li> <li>• Consideration should be given to the type of evidence: generic (class evidence) or unique (individual evidence) and the relative importance of each type of evidence.</li> </ul>
D4	<ul style="list-style-type: none"> <li>• Following the student's analysis from Task 3, students should make a reasoned judgment about: <ul style="list-style-type: none"> <li>○ the effectiveness of the recovery of trace materials</li> <li>○ the effectiveness of the preservation and storage of evidence to prevent contamination and degradation.</li> </ul> </li> </ul>
D5	<ul style="list-style-type: none"> <li>• Students should consider which suggestions in <b>M6</b> would improve confidence in the conclusions made in <b>P11</b>.</li> </ul>

## Synoptic assessment

Some of the knowledge, understanding and skills needed to complete this unit will draw on the learning in Units F180 and F181.

This table details these synoptic links.

Unit F185: Forensic biology		Unit F180: Fundamentals of science	
Topic Area		Topic Area	
2	Cells, tissues and organs in forensic biology	B1	Cell structure and microscopy

Unit F185: Forensic biology		Unit F181: Science in society	
Topic Area		Topic Area	
4	Analytical techniques and evidence interpretation	4	Communicating science
		2	Handling scientific data

More information about synoptic assessment in these qualifications can be found in **Section 5.2 Synoptic assessment**.

## 4.3.5 Unit F186: Medical physics

**Unit Aim**

This unit explores different imaging techniques used for medical diagnosis and different therapies used for medical treatment.

In this unit you will learn about the different diagnosis techniques and therapies that are used in medicine. You will apply what you learn about each technique to some specific scenarios, making decisions about the most appropriate imaging technique and types of therapies that can be used. You will suggest how the imaging and therapy techniques will need to be performed and the impact they will have on patients and professionals.

<b>Unit F186: Medical physics</b>			
<b>Topic Area 1: Application of non-ionising diagnosis techniques</b>			
<b>Teaching content</b>	<b>Exemplification</b>	<b>Opportunities to cover:</b>	
<b>1.1 Magnetic Resonance Imaging (MRI)</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> How an MRI scanner uses a magnetic field and radio waves to stimulate hydrogen atoms</li> <li><input type="checkbox"/> How altering the radio frequency can distinguish between different types of tissues</li> <li><input type="checkbox"/> Why MRI is a safe technique for visualising the entire body</li> <li><input type="checkbox"/> Advantages and disadvantages of MRI, including the quality of the image, cost and availability</li> <li><input type="checkbox"/> Risks to patients and staff, including noise, use of sedatives and contrast agents</li> <li><input type="checkbox"/> Who manages the MRI machine and who produces and interprets MRIs</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Detailed understanding of nuclear precession, spin or Larmor frequency</li> <li><input type="checkbox"/> Calculations relating to relaxation or precession</li> <li><input type="checkbox"/> T1/T2 relaxation time</li> </ul>	<b>Maths</b>	<b>HSW</b>
<b>1.2 Diagnostic ultrasound</b>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> The role of the transducer and boundaries between tissues in generating an image</li> <li><input type="checkbox"/> How to decide which type of transducer to use</li> <li><input type="checkbox"/> The relationships between frequency, gain, wavelength, penetration and resolution in producing clear images using ultrasound</li> <li><input type="checkbox"/> The difference between anatomical and doppler</li> <li><input type="checkbox"/> Ultrasound and its use</li> </ul>	<b>Maths</b>	<b>HSW</b>

<input type="checkbox"/> Safety considerations <input type="checkbox"/> Professionals involved	<input type="checkbox"/> How to select the most appropriate ultrasound gel <input type="checkbox"/> Why ultrasounds are safe to use <input type="checkbox"/> Advantages and disadvantages of ultrasound as an imaging technique, including the quality of the image, cost and availability <input type="checkbox"/> Who manages the ultrasound machine and who produces and interprets ultrasounds  Does not include: <input type="checkbox"/> Theoretical understanding of doppler effect <input type="checkbox"/> Other forms of functional ultrasound <input type="checkbox"/> Determining the speed of blood		
<b>1.3 Endoscopy</b>	<b>To include:</b> <input type="checkbox"/> Modern endoscopes, including the use of non-coherent fibres and capsule endoscopy <input type="checkbox"/> How to decide which type of endoscopy to use <input type="checkbox"/> Advantages and disadvantages of endoscopy as an imaging technique, including the quality of the image, cost and availability <input type="checkbox"/> Risks to the patient undergoing endoscopy <input type="checkbox"/> Who performs endoscopies and interprets the images  Does not include: <input type="checkbox"/> Total internal reflection and critical angle	<b>Maths</b>	<b>HSW</b>
<input type="checkbox"/> Basic structure and function <input type="checkbox"/> Types of endoscopy <input type="checkbox"/> How to prepare for endoscopy <input type="checkbox"/> Safety considerations <input type="checkbox"/> Professionals involved			<b>HSW9 HSW11</b>

<input type="checkbox"/> Basic structure of the heart <ul style="list-style-type: none"> <li>• Sino-atrial node</li> <li>• Atrioventricular node</li> </ul> <input type="checkbox"/> Interpreting ECGs <input type="checkbox"/> Safety considerations <input type="checkbox"/> Professionals involved	<b>To include:</b> <input type="checkbox"/> How the structures of the heart coordinate to create a heartbeat <input type="checkbox"/> Common issues with the heart detected by an ECG <input type="checkbox"/> Position of electrodes, their role in measuring potential difference (p.d.) and the difference between positive and negative deflections <input type="checkbox"/> How to identify P waves, QRS waves, and heart rate <input type="checkbox"/> How to interpret simple ECGs, to include irregular heart rhythms, and evidence of heart attack <input type="checkbox"/> Advantages and disadvantages of ECG as a diagnostic technique <input type="checkbox"/> How ECGs can be used to improve CT scans <input type="checkbox"/> Risks to the patient undergoing an ECG	<b>Maths</b>	<b>HSW</b>
		<b>M1.6 M3.1</b>	<b>HSW4</b>

	Does not include: <input type="checkbox"/> ST segments <input type="checkbox"/> T wave		
<b>Topic Area 2: Application of ionising diagnosis techniques</b>			
Teaching content	Exemplification	Opportunities to cover:	
<b>2.1 X-ray imaging</b>		<b>Maths</b>	<b>HSW</b>
<b>2.1.1 Plain X-ray image</b> <input type="checkbox"/> X-ray tube structure <input type="checkbox"/> Production of X-rays <input type="checkbox"/> X-ray attenuation <input type="checkbox"/> Effective radiation dose <input type="checkbox"/> Safety considerations <input type="checkbox"/> Professionals involved	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Optimizing settings of the X-ray tube voltage (kVp), current (mA) and exposure time (s) for image quality and safety for different types of patients</li> <li><input type="checkbox"/> Common uses of X-ray imaging</li> <li><input type="checkbox"/> The use of image contrast enhancement in X-ray imaging</li> <li><input type="checkbox"/> How to position patients to optimise images and reduce artifacts</li> <li><input type="checkbox"/> Use of collimators and filters to improve image quality</li> <li><input type="checkbox"/> The effective radiation dose from different types of X-ray scan</li> <li><input type="checkbox"/> Advantages and disadvantages of X-ray as an imaging technique</li> <li><input type="checkbox"/> Safety procedures to protect patients and staff from ionising radiation</li> <li><input type="checkbox"/> Who manages the equipment, conducts the procedure and interprets the images</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Types of X-ray (e.g. Bremsstrahlung)</li> <li><input type="checkbox"/> Formation of an X-ray image</li> <li><input type="checkbox"/> X-ray attenuation mechanisms</li> <li><input type="checkbox"/> X-ray spectra graphs</li> <li><input type="checkbox"/> Photographic film</li> <li><input type="checkbox"/> Charge-coupled device</li> <li><input type="checkbox"/> Measuring radiation exposure</li> </ul>		<b>HSW9</b>
<b>2.1.2 Computerised tomography (CT) scans and contrast media</b> <input type="checkbox"/> Basic structure and function of a CT machine <input type="checkbox"/> Radiopaque media <ul style="list-style-type: none"> <li>• Barium swallow</li> <li>• Angiogram</li> </ul> <input type="checkbox"/> Safety considerations	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> How a CT scan is used to image the body</li> <li><input type="checkbox"/> Advantages and disadvantages of CT imaging, including the quality of image, cost and availability</li> <li><input type="checkbox"/> Why some patients may have both an MRI and a CT scan</li> <li><input type="checkbox"/> Use of a contrast medium to form an image including examples such as barium meal</li> <li><input type="checkbox"/> Risks associated with some contrast media</li> <li><input type="checkbox"/> The effective radiation dose from CT scans</li> </ul>	<b>M1.1</b> <b>M1.3</b> <b>M3.1</b>	<b>HSW9</b>

<input type="checkbox"/> Effective radiation dose <input type="checkbox"/> Professionals involved	<input type="checkbox"/> How specific health problems are diagnosed using these methods <input type="checkbox"/> Safety procedures to protect patient and staff from ionising radiation <input type="checkbox"/> Who manages the equipment, conducts the procedure and interprets the images  Does not include: <input type="checkbox"/> Detailed structure of CT scanning machine <input type="checkbox"/> Different types of CT scan		
<b>2.2 Radionuclides</b>		<b>Maths</b>	<b>HSW</b>
<b>2.2.1 Radiopharmaceuticals</b> <input type="checkbox"/> Use of gamma camera <input type="checkbox"/> Function of a tracer <input type="checkbox"/> Radiation dose <input type="checkbox"/> Half-life and effective half-life <input type="checkbox"/> Types of radiation <input type="checkbox"/> Radiation properties <input type="checkbox"/> Health and safety <input type="checkbox"/> Professionals involved	To include: <input type="checkbox"/> Basic structure of the gamma camera <input type="checkbox"/> Function of radiopharmaceuticals in the body as a tracer <input type="checkbox"/> Comparison of dose level from different types, considering half-life and radiation type <input type="checkbox"/> How to select the type of tracer to use based on delivery method, age and health of the patient, lifestyle of the patient and its elimination from the body <input type="checkbox"/> Safety procedures to protect patient and staff from ionising radiation <input type="checkbox"/> Health and safety legislation linked to use of radioactive materials, including ARSAC <input type="checkbox"/> Who prescribes and administers the radiopharmaceutical, and monitors the patient <input type="checkbox"/> Advantages and disadvantages of radiopharmaceuticals for diagnosis, including the quality of image, cost and availability  Does not include: <input type="checkbox"/> Manufacture of radiopharmaceuticals	<b>M1.3</b>	<b>HSW8</b>
<b>2.2.2 Positron emission tomography (PET)</b> <input type="checkbox"/> Use of Gamma camera <input type="checkbox"/> Radiolabelled glucose <input type="checkbox"/> Gamma radiation detection <input type="checkbox"/> Combining with CT scan <input type="checkbox"/> Locating a tumour <input type="checkbox"/> Health and safety	To include: <input type="checkbox"/> Basic principles of a PET scan <input type="checkbox"/> How PET is able to visualise the body, including the role of fluorodeoxyglucose (FDG) <input type="checkbox"/> Why PET scans are used <input type="checkbox"/> Advantages and disadvantages of this imaging technique, including the quality of image, cost and availability <input type="checkbox"/> Why combining this with a CT scan is necessary to accurately locate a tumour <input type="checkbox"/> Safety procedures to protect patient and staff from ionising radiation <input type="checkbox"/> Who administers the FDG, and who performs the PET scan	<b>M4.1</b>	<b>HSW10</b>

<b>Topic Area 3: Application of ionising therapy techniques</b>			
<b>Teaching content</b>	<b>Exemplification</b>	<b>Opportunities to cover:</b>	
<b>3.1 Treatment with external source</b>		<b>Maths</b>	<b>HSW</b>
<input type="checkbox"/> Radiotherapy using X-rays <input type="checkbox"/> Radiotherapy using gamma <input type="checkbox"/> UV skin treatment <input type="checkbox"/> Proton beam <input type="checkbox"/> Safety considerations <input type="checkbox"/> Professionals involved	To include: <input type="checkbox"/> Penetration of each type through the body <input type="checkbox"/> Relative energy delivered to cells from each type <input type="checkbox"/> Accuracy of each type in treating damaged cells/tissues and risks associated <input type="checkbox"/> Conditions for which different types of external source are required and contraindications <input type="checkbox"/> Advantages and disadvantages of these imaging techniques, cost and availability <input type="checkbox"/> Safety procedures to protect patient and staff from ionising radiation <input type="checkbox"/> Who manages the equipment and conducts the procedure		<b>HSW11</b>
<b>3.2 Treatment with internal source</b>		<b>Maths</b>	<b>HSW</b>
<input type="checkbox"/> Radionuclide therapy <input type="checkbox"/> Brachytherapy <input type="checkbox"/> Safety considerations <input type="checkbox"/> Professionals involved	To include: <input type="checkbox"/> Types of radionuclide sources used for different treatments <input type="checkbox"/> The use of internal source therapy instead of external source in some situations <input type="checkbox"/> Conditions for which different types of internal source are required and contraindications <input type="checkbox"/> How to select the type of therapy, considering the dose required, retention in the body, excretion, health of the patient, delivery method and risk to bystanders <input type="checkbox"/> Advantages and disadvantages of these imaging techniques, cost and availability <input type="checkbox"/> Safety procedures to protect patient and staff from ionising radiation <input type="checkbox"/> Who prescribes and administers the radiotherapy, and monitors the patient		<b>HSW7</b>
<b>Topic Area 4: Application of non-ionising therapy techniques</b>			
<b>Teaching content</b>	<b>Exemplification</b>	<b>Opportunities to cover:</b>	
<b>4.1 Lasers</b>		<b>Maths</b>	<b>HSW</b>
<input type="checkbox"/> Basic principles <input type="checkbox"/> Low-level laser therapy (LLLT) <input type="checkbox"/> Laser cutting/burning <input type="checkbox"/> Light frequency and wavelength <input type="checkbox"/> Safety considerations	To include: <input type="checkbox"/> Properties of laser light that make it suitable for therapies <input type="checkbox"/> How different frequencies are used to cut, burn or repair different types of tissue selectively <input type="checkbox"/> Conditions or treatments for which lasers are beneficial and contraindications <input type="checkbox"/> Risks and benefits associated with each technique <input type="checkbox"/> Beam power required for different procedures		<b>HSW7</b>

	<ul style="list-style-type: none"> <li><input type="checkbox"/> Why lasers are not ionising, even at high power, in terms of photon energy</li> <li><input type="checkbox"/> Advantages and disadvantages of lasers for therapy including cost and availability</li> <li><input type="checkbox"/> Who manages the equipment and conducts the procedure</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Types of stimulated emission</li> <li><input type="checkbox"/> Semiconductor lasers</li> <li><input type="checkbox"/> Population inversion</li> <li><input type="checkbox"/> Pumping</li> <li><input type="checkbox"/> Structure of lasers</li> </ul>		
<b>4.2 Photodynamic therapy (PDT)</b>		<b>Maths</b>	<b>HSW</b>
<ul style="list-style-type: none"> <li><input type="checkbox"/> Basic principles</li> <li><input type="checkbox"/> Use of laser</li> <li><input type="checkbox"/> Cancer treatment</li> <li><input type="checkbox"/> Safety considerations</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> How PDT is performed and the role of phototoxicity</li> <li><input type="checkbox"/> Conditions for which PDT is effective</li> <li><input type="checkbox"/> Advantages and disadvantages of PDT over ionising therapies</li> <li><input type="checkbox"/> Risks and benefits associated with PDT</li> <li><input type="checkbox"/> Possible side effects of PDT and comparison to ionising therapies</li> <li><input type="checkbox"/> Who manages the equipment and conducts the procedure</li> </ul>		<b>HSW7</b>
<b>4.3 Artificial cardiac devices</b>		<b>Maths</b>	<b>HSW</b>
<ul style="list-style-type: none"> <li><input type="checkbox"/> Pacemaker structure</li> <li><input type="checkbox"/> Pacemaker function</li> <li><input type="checkbox"/> Pacemaker purpose</li> <li><input type="checkbox"/> ICD structure</li> <li><input type="checkbox"/> ICD function</li> <li><input type="checkbox"/> ICD purpose</li> <li><input type="checkbox"/> Safety considerations</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Conditions for which artificial cardiac devices are appropriate and contraindications</li> <li><input type="checkbox"/> How pacemaker and ICD can affect heart rhythm</li> <li><input type="checkbox"/> Comparison of pacemaker and ICD</li> <li><input type="checkbox"/> Advantages and disadvantages of each device for treating different conditions</li> <li><input type="checkbox"/> Risks and benefits associated with artificial cardiac devices</li> <li><input type="checkbox"/> Who manages the equipment and conducts the procedure</li> </ul> <p>Does not include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Understanding of battery technology</li> <li><input type="checkbox"/> How they are fitted</li> <li><input type="checkbox"/> How pacemakers are charged</li> </ul>	<b>M3.1</b>	<b>HSW7</b>
<b>4.4 Ultrasound therapies</b>		<b>Maths</b>	<b>HSW</b>
<ul style="list-style-type: none"> <li><input type="checkbox"/> Basic principles</li> <li><input type="checkbox"/> Tissue Repair</li> </ul>	<p>To include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Differences in procedure, technique and equipment compared with imaging</li> <li><input type="checkbox"/> Conditions for which each ultrasound therapy is effective and contraindications</li> </ul>		<b>HSW4</b> <b>HSW11</b>

<input type="checkbox"/> High intensity focused ultrasound (HIFU) <input type="checkbox"/> Low intensity pulsed ultrasound (LIPUS) <input type="checkbox"/> Shock wave lithotripsy (SWL) <input type="checkbox"/> Hyperthermia <input type="checkbox"/> Safety considerations	<input type="checkbox"/> Required dose protocols for treating different types of condition <input type="checkbox"/> Risks and benefits of using different ultrasound therapies <input type="checkbox"/> Advantages and disadvantages of each technique for treating different conditions <input type="checkbox"/> Who manages the equipment and conducts the procedure		
<b>Topic Area 5: Planning for diagnosis and therapy</b>			
Teaching content	Exemplification	Opportunities to cover:	
<b>5.1 Diagnosis plan</b>		<b>Maths</b>	<b>HSW</b>
<input type="checkbox"/> Producing a diagnosis plan <input type="checkbox"/> Risk assessment <input type="checkbox"/> Communicating a diagnosis plan <input type="checkbox"/> Information and advice given to patients <input type="checkbox"/> Healthcare professionals involved <input type="checkbox"/> Healthcare professional roles	To include: <ul style="list-style-type: none"> <li><input type="checkbox"/> How to write a logical diagnosis plan</li> <li><input type="checkbox"/> How to assess the quality of a diagnosis plan</li> <li><input type="checkbox"/> How to create a risk assessment that is linked to a diagnosis plan</li> <li><input type="checkbox"/> How to create a presentation of the diagnosis plan that is appropriate for healthcare professionals and other appropriate audiences</li> <li><input type="checkbox"/> How to communicate an appropriate diagnosis plan to healthcare professionals and other appropriate audiences</li> <li><input type="checkbox"/> Why it is important to consider the needs of the patient, costs, and availability of equipment and techniques</li> <li><input type="checkbox"/> The possible social, emotional, and mental health effects to the patient before, during, and after the diagnosis plan</li> <li><input type="checkbox"/> How to obtain appropriate feedback on a diagnosis plan and then summarise the feedback</li> <li><input type="checkbox"/> How to prepare for questions that may be asked by healthcare professionals and other audiences</li> </ul>		<b>HSW10</b> <b>HSW11</b>
<b>5.2 Therapy Plan</b>		<b>Maths</b>	<b>HSW</b>
<input type="checkbox"/> Producing a therapy plan <input type="checkbox"/> Risk assessment <input type="checkbox"/> Communicating a therapy plan <input type="checkbox"/> Information and advice given to patients <input type="checkbox"/> Healthcare professionals involved	To include: <ul style="list-style-type: none"> <li><input type="checkbox"/> How to write a logical therapy plan</li> <li><input type="checkbox"/> How to assess the quality of a therapy plan</li> <li><input type="checkbox"/> How to create a risk assessment that is linked to a therapy plan</li> <li><input type="checkbox"/> How to create a presentation of the therapy plan that is appropriate for patients and other appropriate audiences</li> </ul>		<b>HSW11</b>

<input type="checkbox"/> Healthcare professional roles	<ul style="list-style-type: none"> <li><input type="checkbox"/> How to communicate an appropriate therapy plan to patients and other appropriate audiences</li> <li><input type="checkbox"/> Why it is important to consider the needs of the patient, costs, and availability of equipment and techniques</li> <li><input type="checkbox"/> The possible social, emotional, and mental health effects to the patient before, during, and after the therapy plan</li> <li><input type="checkbox"/> How to obtain appropriate feedback on a therapy plan and then summarise the feedback</li> <li><input type="checkbox"/> How to prepare for questions that may be asked by healthcare professionals and other audiences</li> </ul>		
--	---	--	--

### Assessment criteria

Section 6.4 provides full information on how to assess the NEA units and apply the assessment criteria.

These are the assessment criteria for the tasks for this unit. The assessment criteria indicate what is required in each task. Students' work must show that all aspects of a criterion have been met in sufficient detail for it to be **successfully achieved** (see Section 6.4.1). If a student's work does not fully meet a criterion, you must not award that criterion.

The command words used in the assessment criteria are defined in **Appendix B**.

Pass	Merit	Distinction
<b>P1: Summarise</b> the ionising diagnosis technique(s) that are suitable for the diagnosis scenario.	<b>M1: Explain</b> why other diagnosis techniques are not suitable.	<b>D1: Analyse</b> the advantages and disadvantages of your diagnosis plan.
<b>P2: Summarise</b> the non-ionising diagnosis technique(s) that are suitable for the diagnosis scenario.		
<b>P3: Create</b> a logical diagnosis plan for the patient in the diagnosis scenario, taking into account their needs.	<b>M2: Use</b> research to <b>justify</b> the diagnosis plan for the patient in the therapy scenario.	
<b>P4: Create</b> a risk assessment linked to the diagnosis plan.		
<b>P5: Summarise</b> the ionising therapy technique(s) that are suitable for the therapy scenario.	<b>M3: Explain</b> why other therapy techniques are not suitable.	<b>D2: Analyse</b> the advantages and disadvantages of your therapy plan.

Pass	Merit	Distinction
<b>P6:</b> <b>Summarise</b> the non-ionising therapy technique(s) that are suitable for the therapy scenario.		
<b>P7:</b> <b>Create</b> a logical therapy plan for the patient in the therapy scenario, taking into account their needs.	<b>M4:</b> Use research to <b>justify</b> the therapy plan for the patient in the therapy scenario.	
<b>P8:</b> <b>Create</b> a risk assessment linked to the therapy plan.		
<b>P9:</b> <b>Create</b> an appropriate presentation for the chosen scenario.	<b>M5:</b> <b>Deliver</b> a presentation tailored to the intended audience, including information beyond what is included in the presentation document.	<b>D3:</b> <b>Justify</b> the design and content of the presentation.
<b>P10:</b> <b>Suggest</b> adaptations to the presentation for healthcare professionals or the patient.		
<b>P11:</b> <b>Summarise</b> the feedback received for your chosen plan.	<b>M6:</b> <b>Assess</b> the strengths and weaknesses of your chosen plan.	<b>D4:</b> <b>Justify</b> potential improvements to the plan.
		<b>D5:</b> <b>Evaluate</b> the presentation to better meet the needs of the target audience.

### Assessment guidance

This assessment guidance gives you information relating to the assessment criteria. There might not be additional assessment guidance for each assessment criterion. It is included only where it is needed.

Assessment Criteria	Assessment guidance
P1	<ul style="list-style-type: none"> <li>Students only need to include the important and relevant facts about the suitability of each technique, limited to those explored in Unit F186.</li> </ul>
P2	<ul style="list-style-type: none"> <li>Students only need to include the important and relevant facts about the suitability of each technique, limited to those explored in Unit F186.</li> </ul>
P3	<ul style="list-style-type: none"> <li>The plan should be presented in an appropriate format.</li> </ul>

P4	<ul style="list-style-type: none"> <li>The risk assessment should contain risks to the patient and other individuals.</li> <li>The risk assessment only requires qualitative detail.</li> </ul>
M1	<ul style="list-style-type: none"> <li>The explanations should include scientific reasoning.</li> </ul>
M2	<ul style="list-style-type: none"> <li>This is an extension of the diagnosis plan created in <b>P3</b>.</li> <li>Students should use research to give valid reasons for how the diagnostic techniques should be carried out.</li> <li>The justification should include how the patient's needs were accounted for.</li> <li>The research element of this criterion does not need to be completed under supervised conditions.</li> </ul>
D1	<ul style="list-style-type: none"> <li>The focus of this analysis should be on the specific needs of the patient in the diagnosis scenario.</li> <li>Reasoned comments on the viability of the diagnosis plan should be provided.</li> </ul>
P5	<ul style="list-style-type: none"> <li>Students only need to include the important and relevant facts about the suitability of each technique, limited to those explored in Unit F186.</li> </ul>
P6	<ul style="list-style-type: none"> <li>Students only need to include the important and relevant facts about the suitability of each technique, limited to those explored in Unit F186.</li> </ul>
P7	<ul style="list-style-type: none"> <li>The plan should be presented in an appropriate format.</li> </ul>
P8	<ul style="list-style-type: none"> <li>The risk assessment should contain risks to the patient and other individuals.</li> <li>The risk assessment only requires qualitative detail.</li> </ul>
M3	<ul style="list-style-type: none"> <li>The explanations should be brief and include scientific reasoning.</li> </ul>
M4	<ul style="list-style-type: none"> <li>This is an extension of the therapy plan created in <b>P7</b>.</li> <li>Students should use research to give valid reasons for how the therapy techniques should be carried out.</li> <li>The justification should include how the patient's needs were accounted for.</li> <li>The research element of this criterion does not need to be completed under supervised conditions.</li> </ul>
D2	<ul style="list-style-type: none"> <li>The focus of this analysis should be on the specific needs of the patient in the therapy scenario.</li> <li>Reasoned comments on the viability of the therapy plan should be provided.</li> </ul>
P9	<ul style="list-style-type: none"> <li>The presentation should be in the format they feel is most appropriate, which could include a leaflet, a PowerPoint presentation, a flow diagram, etc.</li> <li>There must be sufficient detail in the presentation to demonstrate the key components of their chosen plan.</li> </ul>
P10	<ul style="list-style-type: none"> <li>If students have chosen to present the diagnosis plan, they should suggest adaptations to the presentation for the patient.</li> <li>If students have chosen to present the therapy plan, they should suggest adaptations to the presentation for healthcare professionals.</li> </ul>
M5	<ul style="list-style-type: none"> <li>Students must deliver their presentation to the class and/or teacher, but it must be delivered as though they were conveying the information to the audience selected.</li> <li>The presentation delivered must go beyond what the students have prepared.</li> <li>The teacher observation record form should comment on students' ability to deliver information that is beyond the presentation content e.g. students could respond appropriately to questions from the audience.</li> </ul>

D3	<ul style="list-style-type: none"> <li>Students should give valid reasons for the design and content of the presentation.</li> <li>Students should also give valid reasons for information that is not explicitly provided in the presentation that created.</li> <li>The scientific understanding of the techniques should inform the justification.</li> </ul>
P11	<ul style="list-style-type: none"> <li>Students should be selective when summarising the feedback received.</li> <li>The feedback on the student's plan can be provided by the teacher and/or other students. Feedback on the student's plan can include feedback on the presentation itself.</li> </ul>
M6	<ul style="list-style-type: none"> <li>This is an extension of <b>P11</b>.</li> </ul>
D4	<ul style="list-style-type: none"> <li>Students should give valid reasons for their suggested improvements.</li> <li>Students should consider any limitations of the information provided in the scenario.</li> <li>The scientific understanding of the techniques should inform the justification.</li> </ul>

### Synoptic assessment

Some of the knowledge, understanding and skills needed to complete this unit will draw on the learning in Units F180 and F181.

This table details these synoptic links.

Unit F186: Medical physics		Unit F180: Fundamentals of science	
Topic Area		Topic Area	
1	Application of non-ionising diagnosis techniques	P3	Medical physics
2	Application of ionising diagnosis techniques	P3	Medical physics

Unit F186: Medical physics		Unit F181: Science in society	
Topic Area		Topic Area	
5	Planning for diagnosis and therapy	4	Communicating science
		1	What scientists do

More information about synoptic assessment in these qualifications can be found in **Section 5.2 Synoptic assessment**.

## 5 Assessment and grading

### 5.1 Overview of the assessment

Entry code	H051
Qualification title	OCR Level 3 Alternative Academic Qualification Cambridge Advanced National in Applied Science (Certificate)
GLH	180*
Reference	610/3947/0
Total Units	<p>Has two units:</p> <ul style="list-style-type: none"> <li>Two mandatory units: F180, F182.</li> </ul>

Entry code	H151
Qualification title	OCR Level 3 Alternative Academic Qualification Cambridge Advanced National in Applied Science (Extended Certificate)
GLH	360*
Reference	610/3948/2
Total Units	<p>Has five units:</p> <ul style="list-style-type: none"> <li>Three mandatory units F180, F181, F182</li> <li>Two optional units from: F183, F184, F185, F186.</li> </ul>

\*the GLH includes assessment time for each unit

<b>Unit F180: Fundamentals of science</b>
90 GLH
1 hour 30 minute written exam
70 marks (70 UMS)
OCR-set and marked
A scientific calculator and a ruler are required in this exam
The exam has four sections:
<ul style="list-style-type: none"> <li>Section A – 20 marks which assess content from B1-B4 in F180</li> <li>Section B – 20 marks which assess content from C1-C4 in F180</li> <li>Section C – 20 marks which assess content from P1-P3 in F180</li> <li>Section D – 10 marks which assess content from Practicals 1-6.</li> </ul>

Sections A-C do **not** explicitly assess knowledge of practicals 1-6. However, knowledge of the practicals may help to answer the questions in these sections.

Section D explicitly assesses knowledge of practicals 1-6. Knowledge from B1-B4, C1-C4, and P1-P3 will help to answer the questions in Section D.

A range of item types will be used in this assessment including:

- Forced choice/controlled response questions - typically 1 mark but a maximum of four marks for a single MCQ.
- Short answer, closed response questions (with or without diagrams) – typically 1 to 4 marks.
- Short answer with calculation/working – typically 1 to 4 marks.
- Extended constructed response with points-based mark scheme – 1 mark per factor or feature to a stated maximum, typically 1 to 4 marks.

### **Unit F181: Science in society**

60 GLH

1 hour 15 minute written exam

50 marks (50 UMS)

OCR-set and marked

A scientific calculator and a ruler are required in this exam.

The exam has two sections:

- Section A (pre-release based) has a range of 23-27 marks. Questions in Section A are specifically based on the pre-release material and can come from anywhere in the unit content of F181.
- Section B (**not** pre-release based) has a range of 23-27 marks. Questions in Section B are not based on the pre-release material and can come from anywhere in the unit content of F181.

The combined total of Section A and Section B will be 50 marks.

A range of question types will be used in this assessment including:

- Forced choice/controlled response questions - typically 1 mark but a maximum of four marks for a single MCQ.
- Short answer, closed response questions (with or without diagrams) – typically 1 to 4 marks.
- Short answer with calculation/working – typically 1 to 4 marks.
- Extended constructed response with points-based mark scheme – typically 1 to 4 marks, 1 mark per factor or feature to a stated maximum.
- Extended constructed response with levels of response mark scheme – one 6 mark question and one 9 mark question.

### **Unit F182: Investigating science**

90 GLH

OCR-set assignment

Centre-assessed and OCR-moderated

This set assignment has 5 practical tasks.

It should take about 20 hours of supervised time and 5 hours of unsupervised time to complete.

### **Unit F183: Analytical techniques in chemistry**

60 GLH

OCR-set assignment

Centre-assessed and OCR-moderated

This set assignment has 5 practical tasks.

It should take about 20 hours of supervised time and 4 hours of unsupervised time to complete.

### **Unit F184: Environmental studies**

60 GLH

OCR-set assignment

Centre-assessed and OCR-moderated

This set assignment has 5 practical tasks.

It should take about 18 hours of supervised time and 8 hours of unsupervised time to complete.

### **Unit F185: Forensic biology**

60 GLH

OCR-set assignment

Centre-assessed and OCR-moderated

This set assignment has 4 practical tasks.

It should take about 18 hours of supervised time and 5 hours of unsupervised time to complete.

<b>Unit F186: Medical physics</b>
60 GLH
OCR-set assignment
Centre-assessed and OCR-moderated
This set assignment has 4 practical tasks.
It should take about 15 hours of unsupervised time and 8 hours of unsupervised time to complete.

OCR-set assignments for NEA units are on our secure website, **Teach Cambridge**. Each NEA assignment is live for two years. The intended cohort is shown on the front cover. It is important you use the correct NEA set assignment for each cohort, as starting a new cohort of Year 12 students on an NEA set assignment that has already been live for one year will mean that these students will only have one year to work on the assignment.

## 5.2 Synoptic assessment

Synoptic assessment is a built-in feature of these qualifications. It means that students need to use an appropriate selection of their knowledge, understanding and skills developed across each qualification in an integrated way and apply them to a key task or tasks.

This helps students to build a holistic understanding of the subject and the connections between different elements of learning, so they can go on to apply what they learn from these qualifications to new and different situations and contexts.

The externally assessed units allow students to gain underpinning knowledge and understanding relevant to Applied Science. The NEA units draw on and strengthen this learning by assessing it in an applied and practical way.

It is important to be aware of the synoptic links between the units so that teaching, learning and assessment can be planned accordingly. Then students can apply their learning in ways which show they are able to make connections across the qualification. **Section 4.3** shows the synoptic links for each unit.

## 5.3 Transferable skills

These qualifications give students the opportunity to gain broad, transferable skills and experiences that they can apply in future study, employment and life.

Higher Education Institutions (HEIs) have told us that developing some of these skills helps students to transition into higher education.

These skills include:

- Communication
- Creativity
- Critical thinking
- Independent learning
- Presentation skills
- Problem solving
- Project and team-based working
- Referencing
- Reflection

- Research skills
- Self-directed study
- Time management
- Writing for different purposes

## 5.4 Grading and awarding grades

### Externally assessed units

We mark all the externally assessed units.

Each external assessment is marked according to a mark scheme, and the mark achieved will determine the unit grade awarded (Pass, Merit or Distinction). We determine grade boundaries for each of the external assessments in each assessment series.

If a student doesn't achieve the mark required for a Pass grade, we issue an unclassified result for that unit. The marks achieved in the external assessment will contribute towards the student's overall qualification grade, even if a Pass is not achieved in the unit assessment.

### NEA units

NEA units are assessed by the teacher and externally moderated by us.

Each unit has specified Pass, Merit and Distinction assessment criteria. The assessment criteria for each unit are provided with the unit content in **Section 4.3** of this specification. Teachers must judge whether students have met the criteria or not.

A unit grade can be awarded at Pass, Merit or Distinction. The number of assessment criteria needed to achieve each grade has been built into each assignment. These are referred to as design thresholds. The table below shows the design thresholds for each grade outcome for the NEA assessments in these qualifications. This table shows the number of criteria needed to achieve a Pass, Merit or Distinction for the NEA units in these qualifications. The unit grade awarded is based on the **total** number of achieved criteria for the unit. The total number of achieved criteria for each unit can come from achievement of any of the criteria (Pass, Merit or Distinction). This is **not** a 'hurdles-based' approach, so students do **not** have to achieve **all** criteria for a specific grade to achieve that grade (e.g. all Pass criteria to achieve a Pass).

To make sure we can keep outcomes fair and comparable over time, we will review the performance of the qualifications through their lifetime. The review process might lead to changes in these design thresholds if any unexpected outcomes or significant changes are identified.

Unit size (GLH)	60	90
Total number of criteria	22	28
Number of pass criteria	11	14
Number of merit criteria	6	8
Number of distinction criteria	5	6
Total number of criteria needed for a unit pass	9	12
Total number of criteria needed for a unit merit	13	17
Total number of criteria needed for a unit distinction	18	23

If a student doesn't achieve enough criteria to achieve a unit Pass, we will issue an unclassified result for that unit. The number of criteria achieved will be converted into a mark on the Uniform Mark Scale (UMS) and will contribute towards the student's overall qualification grade, even if a

Pass is not achieved in the unit assessment. More information about this is in Section below (**Calculating the qualification grades**).

## Qualifications

The overall qualification grades are:

- Distinction\* (D\*)
- Distinction (D)
- Merit (M)
- Pass (P)
- Unclassified (U)

## Calculating the qualification grades

When we work out students' overall grades, we need to be able to compare performance on the same unit in different assessments over time and between different units. We use a Uniform Mark Scale (UMS) to do this.

A student's uniform mark for each externally assessed unit is calculated from the student's raw mark on that unit. A student's uniform mark for each NEA unit is calculated from the number of criteria the student achieves for that unit. The raw mark or number of criteria achieved are converted to the equivalent mark on the uniform mark scale. Marks between grade boundaries are converted on a pro rata basis.

When unit results are issued, the student's unit grade and uniform mark are given. The uniform mark is shown out of the maximum uniform mark for the unit (for example, 48/60).

The student's uniform marks for each unit will be aggregated to give a total uniform mark for the qualification. The student's overall grade will be determined by the total uniform mark.

The tables below show:

- the maximum raw marks or number of criteria, and uniform marks for each unit in the qualifications
- the uniform mark boundaries for each of the assessments in each qualification
- the minimum total mark for each overall grade in the qualifications.

## Certificate Qualification:

Unit	Maximum raw mark/number of criteria	Maximum uniform mark (UMS)	Distinction* (UMS)	Distinction (UMS)	Merit (UMS)	Pass (UMS)
F180	70	70	56	42	28	
F182	28	70	56	42	28	
Qualification Totals	98	140	135	112	84	56

## Extended Certificate Qualification:

Unit	Maximum raw mark/number of criteria	Maximum uniform mark (UMS)	Distinction* (UMS)	Distinction (UMS)	Merit (UMS)	Pass (UMS)
F180	70	70		56	42	28
F181	50	50		40	30	20
F182	28	70		56	42	28
F183	22	55		44	33	22
F184	22	55		44	33	22
F185	22	55		44	33	22
F186	22	55		44	33	22
Qualification Totals	192	300	270	240	180	120

You can find a marks calculator on the qualification page of the OCR website to help you convert raw marks/number of achieved criteria into uniform marks.

## 5.5 Performance descriptors

Performance descriptors indicate likely levels of attainment by representative students performing at the Pass, Merit and Distinction grade boundaries at Level 3.

The descriptors must be interpreted in relation to the content in the units and the qualification as a whole. They are not designed to define that content. The grade achieved will depend on how far the student has met the assessment criteria overall. Shortcomings in some parts of the assessment might be balanced by better performance in others.

### Level 3 Pass

At Pass, students show adequate knowledge and understanding of the basic elements of much of the content being assessed. They can develop and apply their knowledge and understanding to some basic and familiar contexts, situations and problems.

Responses to higher order tasks involving detailed discussion, evaluation and analysis are often limited.

Many of the most fundamental skills and processes relevant to the subject are executed effectively but lack refinement, producing functional outcomes. Demonstration and application of more advanced skills and processes might be attempted but not always executed successfully.

### Level 3 Merit

At Merit, students show good knowledge and understanding of many elements of the content being assessed. They can sometimes develop and apply their understanding to different contexts, situations and problems, including some which are more complex or less familiar.

Responses to higher order tasks involving detailed discussion, evaluation and analysis are likely to be mixed, with some good examples at times and others which are less accomplished.

Skills and processes relevant to the subject, including more advanced ones, are developed in terms of range and quality. They generally lead to outcomes which are of good quality, as well as being functional.

### **Level 3 Distinction**

At Distinction, students show thorough knowledge and understanding of most elements of the content being assessed. They can consistently develop and apply their understanding to different contexts, situations and problems, including those which are more complex or less familiar.

Responses to higher order tasks involving detailed discussion, evaluation and analysis are successful in most cases.

Most skills and processes relevant to the subject, including more advanced ones, are well developed and consistently executed, leading to high quality outcomes.

## 6 Non examined assessment (NEA) units

This section gives guidance on completing the NEA units. In the NEA units, students build a portfolio of evidence to meet the assessment criteria for the unit.

Assessment for these qualifications **must** adhere to **JCQ's Instructions for Conducting Coursework**. Do **not** use JCQ's Instructions for Conducting Non-examination Assessments – these are only relevant to GCE and GCSE specifications.

The NEA units are centre-assessed and externally moderated by us.

You **must** read and understand all the rules and guidance in this section **before** your students start the set assignments.

If you have any questions, please contact us for help and support.

### 6.1 Preparing for NEA unit delivery and assessment

#### 6.1.1 Centre and teacher/assessor responsibilities

We assume the teacher is the assessor for the NEA units.

**Before** you apply to us for approval to offer these qualifications you must be confident your centre can fulfil all the responsibilities described below. Once you're approved, you can offer any of our general qualifications, Cambridge Nationals or Cambridge Advanced Nationals **without** having to seek approval for individual qualifications.

Here's a summary of the responsibilities that your centre and teachers must be able to fulfil. It is the responsibility of the head of centre<sup>1</sup> to make sure our requirements are met. The head of centre must ensure that:

- there are enough trained or qualified people to teach and assess the expected number of students you have in your cohorts.
- teaching staff have the relevant level of subject knowledge and skills to deliver and assess these qualifications.
- teaching staff will fully cover the knowledge, understanding and skills requirements in teaching and learning activities.
- allowed combinations of units are considered at the start of the course to be confident that all students can access a valid route through the qualifications.
- all necessary resources are available for teaching staff and students during teaching and assessment activities. This gives students every opportunity to meet the requirements of the qualification and reach the highest grade possible.
- there is a system of internal standardisation in place so that all assessment decisions for centre-assessed assignments are consistent, fair, valid and reliable (see **Section 6.4.3**).
- there is enough time for effective teaching and learning, assessment and internal standardisation.
- processes are in place to make sure that students' work is individual and confirmed as authentic (see **Section 6.2.1**).

---

<sup>1</sup> This is the most senior officer in the organisation, directly responsible for the delivery of OCR qualifications. For example, the headteacher or principal of a school/college. The head of centre accepts full responsibility for the correct administration and conduct of OCR exams.

- OCR-set assignments are used for students' summative assessments.
- OCR-set assignments are **not** used for practice. Sample assessment material for each of the NEA units is available on the OCR website. This sample assessment material can be used for practice purposes.
- students understand what they need to do to achieve the criteria.
- students understand what it means when we say work must be authentic and individual and they (and you) follow our requirements to make sure their work is their own.
- students know they must not reference another individual's personal details in any evidence produced for summative assessment, in accordance with the Data Protection Act 2018 and the UK General Data Protection Regulations (UK GDPR). It is the student's responsibility to make sure evidence that includes another individual's personal details is anonymised.
- outcomes submitted to us are correct and are accurately recorded.
- assessment of set assignments adheres to the **JCQ Instructions for Conducting Coursework** and **JCQ AI Use in Assessments: Protecting the Integrity of Qualifications**.
- a declaration is made at the point you're submitting any work to us for assessment that confirms:
  - all assessment is conducted according to the specified regulations identified in the **Administration** area of our website,
  - students' work is authentic.
  - marks have been transcribed accurately.
- centre records and students' work are kept according to these requirements:
  - students' work **must** be kept until **after** the unit has been awarded and any review of results or appeals processed. We cannot consider any review if the work has not been kept.
  - internal standardisation and assessment records must be kept securely for a minimum of three years after the date we've issued a certificate for a qualification.
- all cases of suspected malpractice involving teachers or students are reported (see **Section 6.3.1**).

#### 6.1.2 Health and safety

In UK law, health and safety is primarily the responsibility of the employer. In a school or college the employer could be a local education authority, the governing body or board of trustees. Employees (teachers/lecturers, technicians etc.), have a legal duty to cooperate with their employer on health and safety matters. Various regulations, but especially the Coshh Regulations 2002 (as amended) and the Management of Health and Safety at Work Regulations 1999, require that before any activity involving a hazardous procedure or harmful microorganisms is carried out, or hazardous chemicals are used or made, the employer must carry out a risk assessment. A useful summary of the requirements for risk assessment in school or college science can be found at: <https://www.ase.org.uk>

For members, the CLEAPSS® guide, PS90, *Making and recording risk assessments in school science*<sup>2</sup> offers appropriate advice.

---

<sup>2</sup> These, and other CLEAPSS® publications, are on the CLEAPSS® Science Publications website [www.cleapss.org.uk](http://www.cleapss.org.uk). Note that CLEAPSS® publications are only available to members. For more information about CLEAPSS® go to [www.cleapss.org.uk](http://www.cleapss.org.uk)

Most education employers have adopted nationally available publications as the basis for their Model Risk Assessments.

Where an employer has adopted model risk assessments an individual school or college then has to review them, to see if there is a need to modify or adapt them in some way to suit the particular conditions of the establishment.

Such adaptations might include a reduced scale of working, deciding that the fume cupboard provision was inadequate or the skills of the learners were insufficient to attempt particular activities safely. The significant findings of such risk assessment should then be recorded in a *“point of use text”*, for example on schemes of work, published teachers guides, work sheets, etc. There is no specific legal requirement that detailed risk assessment forms should be completed for each practical activity, although a minority of employers may require this.

Where project work or investigations, sometimes linked to work-related activities, are included in specifications this may well lead to the use of novel procedures, chemicals or microorganisms, which are not covered by the employer's model risk assessments. The employer should have given guidance on how to proceed in such cases. Often, for members, it will involve contacting CLEAPSS®.

## 6.2 Requirements and guidance for delivering and marking the OCR-set assignments

The assignments are:

- set by us.
- taken under supervised conditions (unless we specify otherwise in the assessment guidance)
- assessed by the teacher.
- moderated by us.

You can find the set assignments on our secure website, **Teach Cambridge**.

The set assignments give an approximate time that it will take to complete all the tasks. These timings are for guidance only, but should be used by you, the teacher, to give students an indication of how long to spend on each task. You can decide how the time should be allocated between each task or part task. Students can complete the tasks and produce the evidence across several sessions. Students' evidence (either hard copy or digital) must be kept securely by the teacher and access to assessment responses must be controlled. Students aren't permitted to access their work in between the assessment sessions.

We will publish a new set assignment each year and they will be live for 2 years(s). Each new set assignment will be released on 1 June. You must check our secure website, **Teach Cambridge**, and use a set assignment that is live for assessment. The live assessment dates will be shown on the front cover alongside the intended cohort. You should use the set assignment released in the same calendar year as the new cohort starts to ensure they have two years for that assignment. Students are allowed one resubmission of work based on the same live assignment.

You must have made unit entries before submitting NEA work for moderation.

**Appendix A** of this specification gives guidance for creating electronic evidence for the NEA units. Read Appendix A in conjunction with the unit content and assessment criteria grids to help you plan the delivery of each unit.

The rest of this section is about how to manage the delivery and marking of the set assignments so that assessment is valid and reliable. Please note that failing to meet these requirements might be considered as malpractice.

Here is a summary of what you need to do.

You **must**:

- have covered the knowledge, understanding and skills with your students and be sure they are ready for assessment **before** you start the summative assessment. This may include students practising applying their learning and receiving feedback from teachers in preparing to take the assessment.
- use an OCR-set assignment for summative assessment of the students.
- give students the **Student Guide** before they start the assessment.
- familiarise yourself with the assessment guidance relating to the tasks. The assessment guidance for each unit is in **Section 4** after the assessment criteria grids and with the student tasks in the assignments.
- make sure students are clear about the tasks they must complete and the assessment criteria they are attempting to meet.
- students need to be supervised in all 'practical' work to ensure that they are following health and safety protocols.
- in a number of units there are specific criteria which require safe working; where this is the case, the criteria cannot be achieved if staff have to intervene during the assessment to ensure the students' safety. In such instances, staff should assist the student to ensure their safety and so that they can continue with the subsequent assessment tasks, but they cannot be credited for the criteria directly addressing the practical skills where they have had to be helped unless the assessment guidance states otherwise.
- give students a reasonable amount of time to complete the assignments and be fair and consistent to all students. The estimated time we think each assignment should take is stated in the OCR-set assignments. In that time students can work on the tasks under the specified conditions until the date that you collect the work for centre assessment.
- tell the students the resources they can use in the assignment before they start the assessment tasks.
- only give students OCR-provided templates. If they choose to use a different template from a book, a website or course notes (for example, to create a plan) they **must** make sure the source is referenced.
- monitor students' progress to make sure work is capable of being assessed against the assessment criteria, on track for being completed in good time and is the student's own work:
  - NEA work must be completed in the centre under teacher supervision in normal curriculum time:
    - work must be completed with enough supervision to make sure that it can be authenticated as the student's own work. You must be familiar with the requirements of the JCQ document **AI Use in Assessments: Protecting the Integrity of Qualifications** before assessment starts.
    - there may be exceptions to the requirement for supervised conditions if there is work to complete to support the assignment tasks (e.g. research). The assignment and assessment guidance will specify if there are exceptions.

- Where students are allowed to complete work outside of supervised conditions (e.g. research that may be allowed between supervised sessions) you **must** make sure that they only bring notes relating to the work they are allowed to complete unsupervised into the supervised sessions (e.g. notes relating to the research they have done) and to make sure any work they have done is independent. They must not use unsupervised time as an opportunity to:
  - Create drafts of work for their tasks.
  - Gather information to use in other aspects of their tasks.
- if you provide any material to prepare students for the set assignment, you must adhere to the rules on using referencing and on acceptable levels of guidance to students. This is in section **6.2.3** and **6.3**.
- students must produce their work independently (see sections **6.2.1** and **6.3**).
- you must make sure students know to keep their work and passwords secure and know that they must not share completed work with other students, use any aspect of another student's work or share their passwords.

- complete the **Teacher Observation Record** that is with the assignments for tasks that state it is needed. You **must** follow the guidance given when completing it.
- use the assessment criteria to assess students' work.
- before submitting a final outcome to us, you can allow students to repeat any part of the assignment and rework their original evidence. But any feedback you give to students on the original (assessed) evidence, must:
  - only be generic.
  - be recorded.
  - be available to the OCR assessor.

(See **Section 6.3** on **Feedback** and **Section 6.4.4** on **resubmitting work**).

You **must not**:

- change any part of the OCR-set assignments (scenarios or tasks).
- accept multiple reattempts of work where small changes have been made in response to feedback.
- allow teachers or students to add, amend or remove any work **after** submission for moderation by OCR. This will constitute malpractice.
- give detailed advice and suggestions to individuals or the whole class on how work may be improved to meet the assessment criteria. This includes giving access to student work as an exemplar.
- allow students access to their assignment work between teacher supervised sessions. (There may be exceptions where students are allowed to complete work independently (e.g. research). Any exceptions will be stated in the assignments.)
- practise the live OCR-set assignment tasks with the students.

### 6.2.1 Ways to authenticate work

You must use enough supervision and complete enough checks to be confident that the work you mark is the student's own and was produced independently.

Where possible, you should discuss work in progress with students. This will make sure that work is being completed in a planned and timely way and will give you opportunities to check the authenticity of the work.

**You must:**

- have read and understood the JCQ document **AI Use in Assessments: Protecting the Integrity of Qualifications**.
- make sure students and other teachers understand what constitutes plagiarism.
- not accept plagiarised work as evidence.
- use supervision and questioning as appropriate to confirm authenticity.
- make sure students and teachers fill in declaration statements.

### 6.2.2 Group work

Group work is not allowed for the NEA assignments in these qualifications.

Where this is allowed, you must make sure that each student generates their own individual evidence to show they've met the assessment criteria.

When working in a group, all students in the group must have a responsibility and/or a role that gives them the opportunity to generate individual evidence for assessment. For example, if the unit requires students to plan the organisation of an activity this could be managed in a group discussion. The group discusses ideas for the activity, organisational requirements, roles and responsibilities to complete the activity, etc. All students must show that they've demonstrated the skill of planning so all members of the group must take part in the discussion. If three members of the group contributed to the discussion and one member took notes but did not contribute to the discussion, their note taking would not be considered a contribution towards planning.

### 6.2.3 Plagiarism

Students must use their own words when they produce final written pieces of work to show they have genuinely applied their knowledge and understanding. When students use their own words, ideas and opinions, it reduces the possibility of their work being identified as plagiarised.

Plagiarism is:

- the submission of someone else's work as your own
- failure to acknowledge a source correctly, including any use of Artificial Intelligence (AI).

You might find the following JCQ documents helpful:

- **Plagiarism in Assessments**
- **AI Use in Assessments: Protecting the Integrity of Qualifications**

Due to increasing advancements in AI technology, we strongly recommend that you are familiar with the likely outputs from AI tools. This could include using AI tools to produce responses to some of the assignment tasks, so that you can identify typical formats and wording that these may produce. This may help you identify any cases of potential plagiarism from students using AI tools to generate written responses.

Plagiarism makes up a large percentage of cases of suspected malpractice reported to us by our assessors. You must **not** accept plagiarised work as evidence.

Plagiarism often happens innocently when students do not know that they must reference or acknowledge their sources or aren't sure how to do this. It's important to make sure your students understand:

- the meaning of plagiarism and what penalties may be applied.
- that they can refer to research, quotations or evidence produced by somebody else, but they must list and reference their sources and clearly mark quotations.
- quoting someone else's work, even when it's properly sourced and referenced, doesn't evidence understanding. The student must 'do' something with that information to show they understand it. For example, if a student has to analyse data from an experiment, quoting data doesn't show that they understand what it means. The student must interpret the data and, by relating it to their assignment, say what they think it means. The work must clearly show how the student is using the material they have referenced to inform their thoughts, ideas or conclusions.

We have **The OCR Guide to Referencing** on our website. We have also produced a **poster** about referencing and plagiarism which may be useful to share with your students.

Teach your students how to reference and explain why it's important to do it. At Key Stage 5 they must:

- use quote marks to show the beginning and end of the copied work.
- list the html address for website text and the date they downloaded information from the website.
- for other publications, list:
  - the name of the author.
  - the name of the resource/book/printed article.
  - the year in which it was published.
  - the page number.

Teach your students to:

- always reference material copied from the internet or other sources. This also applies to infographics (graphical information providing data or knowledge).
- always identify information they have copied from teaching handouts and presentations for the unit, using quote marks and stating the text is from class handouts.

### **Identifying copied/plagiarised work**

Inconsistencies throughout a student's work are often indicators of plagiarism. For example:

- different tones of voice, sentence structure and formality across pieces of work.
- use of American expressions, spellings and contexts (such as American laws and guidelines).
- dated expressions and references to past events as being current.
- sections of text in a document where the font or format is inconsistent with other sections.

### **What to do if you think a student has plagiarised**

If you identify plagiarised work during assessment or internal standardisation, you must:

- consider the plagiarism when judging the number of assessment criteria achieved.
  - if the work is part of the moderation sample, it must be included with the other work provided to the OCR assessor. You must add a note on the Unit Recording Sheet to state that there is plagiarism in the work and the number of criteria achieved has been adjusted accordingly.
- report the student(s) for plagiarism in line with the JCQ document **Suspected Malpractice Policies and Procedures**
  - fill in the **JCQ form M1**.

In line with JCQ's policies and procedures on suspected malpractice, the penalties applied for plagiarism will usually result in the work not being allowed or the mark being significantly reduced.

## 6.3 Feedback

### **Feedback to students on work in progress towards summative assessment**

You can discuss work in progress towards summative assessment with students to make sure it's being done in a planned and timely way. It also provides an opportunity to check the authenticity of the work. You must intervene if there's a health and safety risk (and reflect this in your assessment if the student's ability to operate safely and independently if that is part of the criteria).

Generic guidance to the whole class is also allowed. This could include reminding students to check they have provided evidence to cover all key aspects of the task. Individual students can be prompted to double check for gaps in evidence providing that specific gaps are not pointed out to them.

You can give general feedback and support if one or more students are struggling to get started on an aspect of the assignment or following a break between sessions working on the assignment. For example, if a student is seeking more guidance that suggests they are not able to apply knowledge, skills and understanding to complete their evidence, you can remind them that they had a lesson which covered the topic. The student would then need to review their own notes to find this information and apply it as needed.

If a student needs additional help to get started on an initial task that is critical to accessing the rest of the assessment, you can provide this help if you feel it is necessary, but you must not award the student with any assessment criteria directly associated with the part(s) of the task for which they received help.

With the exception of the specific feedback allowed to help students start a critical task, mentioned above, feedback must not provide specific advice and guidance that would be construed as coaching. This would compromise the student's ability to independently perform the task(s) they are doing and constitutes malpractice. Our assessors use a number of measures to assure themselves the work is the student's own.

Once work has been assessed, you must give feedback to students on the work they submitted for assessment.

#### **Feedback **must**:**

- be supportive, encouraging and positive.
- tell the student what has been noticed, not what the teacher thinks (for example, if you have observed the student completing a task, you can describe what happened, what was produced and what was demonstrated).

#### **Feedback **can**:**

- identify what task and part of the task could be improved, but not say how to improve it. You could show the student work from a **different** unit that demonstrates higher achievement, but you must not detail to the student how they could achieve that in their work. If you are using another student's work from a different unit as an example, you must anonymise this work and make sure that the potential to plagiarise from this work is minimised. You could remind students that they had a lesson on a specific topic and that they could review their notes, but you must not tell them how they could apply the teaching to improve their work.
- comment on what has been achieved, for example 'the evidence meets the P2 and M2 criteria'.
- identify that the student hasn't met a command word or assessment criteria requirement. For example, 'This is a description, not an evaluation'.
- use text from the specification, assignment or assessment criteria in general guidance to clarify what is needed in the work. For example, 'You demonstrated that you safely preserved and collected evidence from the crime scene'.

**Feedback must not:**

- point out specific gaps. For example, you must not prompt the student to include specific detail in their work, such as 'You should be using a bar chart rather than a line graph for this type of data'
- be so detailed that it leads students to the answer. For example, you must not give:
  - model answers.
  - step-by-step guidance on what to do to complete or improve work.
  - headings or templates that include examples which give all or part of what students have to write about or produce.
- talk the student through how to achieve or complete the task.
- give detail on where to find information/evidence.

In other words, feedback must help the student to take the initiative in making changes. It must not direct or tell the student what to do to complete or improve their work in a way that means they do not need to think how to apply their learning. Students need to recall or apply their learning. You must not do the work for them.

Neither you nor the student can add, amend or remove any work after the final mark has been submitted for moderation.

**Sections 6.4.4 and 6.4.6** give more guidance for students who wish to reattempt or resubmit their work following feedback.

**What over-direction might look like**

When we see anything that suggests the teacher has led students to the answer, we become concerned because it suggests students have not worked independently to produce their assignment work. The following are examples of what might indicate over-direction by the teacher:

- prompts that instruct students to include specific detail in their work, such as, 'You need to include the aims of the activity. Who is it aimed at? What is the purpose of the activity? How will it benefit the specific group/individual?'
- headings or templates that include examples which give all or part of what students have to write about or produce, such as sources of support.

OCR Assessors will report suspected malpractice when they cannot see differences in content between students' work in the sample they are moderating. An exception is when students have

only used and referenced technical facts and definitions. If the OCR assessor is in any doubt, they will report suspected malpractice. The decision to investigate or not is made by us, not the assessor.

### 6.3.1 Reporting suspected malpractice

It is the responsibility of the head of centre to report all cases of suspected malpractice involving teachers or students.

A JCQ Report of Suspected Malpractice form (JCQ/M1 for student suspected malpractice or JCQ/M2 for staff suspected malpractice) is available to download from the [JCQ website](#). The form must be completed as soon as possible and emailed to us at [malpractice@ocr.org.uk](mailto:malpractice@ocr.org.uk).

When we ask centres to gather evidence to assist in any malpractice investigation, heads of centres must act promptly and report the outcomes to us.

The JCQ document **Suspected Malpractice Policies and Procedures** has more information about reporting and investigating suspected malpractice, and the possible sanctions and penalties which could be imposed. You can also find out more on our [website](#).

### 6.3.2 Student and centre declarations

Both students and teachers must declare that the work is the student's own:

- **each student** must sign a declaration before submitting their work to their teacher. A **candidate authentication statement** can be used and is available to download from our [website](#). You must keep these statements in the centre until all enquiries about results, malpractice and appeal issues have been resolved. You **must** record a mark of zero if a student cannot confirm the authenticity of their work.
- **teachers** must declare the work submitted for centre assessment is the students' own work by completing a **centre authentication form (CCS160)** for each cohort of students for each unit. You must keep centre authentication forms in the centre until all post-results issues have been resolved.

### 6.3.3 Generating evidence

The set assignments will tell the students what they need to do to meet the assessment criteria for the NEA units. It is your responsibility to make sure that the methods of generating evidence for the assignments are:

- valid
- safe and manageable
- suitable to the needs of the student.

#### Valid

The evidence presented must be valid. For example, it would not be appropriate to present an organisation's equal opportunities policy as evidence towards a student's understanding of how the equal opportunities policy operates in an organisation. It would be more appropriate for the student to incorporate the policy in a report describing the different approaches to equal opportunities.

#### Safe and manageable

You must make sure that methods of generating evidence are safe and manageable and do not put unnecessary demands on the student.

#### Suitable to the needs of the student

We are committed to ensuring that achievement of these qualifications is free from unnecessary barriers.

You must follow this commitment through when modifying tasks (where this is allowed) and/or considering assessment and evidence generation. If you are modifying tasks and are not sure what is acceptable, **contact us**.

### **Observation and questioning**

The primary evidence for assessment is the work submitted by the student, however the following assessment methods might be suitable for teachers/assessors to use for some aspects of these qualifications, where identified:

- **observation** of a student doing something
- **questioning** of the student or witness.

#### **Observation**

The teacher/assessor and student should plan observations together, but it is the teacher's/assessor's responsibility to record the observation properly (for example observing a student undertaking a practical task). More information is in the Teacher Observation Records section.

#### **Questioning**

Questioning the student is normally an ongoing part of the formative assessment process and may, in some circumstances, provide evidence to support achievement of the criteria.

Questioning is often used to:

- test a student's understanding of work which has been completed outside of the classroom
- check if a student understands the work they have completed
- collect information on the type and purpose of the processes a student has gone through.

If questioning is used as evidence towards achievement of specific topic areas, it is important that teachers/assessors record enough information about what they asked and how the student replied, to allow the assessment decision to be moderated.

#### **6.3.4 Teacher Observation Records (TOR)**

You **must** complete the Teacher Observation Record form in the OCR-set assignment for:

Unit F182 Investigating Science (Tasks 2, 3, and 5, Topic Areas 1, 2, 3, and 4) for each student as evidence of the independent collection of data from preliminary testing, the safe carrying out of the procedures for the full investigation, the skilful use of apparatus to collect accurate and precise data, and how well students answered questions following the presentation of their conclusions.

Unit F183 Analytical Techniques in Chemistry (Tasks 2 and 4, Topic Areas 1, 2, and 3) for each student as evidence of the safe carrying out of the separating techniques and the skilful use of apparatus to collect data of sufficient quality, the safe carrying out of the qualitative tests, the skilful preparation of standard solutions, and the safe carrying out of the quantitative tests.

Unit F184 Environmental Studies (Task 3, Topic Area 5) for each student as evidence of the safe carrying out of the student's plan according to their risk assessment, and students independently collecting all of the data recorded.

Unit F185 Forensic Biology (Tasks 2 and 3, Topic Areas 2, 3, and 4) for each student as evidence of how safely students preserved and collected evidence from the crime scene, the safe and skilful

use of observational analytical techniques, and the safe and skilful use of microbiological analytical techniques.

Unit F186 Medical Physics (Task 3, Topic Areas 1, 2, 3, 4, and 5) for each student as evidence of student's ability to deliver information that is beyond the presentation content. Teacher observation **cannot** be used as evidence of achievement for a whole unit. Most evidence **must** be produced directly by the student. Teacher observation **must only** be used where specified as an evidence requirement.

Teacher Observation Records must be suitably detailed for each student, to help assessors to determine if the assessment criteria have been met. You must follow the guidance provided in the 'guidance notes' section of the form so that the evidence captured and submitted is appropriate. Both you and the student must sign and date the form to show that you both agree its contents.

Where the guidance has not been followed, the reliability of the form as evidence may be called into question. If doubt about the validity of the Teacher Observation Record form exists, it cannot be used as assessment evidence and marks based on it cannot be awarded. OCR assessors will be instructed to adjust centre marks accordingly.

### 6.3.5 Presentation of the final piece of work

Students must submit their evidence in the format specified in the tasks where specific formats are given. Written work can be digital (e.g. word processed) or hand-written and tables and graphs (if relevant) can be produced using appropriate ICT.

Any sourced material must be suitably acknowledged. Quotations must be clearly marked and a reference provided.

A completed Unit Recording Sheet (URS) must be attached to work submitted for moderation.

The URS can be downloaded from the qualification webpage. Centres **must** show on the URS where specific evidence can be found. The URS tells you how to do this.

Work submitted digitally for moderation should be on electronic media (for example, on our portal, CD or USB Drive). Work **must** be in a suitable file format and structure. **Appendix A** gives more guidance about submitting work in digital format.

## 6.4 Assessing NEA units

All NEA units are assessed by teachers and externally moderated by OCR assessors. Assessment of the set assignments must adhere to JCQ's **Instructions for Conducting Coursework**.

The centre is responsible for appointing someone to act as the internal assessor. This would usually be the teacher who has delivered the programme but could be another person from the centre. The assessment criteria must be used to assess the student's work. These specify the levels of skills, knowledge and understanding that the student needs to demonstrate.

### 6.4.1 Applying the assessment criteria

When students have completed the assignment, they must submit their work to you to be assessed.

You must assess the tasks using the assessment criteria and any additional assessment guidance provided. Each criterion states what the student needs to do to achieve that criterion (e.g. Produce a plan for the full investigation which includes a method for the preliminary testing). The command word and assessment guidance provide additional detail about breadth and depth where it is needed.

You must judge whether each assessment criterion has been **successfully achieved** based on the evidence that a student has produced. For the criterion to be achieved, the evidence must show that all aspects have been met in sufficient detail.

When making a judgement about whether a criterion has been **successfully achieved**, you must consider:

- the requirements of the NEA task
- the criterion wording, including the command word used and its definition
- any assessment guidance for the criterion
- the unit content that is being assessed.

You must annotate the work to show where evidence meets each criterion (see **Section 6.4.2**).

You can then award the criterion on the Unit Recording Sheet (URS). Assessment should be positive, rewarding achievement rather than penalising failure or omissions.

The number of criteria needed for each unit grade (Pass, Merit or Distinction) is provided in **Section 5**.

You must complete a Unit Recording Sheet (URS) for each unit a student completes. On the URS you must identify:

- whether the student has met each criterion or not (by adding a tick (✓) or X in the column titled **Assessment criteria achieved**)
  - you should also indicate where the evidence can be found if a '✓' is identified.
  - a X indicates that there is insufficient evidence to fully meet the criterion or it was not attempted.
- the total number of criteria achieved by the student for the unit.

You must be convinced, from the evidence presented, that students have worked independently to the required standard.

Your centre must internally standardise the assessment decisions for the cohort **before** you give feedback to students (see **Section 6.4.3**). When you are confident the internal assessment and standardisation process is complete, you can submit work for moderation at the relevant time. You **must not** add, amend or remove any work after it has been submitted to us for final moderation.

#### **6.4.2 Annotating students' work**

Each piece of NEA work must show how you are satisfied the assessment criteria have been met.

Comments on students' work and the Unit Recording Sheet (URS) provide a means of communication between teachers during internal standardisation, and with the OCR assessor if the work is part of the moderation sample.

#### **6.4.3 Internal standardisation**

It is important that all teachers are assessing work to common standards. For each unit, centres must make sure that internal standardisation of outcomes across teachers and teaching groups takes place using an appropriate procedure.

This can be done in a number of ways. In the first year, reference material and OCR training meetings will provide a basis for your centre's own standardisation. In following years, this, and/or your own centre's archive material, can be used. We advise you to hold preliminary meetings of staff involved to compare standards through cross-marking a small sample of work. After you have

completed most of the assessment, a further meeting at which work is exchanged and discussed will help you make final adjustments.

If you are the only teacher in your centre assessing these qualifications, we still advise you to make sure your assessment decisions are internally standardised by someone else in your centre. Ideally this person will have experience of these types of qualifications, for example someone who:

- is delivering a similar qualification in another subject.
- has relevant subject knowledge.

You must keep evidence of internal standardisation in the centre for the OCR assessor to see.

We have a **guide** to how internal standardisation can be approached on our website.

#### **6.4.4 Reattempting work to improve the grade before submitting marks to OCR**

As described in Section 6.2, before submitting a final outcome to us for external moderation, you can allow students to repeat any element of the assignment and rework their original evidence. We refer to this as a reattempt. A reattempt allows the student to reflect on internal feedback, and to improve their work. A reattempt is not an iterative process where students make small modifications through ongoing feedback to eventually achieve the desired outcome.

Any feedback must be noted by the teacher and a record of this kept in centre. We have provided a feedback form for this purpose, which can be found on the OCR website.

**A reattempt must be done before submission for external moderation. When a student submits the work to you as final for external moderation, they cannot complete any further work on any aspect of it.**

#### **6.4.5 Submitting outcomes**

When you have assessed the work and it has been internally standardised, outcomes can be submitted to us. For the purpose of submission, outcomes will be considered as 'marks'. You will submit the total number of criteria achieved for units as marks. You can find the key dates and timetables on our **website**.

There should be clear evidence that work has been attempted and some work produced. If a student does not submit any work for an NEA unit, the student should be identified as being absent from that unit.

If a student completes any work at all for an NEA unit, you must assess the work using the assessment criteria and award the appropriate number of criteria. This might be zero.

#### **6.4.6 Resubmitting moderated work to OCR to improve the grade**

We use the term 'resubmission' when referring to student work that has previously been submitted to OCR for moderation. Following OCR moderation, if you and the student feel they have not performed at their best during the assessment, the student can, with your agreement, improve their work and resubmit it to you again for assessment. You must be sure it is in the student's best interests to resubmit the work for assessment. There is one resubmission opportunity per NEA assignment.

Students can only resubmit work using the same assignment if the assignment is still live. The live assessment dates and intended cohort will be shown on the front cover of the assignment. We will not accept work based on an assignment that is no longer live.

If students wish to resubmit a unit after the live assessment date has passed, they must submit work using the new live assignment.

## 6.5 Moderating NEA units

The purpose of external moderation is to make sure that the standard of assessment is the same for all centres and that internal standardisation has taken place.

The administration pages of our **website** give full details about how to submit work for moderation.

This includes the deadline dates for entries and submission of marks. For moderation to happen, you must submit your marks by the deadline.

### 6.5.1 Sample requests

Once you have submitted your marks, we will tell you which work will be sampled as part of the moderation process. Samples will include work from across the range of students' attainment. Copies of students' work must be kept until after their qualifications have been awarded and any review of results or appeals processed.

Centres will receive the final outcomes of moderation when the provisional results are issued. Results reports will be available for you to access. More information about the reports that are available is on our website.

We need sample work to help us monitor standards. We might ask some centres to release work for this purpose. We will let you know as early as possible if we need this from you. We always appreciate your co-operation.

## 7 Administration

This section gives an overview of the processes involved in administering these qualifications. Some of the processes require you to submit something to OCR by a specific deadline. More information about the processes and deadlines involved at each stage is on our **administration pages**.

### 7.1 Assessment availability

There are two assessment opportunities available each year for the externally assessed units: one in January and one in June. Students can be entered for different units in different assessment series.

All students must take the exams at a set time on the same day in a series.

NEA assignments can be taken by students at any time during the live period shown on the front cover. It is important you use the set assignment that is released in the same calendar year as the new cohort starts to ensure that students have two years to use the assignment.

There are two windows each year to submit NEA outcomes. Submission of student outcomes will initiate the moderation visit by the OCR Assessor.

You must make unit entries for students before you can submit outcomes to request a visit. All dates relating to NEA moderation are on our administration pages.

Qualification certification is available at each results release date.

### 7.2 Collecting evidence of student performance to ensure resilience in the qualifications system

Regulators have published guidance on collecting evidence of student performance as part of long-term contingency arrangements to improve the resilience of the qualifications system. You should review and consider this guidance when delivering this qualification to students at your centre.

For more detailed information on collecting evidence of student performance please visit our [website](#).

### 7.3 Equality Act information relating to Cambridge Advanced Nationals

The Cambridge Advanced Nationals require assessment of a broad range of skills and, as such, prepare students for further study and higher-level courses.

The Cambridge Advanced National qualifications have been reviewed to check if any of the competences required present a potential barrier to disabled students. If this was the case, the situation was reviewed again to make sure that such competences were included only where essential to the subject.

### 7.4 Accessibility

There can be adjustments to standard assessment arrangements based on the individual needs of students. It is important that you identify as early as possible if students have disabilities or particular difficulties that will put them at a disadvantage in the assessment situation and that you choose a qualification or adjustment that allows them to demonstrate attainment.

If a student requires access arrangements that need approval from us, you must use **Access arrangements (online)** to gain approval. You must select the appropriate qualification type(s) when you apply. Approval for GCSE or GCE applications alone does not extend to other

qualification types. You can select more than one qualification type when you make an application. For guidance or support please contact the **OCR Special Requirements Team**.

The responsibility for providing adjustments to assessment is shared between your centre and us. Please read the JCQ document **Access Arrangements and Reasonable Adjustments**.

If you have students who need a post-exam adjustment to reflect temporary illness, indisposition or injury when they took the assessment, please read the JCQ document **A guide to the special consideration process**.

If you think any aspect of these qualifications unfairly restricts access and progression, please email **Support@ocr.org.uk** or call our Customer Support Centre on **01223 553998**.

The following access arrangements are allowed for this specification:

Access arrangement	Type of assessment
Reader/Computer reader	All assessments
Scribes/Speech recognition technology	All assessments
Practical assistants	All assessments
Word processors	All assessments
Communication professional	All assessments
Language modifier	All assessments
Modified question paper	Timetabled exams
Extra time	All assessments with time limits

## 7.5 Requirements for making an entry

We provide information on key dates, timetables and how to submit marks on our **website**.

Your centre must be registered with us to make entries. We recommend that you apply to become a registered centre with us well in advance of making your first entries. Details on how to register with us are on our **website**.

It is essential that unit entry codes are stated in all correspondence with us.

### 7.5.1 Making estimated unit entries

Estimated entries are not needed for Cambridge Advanced National qualifications.

### 7.5.2 Making final unit entries

When you make an entry, you must state the unit entry codes and the component codes. Students submitting work must be entered for the appropriate unit entry code from the table below.

The short title for these Cambridge Advanced Nationals is CAN AAQ. This is the title that will be displayed on our secure website, **Teach Cambridge**, and some of our administrative documents.

You do **not** need to register your students first. **Individual unit entries should be made for each series in which you intend to submit or resubmit an NEA unit or sit an externally assessed examination.**

Make a certification entry using the overall qualification code (see **Section 7.5**) in the final series only.

Unit entry code	Component code	Assessment method	Unit titles
F180	01	Written paper	Fundamentals of science
F181	01	Written paper	Science in society
F182A	01	Visiting	Investigating science
F182B	02	Remote	Investigating science
F183A	01	Visiting	Analytical techniques in chemistry
F183B	02	Remote	Analytical techniques in chemistry
F184A	01	Visiting	Environmental studies
F184B	02	Remote	Environmental studies
F185A	01	Visiting	Forensic biology
F185B	02	Remote	Forensic biology
F186A	01	Visiting	Medical physics
F186B	02	Remote	Medical physics

## 7.6 Certification rules

You must enter students for qualification certification separately from unit assessment(s). If a certification entry is **not** made, no overall grade can be awarded. These are the qualifications that students should be entered for:

- OCR Level 3 Alternative Academic Qualification Cambridge Advanced National in Applied Science (Certificate) - certification code H051.
- OCR Level 3 Alternative Academic Qualification Cambridge Advanced National in Applied Science (Extended Certificate) - certification code H151.

## 7.7 Unit and qualification resits

Students can resit each unit and the best result will be used to calculate the certification result.

Resit opportunities must be fair to all students and **not** give some students an unfair advantage over other students. For example, the student must not have direct guidance and support from the teacher in producing further evidence for NEA units. When resitting an NEA unit, students must submit new, amended or enhanced work, as detailed in the JCQ **Instructions for Conducting Coursework**.

When you arrange resit opportunities, you must make sure that you do not adversely affect other assessments being taken.

Arranging a resit opportunity is at the centre's discretion. Summative assessment series must not be used as a diagnostic tool and resits should only be planned if the student has taken full advantage of the first assessment opportunity and any formative assessment process.

## 7.8 Post-results services

A number of post-results services are available:

- Reviews of results - if you think there might be something wrong with a student's results, you may submit a review of marking or moderation.
- Missing and incomplete results - if an individual subject result for a student is missing, or the student has been omitted entirely from the results supplied you should use this service.
- Access to scripts - you can ask for access to marked scripts.
- Late certification - following the release of unit results, if you have not previously made a certification entry, you can make a late request, which is known as a **late certification**. This is a free service.

Please refer to the **JCQ Post-Results Services booklet** and the **OCR Administration page** for more guidance about action on the release of results.

For NEA units the enquiries on results process cannot be carried out for one individual student; the outcome of a review of moderation must apply to a centre's entire cohort.

## Appendix A: Guidance for the production of electronic evidence

### Structure for evidence

The NEA units in these qualifications are units F182-F186. For each student, all the tasks together will form a portfolio of evidence, stored electronically. Evidence for each unit must be stored separately.

An NEA portfolio is a collection of folders and files containing the student's evidence. Folders should be organised in a structured way so that the evidence can be accessed easily by a teacher or OCR assessor. This structure is commonly known as a folder tree. It would be helpful if the location of particular evidence is made clear by naming each file and folder appropriately and by use of an index called 'Home Page'.

There should be a top-level folder detailing the student's centre number, OCR candidate number, surname and forename, together with the unit code (F182–F186), so that the portfolio is clearly identified as the work of one student.

Each student's portfolio should be stored in a secure area on the centre's network. Before submitting the portfolio to OCR, the centre should add a folder to the folder tree containing the internal assessment and summary forms.

### Data formats for evidence

It is necessary to save students' work using an appropriate file format to minimise software and hardware capability issues.

Students must use formats appropriate:

- to their evidence
- for viewing for assessment and moderation.

Formats must be open file formats or proprietary formats for which a downloadable reader or player is available. If a downloadable reader or player is not, the file format is **not** acceptable.

Evidence submitted is likely to be in the form of word-processed documents, presentation documents, digital photos and digital video.

All files submitted electronically must be in the formats listed on the following page. Where new formats become available that might be acceptable, we will give more guidance. It is the centre's responsibility to make sure that the electronic portfolios submitted for moderation are accessible to the OCR assessor and fully represent the evidence available for each student.

Standard file formats acceptable as evidence for the Cambridge Advanced Nationals are listed here.

File type	File format	Max file size*
Audio	.3g2 .3ga .aac .aiff .amr .m4a .m4b .m4p .mp3 .wav	25GB
Compression	.zip .zipx .rar .tar .tar .gz .tgz .7z .zipx .zz	25GB
Data	.xls .xlsx .mdb .accdb .xlsb	25GB
Document	.odt .pdf .rtf .txt .doc .docx .dotx .	25GB
Image	.jpg .png .jpeg .tif .jfif .gif .heic .psd .dox .pcx .bmp .wmf	25GB
Presentation	.ppt .pptx .pdf .gslides .pptm .odp .ink .potx .pub	25GB
Video	.3g2 .3gp .avi .flv .m4v .mkv .mov .mp4 .mp4v .wmp .wmv	25GB
Web	.wlmp .mts .mov-1 .mp4-1 .xspf .mod .mpg	25GB

If you are using **pages** as a file type, please convert this to a .pdf prior to submission.

\*max file size is only applicable if using our Submit for Assessment service.

**Submit for Assessment** is our secure web-based submission service. You can access Submit for Assessment on any laptop or desktop computer running Windows or macOS and a compatible browser. It supports the upload of files in the formats listed in the table above as long as they do not exceed the maximum file size. Other file formats and folder structures can be uploaded within a compressed file format.

When you view some types of files in our Submit for Assessment service, they will be streamed in your browser. It would help your OCR assessor or examiner if you could upload files in the format shown in the table below:

File type	File format	Chrome	Firefox
Audio	.mp3	Yes	Yes
Audio	.m4a	Yes	Yes
Audio	.aac	No	Yes
Document	.txt	Yes	Yes
Image	.png	Yes	Yes
Image	.jpg	Yes	Yes
Image	.jpeg	Yes	Yes
Image	.gif	Yes	Yes
Presentation	.pdf	Yes	Yes
Video	.mp4	Yes	Yes
Video	.mov	No	Yes
Video	.3gp	Yes	No
Video	.m4v	Yes	Yes
Web	.html	Yes	Yes
Web	.htm	Yes	Yes

## Appendix B: Command Words

### External assessment

The table below shows the command words that will be used in exam questions. This shows what we mean by the command word and how students should approach the question and understand its demand. Remember that the rest of the wording in the question is also important.

Command Word	Meaning
<b>Analyse</b>	<ul style="list-style-type: none"> <li>Separate or break down information into parts and identify their characteristics or elements</li> <li>Explain the different elements of a topic or argument and make reasoned comments</li> <li>Explain the impacts of actions using a logical chain of reasoning</li> </ul>
<b>Annotate</b>	<ul style="list-style-type: none"> <li>Add information, for example, to a table, diagram or graph</li> </ul>
<b>Calculate</b>	<ul style="list-style-type: none"> <li>Work out the numerical value. Show your working unless otherwise stated</li> </ul>
<b>Choose</b>	<ul style="list-style-type: none"> <li>Select an answer from options given</li> </ul>
<b>Compare</b>	<ul style="list-style-type: none"> <li>Give an account of the similarities and differences between two or more items or situations</li> </ul>
<b>Complete</b>	<ul style="list-style-type: none"> <li>Add information, for example, to a table, diagram or graph to finish it</li> </ul>
<b>Describe</b>	<ul style="list-style-type: none"> <li>Give an account that includes the relevant characteristics, qualities or events</li> </ul>
<b>Discuss (how/whether/etc)</b>	<ul style="list-style-type: none"> <li>Present, analyse and evaluate relevant points (for example, for/against an argument) to make a reasoned judgement</li> </ul>
<b>Draw</b>	<ul style="list-style-type: none"> <li>Produce a picture or diagram</li> </ul>
<b>Explain</b>	<ul style="list-style-type: none"> <li>Give reasons for and/or causes of something</li> <li>Make something clear by describing and/or giving information</li> </ul>
<b>Give examples</b>	<ul style="list-style-type: none"> <li>Give relevant examples in the context of the question</li> </ul>
<b>Identify</b>	<ul style="list-style-type: none"> <li>Name or provide factors or features from stimulus</li> </ul>
<b>Label</b>	<ul style="list-style-type: none"> <li>Add information, for example, to a table, diagram or graph until it is final</li> </ul>
<b>Outline</b>	<ul style="list-style-type: none"> <li>Give a short account or summary</li> </ul>
<b>State</b>	<ul style="list-style-type: none"> <li>Give factors or features</li> <li>Give short, factual answers</li> </ul>

## Non examined assessment (NEA)

The table shows the command words that will be used in the NEA assignments and/or assessment criteria.

Command Word	Meaning
<b>Adapt</b>	<ul style="list-style-type: none"> <li>Change to make suitable for a new use or purpose</li> </ul>
<b>Analyse</b>	<ul style="list-style-type: none"> <li>Separate or break down information into parts and identify their characteristics or elements</li> <li>Explain the different elements of a topic or argument and make reasoned comments</li> <li>Explain the impacts of actions using a logical chain of reasoning</li> </ul>
<b>Assess</b>	<ul style="list-style-type: none"> <li>Offer a reasoned judgement of the standard or quality of situations or skills. The reasoned judgement is informed by relevant facts</li> </ul>
<b>Calculate</b>	<ul style="list-style-type: none"> <li>Work out the numerical value. Show your working unless otherwise stated</li> </ul>
<b>Classify</b>	<ul style="list-style-type: none"> <li>Arrange in categories according to shared qualities or characteristics</li> </ul>
<b>Compare</b>	<ul style="list-style-type: none"> <li>Give an account of the similarities and differences between two or more items, situations or actions</li> </ul>
<b>Conclude</b>	<ul style="list-style-type: none"> <li>Judge or decide something</li> </ul>
<b>Describe</b>	<ul style="list-style-type: none"> <li>Give an account that includes the relevant characteristics, qualities or events</li> </ul>
<b>Discuss (how/whether/etc)</b>	<ul style="list-style-type: none"> <li>Present, analyse and evaluate relevant points (for example, for/against an argument) to make a reasoned judgement</li> </ul>
<b>Evaluate</b>	<ul style="list-style-type: none"> <li>Make a reasoned qualitative judgement considering different factors and using available knowledge/experience</li> </ul>
<b>Examine</b>	<ul style="list-style-type: none"> <li>To look at, inspect, or scrutinise carefully, or in detail</li> </ul>
<b>Explain</b>	<ul style="list-style-type: none"> <li>Give reasons for and/or causes of something</li> <li>Make something clear by describing and/or giving information</li> </ul>
<b>Interpret</b>	<ul style="list-style-type: none"> <li>Translate information into recognisable form</li> <li>Convey one's understanding to others, e.g. in a performance</li> </ul>
<b>Investigate</b>	<ul style="list-style-type: none"> <li>Inquire into (a situation or problem)</li> </ul>
<b>Justify</b>	<ul style="list-style-type: none"> <li>Give valid reasons for offering an opinion or reaching a conclusion</li> </ul>
<b>Research</b>	<ul style="list-style-type: none"> <li>Do detailed study in order to discover (new) information or reach a (new) understanding</li> </ul>
<b>Summarise</b>	<ul style="list-style-type: none"> <li>Express the most important facts or ideas about something in a short and clear form</li> </ul>

We might also use other command words but these will be:

- commonly used words whose meaning will be made clear from the context in which they are used (e.g. create, improve, plan)
- subject specific words drawn from the unit content.

## Appendix C: How Science Works Concepts and Skills

In order to be able to develop their skills, knowledge and understanding in OCR Level 3 Alternative Academic Qualification Cambridge Advanced National in Applied Science, students need to have acquired competence in the ‘how science works’ concepts and skills listed in the table of coverage.

The concepts and skills set out in this section are intended to develop learners as critical and creative thinkers, and to enable learners to solve problems in a variety of contexts. The concepts and skills are set out as references and associated statements.

All ‘how science works’ references will be assessed within the lifetime of the specification across the examined assessment units as appropriate. Students will also be required to apply their knowledge and understanding of the ‘how science works concepts and skills’ across the NEA units as appropriate.

Terms associated with measurement and data analysis are used in accordance with their definitions in the Association of Science Education publication *The Language of Measurement* (2010).

How Science Works Reference	How Science Works Statement	To include understanding of:	Areas of the specification covering the HSW concepts and skills
<b>HSW1</b>	Use theories, models, and ideas to develop scientific explanations	<ul style="list-style-type: none"> <li>Peer review</li> <li>Use of a variety of models (representational, spatial, descriptive, computational, and mathematical) to solve problems</li> <li>Hypotheses and predictions</li> </ul>	<b>F180:</b> B1.1.1, B1.1.2, B1.1.3, B2.2.1, B3.1.1, B3.1.2, B3.1.4, C1.2, C2.1.4, C3.1.1, C3.2.1, P3.1.4 <b>F183:</b> 1.1.1 <b>F184:</b> 1.2.1
<b>HSW2</b>	Use knowledge and understanding to pose scientific questions, define scientific problems, present scientific arguments and ideas	<ul style="list-style-type: none"> <li>Use of online and offline research skills</li> <li>Correctly citing sources of information</li> <li>How to present reasoned explanations, including relating data to hypotheses</li> </ul>	<b>F180:</b> B2.1.1, C2.1.2 <b>F182:</b> 1.1.1, 1.1.2 <b>F183:</b> 1.2.2 <b>F184:</b> 1.4.1
<b>HSW3</b>	Use appropriate methodology, including information and communication technology (ICT) to answer scientific questions and solve scientific problems	<ul style="list-style-type: none"> <li>Experimental design, including to solve problems in a practical context</li> <li>Control variables, dependent variables, and independent variables</li> <li>Appropriateness of an experimental method to meet expected outcomes</li> <li>Importance of scientific quantities and how they are determined</li> <li>How to determine an appropriate sample size and/or range of values to be measured</li> </ul>	<b>F180:</b> B3.1.3, C1.1.1, C2.1.1, C4.1.2 <b>F181:</b> 1.1.1, 1.2.1, 2.2 <b>F182:</b> 1.2.1, 1.3.1, 2.1.1 <b>F183:</b> 2.1.1, 2.1.2 <b>F184:</b> 5.3.1, 5.5

<b>HSW4</b>	Carry out experimental and investigative activities, including appropriate risk management, in a range of contexts	<ul style="list-style-type: none"> <li>How to use the apparatus, techniques and procedures correctly, skilfully and safely</li> <li>Apply investigative approaches and methods to practical work</li> </ul>	<b>F180:</b> B1.2.1, B1.2.2, C2.1.5, P2.1.1, P2.1.6 <b>F182:</b> 2.1.1, 4.1.1 <b>F183:</b> 1.2.1, 2.2.1 <b>F185:</b> 2.1.1, 2.1.2, 2.1.3, 2.3.2, 2.3.3 <b>F186:</b> 1.4, 4.4
<b>HSW5</b>	Use data to provide evidence, and recognise correlations and causal relationships	<ul style="list-style-type: none"> <li>Appropriate units for measurements (this already exists as part of Maths skills)</li> <li>How to present observations and data in an appropriate format</li> <li>How to process data using appropriate prefixes (e.g. tera, giga, mega, kilo, centi, milli, micro and nano) and powers of ten for orders of magnitude</li> <li>How to distinguish between a correlation and a cause-effect link</li> <li>How to translate data from one form to another</li> <li>How to identify the presence/absence of a mechanism as reasonable grounds for accepting/rejecting a claim that a factor is a cause of an outcome</li> </ul>	<b>F180:</b> B1.2.1, C2.1.2, C2.1.3, C3.1.2, C4.2.2, P1.1.4, P1.1.5, P2.1.6 <b>F181:</b> 1.2.2, 1.3.1 <b>F182:</b> 3.2.1 <b>F183:</b> 3.1.1 <b>F185:</b> 3.2.1
<b>HSW6</b>	How to evaluate methodology, evidence and data, and resolve conflicting evidence	<ul style="list-style-type: none"> <li>How to interpret and make judgments and draw conclusions from qualitative and quantitative experimental results (including observations and graphs)</li> <li>Anomalies and outliers in experimental measurements</li> <li>How to use appropriate maths skills for analysis of quantitative data</li> <li>Limitations in experimental procedures</li> <li>Precision, accuracy, repeatability, reproducibility, and validity of measurements and data, including margins of error, percentage errors and uncertainties in apparatus</li> <li>How to refine experimental design by suggestion of improvements to the apparatus, procedures, and techniques</li> <li>Confidence in a prediction or hypothesis</li> </ul>	<b>F180:</b> B2.1.2, C4.1.1, P2.1.3 <b>F181:</b> 2.1, 3.1.1, 4.2, 4.4.1 <b>F182:</b> 2.2.1, 3.1.1, 3.1.2, 3.3.2 <b>F183:</b> 2.2.2 <b>F184:</b> 5.4 <b>F185:</b> 4.2.1, 4.3.1

<b>HSW7</b>	How scientific knowledge and understanding develops over time	<ul style="list-style-type: none"> <li>How theories have developed over time and been modified when new evidence has become available</li> <li>Problems that science cannot currently answer</li> </ul>	<b>F180:</b> B4.2.1, P3.1.2 <b>F181:</b> 3.3.2 <b>F184:</b> 3.1.1, 3.1.2, 4.2.2 <b>F185:</b> 1.3.1, 2.3.1, 2.3.4, 4.1.2 <b>F186:</b> 3.2, 4.1, 4.2, 4.3
<b>HSW8</b>	How to communicate information and ideas in appropriate ways using appropriate scientific terminology	<ul style="list-style-type: none"> <li>Use of diagrammatical, graphical, numerical and symbolic forms in communication</li> <li>Paper based and electronic forms of presentation</li> <li>Accurate representation and labelling of objects observed</li> </ul>	<b>F180:</b> B4.2.2, C3.3.1, C4.1.1, C4.2.1, P1.1.1, P1.1.2, P1.1.5, P2.1.5 <b>F181:</b> 2.4.1, 4.1.2 <b>F183:</b> 3.1.2, 3.1.3 <b>F184:</b> 4.2.4, 5.1.1, 5.3.2, 5.3.3 <b>F185:</b> 3.2.3 <b>F186:</b> 1.1, 2.2.1
<b>HSW9</b>	Consider applications and implications of science and evaluate their associated benefits and risks	<ul style="list-style-type: none"> <li>Examples of technological applications of science that have made significant positive differences to people's lives</li> <li>Risks that have arisen from new scientific or technological advances</li> <li>Perceived and calculated risk in relation to data and consequences</li> </ul>	<b>F180:</b> P3.1.3, P3.1.5 <b>F181:</b> 2.3.1, 3.2.1, 3.2.2, 3.3.2 <b>F182:</b> 1.2.2 <b>F185:</b> 2.2.1, 3.2.2, 4.1.2 <b>F186:</b> 1.1, 1.2, 1.3, 2.1.1, 2.1.2
<b>HSW10</b>	Consider impact of science and technology on humans, other organisms, and the environment	<ul style="list-style-type: none"> <li>Reasons why different decisions on the same issue might be appropriate in view of differences in personal, social, economic or environmental context, and be able to make decisions based on the evaluation of evidence and arguments</li> </ul>	<b>F180:</b> B2.2.2, P3.2.3, P3.2.4 <b>F181:</b> 3.2.1, 3.2.2, 3.3.1, 4.3 <b>F183:</b> 1.2.2 <b>F184:</b> 1.3.2, 2.1.1, 2.1.2, 2.2.1, 3.1.1, 3.2.1, 4.3.1, 4.3.2 <b>F186:</b> 2.2.2, 5.1
<b>HSW11</b>	How to evaluate the role of the scientific community in validating new knowledge and ensuring integrity	<ul style="list-style-type: none"> <li>Reasons why scientists should communicate their work to a range of audiences</li> </ul>	<b>F180:</b> B3.1.2, C2.1.6, C4.2.1, C4.2.2, P1.1.3, P2.1.2, P3.1.1, P3.2.1, P3.2.2 <b>F181:</b> 1.3.2, 1.4, 2.3.2, 3.1.2, 3.3.1, 4.1.1, 4.1.2, 4.4.2 <b>F182:</b> 3.2.2, 3.3.1 <b>F184:</b> 1.1.1, 1.1.2, 1.3.1, 2.1.3, 2.1.4, 2.2.2, 3.2.1, 4.2.1, 4.2.3, 4.3.1, 4.3.2, 5.1.1, 5.2 <b>F185:</b> 1.1.1, 1.2.1, 3.1.1, 3.1.2, 4.1.1, 4.3.2 <b>F186:</b> 1.2, 1.3, 3.1, 4.4, 5.1, 5.2

<b>HSW12</b>	How to evaluate the ways in which society uses science to inform decision making	<ul style="list-style-type: none"><li>• How to distinguish between questions that could be answered using a scientific approach, from those that could not</li></ul>	<b>F180:</b> B4.1.1 <b>F181:</b> 1.3.3, 3.3.1 <b>F184:</b> 4.1.1 <b>F185:</b> 2.3.1
--------------	--	--	--

## Appendix D: Mathematical skills for Applied Science

In order to be able to develop their skills, knowledge and understanding in OCR Level 3 Alternative Academic Qualification Cambridge Advanced National in Applied Science, students need to have acquired competence in the mathematical skills listed in the table of coverage.

All mathematical references will be assessed within the lifetime of the specification across the examined assessment units as appropriate. Students will also be required to apply their knowledge and understanding of the 'mathematical skills' across the NEA units as appropriate.

A minimum of 25% of the overall marks available in the exams for the externally assessed units will be for the assessment of mathematical skills. These skills will be applied in the context of the relevant science.

A minimum of 10% of the criteria in any combination of the NEA assignments will be for the explicit assessment of mathematical skills.

Mathematical skill to be assessed	Exemplification of the mathematical skill in context	Areas of the specification which exemplify the mathematical skill (assessment is not limited to the examples below)
<b>M0 – Arithmetic and numerical computation</b>		
M0.1	Recognise and make use of appropriate units in calculations	e.g. converting $\text{mm}^3$ to $\text{cm}^3$ or $\text{cm}^3$ to $\text{dm}^3$ as part of volumetric calculations.  <b>F180:</b> B1.1.1, B1.1.3, B1.2.1, B1.2.2, B2.1.1, B2.2.1, B3.1.2, C2.1.6 <b>F183:</b> 3.1.1 <b>F184:</b> 5.2 <b>F185:</b> 2.1.2, 2.2.1
M0.2	Recognise and use expressions in decimal, ordinary and standard form	e.g. carrying out calculations using numbers expressed in standard form such as speed of light in a vacuum.
M0.3	Use ratios, fractions and percentages	e.g. calculating surface area to volume ratio  <b>F180:</b> B4.1.1, B4.2.1, B4.2.2, C2.1.2, C2.1.3, C2.1.4, C2.1.5, C3.1.2 <b>F183:</b> 1.2.2, 2.1.1, 2.1.2 <b>F185:</b> 2.3.4
M0.4	Estimate results	e.g. estimating effect of changing experimental parameters on measurable values  <b>F180:</b> B4.2.1 <b>F181:</b> 3.1.1 <b>F183:</b> 3.1.1 <b>F184:</b> 5.1.1 <b>F185:</b> 2.1.2, 3.1.2
M0.5	Use calculators to find and use power functions	e.g. solving for number of undecayed nuclei in $N = N_0 e^{-kt}$
M0.6	Use calculators to find $\cos x$ when $x$ is expressed in degrees	e.g. calculating the work done when the direction of the force is not in the same direction as the displacement
<b>M1 – Handling data</b>		
M1.1	Use an appropriate number of significant figures	e.g. reporting calculations to an appropriate number of significant figures given raw data quoted to varying numbers of significant figures  <b>F180:</b> B1.1.1, B1.2.2, B4.1.1, C1.1.1, P1.1.5 <b>F185:</b> 2.1.1, 2.2.1 <b>F186:</b> 2.1.2
M1.2	Understand the terms mean, median and mode	e.g. calculating or comparing the mean, median and mode of a set of data such as height/mass of a group of organisms  <b>F180:</b> B4.1.1 <b>F181:</b> 2.3.1 <b>F182:</b> 1.3.1 <b>F184:</b> 3.1.2, 3.2.1, 5.3.1, 5.5

M1.3	Understand simple probability	e.g. understanding probability in context of radioactive decay	<b>F180:</b> P3.1.3 <b>F185:</b> 4.1.1 <b>F186:</b> 2.1.2, 2.2.1
M1.4	Make order of magnitude calculations	e.g. making order of magnitude calculations in relation to magnification	<b>F180:</b> B1.1.1, B1.1.2, B1.2.1, B1.2.2, P3.2.2 <b>F185:</b> 4.2.1
M1.5	Uncertainties in measurements and use of simple techniques to determine uncertainty when data are combined by addition, subtraction, multiplication, division and raising to powers	e.g. determining uncertainty when two burette readings are used to calculate a titre value/calculate percentage error where there are uncertainties in measurement	<b>F180:</b> C2.1.5, C4.2.2 <b>F182:</b> 1.2.1, 2.1.1 <b>F183:</b> 2.1.1, 2.1.2 <b>F184:</b> 4.3.1, 4.3.2
M1.6	Frequency tables and diagrams, bar charts, line graphs, scatter plots, pie charts, and histograms	e.g. plotting a range of data in an appropriate format, e.g. data relating to cars	<b>F180:</b> C3.2.1, P3.2.2 <b>F181:</b> 2.1, 2.3.2 <b>F182:</b> 1.1.1, 2.2.1, 3.1.1 <b>F184:</b> 5.1.1 <b>F186:</b> 1.4
M1.7	Understand the principles of sampling as applied to scientific data, including representative sampling	e.g. how to ensure sampling is representative in a population	<b>F180:</b> B4.2.1, B4.2.2 <b>F181:</b> 2.2 <b>F184:</b> 1.3.2, 5.3.1, 5.3.2, 5.3.3 <b>F185:</b> 2.3.4, 3.1.2
M1.8	Understand measures of dispersion, including standard deviation and range	e.g. understanding why standard deviation might be a more useful measure of dispersion for a given set of data, such as where there is an outlying result	<b>F180:</b> B4.2.2 <b>F182:</b> 1.2.1, 3.1.2, 4.1.1 <b>F183:</b> 2.1.1 <b>F185:</b> 4.3.1
<b>M2 - Algebra</b>			
M2.1	Understand and use the symbols: $=$ , $<$ , $>$ , $\leq$ , $\geq$ , $<<$ , $>>$ , $\propto$ , $\neq$ , $\pm$ , $\approx$ , D	e.g. recognising the significance of the symbols in the expression $F \propto Dp/ Dt$	<b>F180:</b> B3.1.3, C2.1.2, C4.2.1, P3.1.5 <b>F184:</b> 4.1.1
M2.2	Change the subject of an equation, including non-linear equations	e.g. carrying out structured and unstructured mole calculations	<b>F180:</b> C2.1.1, C2.1.3, C2.1.6, P1.1.3, P2.1.3, P2.1.4, P2.1.5, P3.1.3
M2.3	Substitute numerical values into algebraic equations using appropriate units for physical quantities	e.g. carrying out enthalpy change calculations	<b>F180:</b> B2.2.2, B4.1.1, C1.1.1, C2.1.1, C2.1.3, C4.1.1, C4.2.2, P1.1.1, P1.1.3, P1.1.4, P2.1.3, P2.1.4, P3.1.3, P3.1.5 <b>F183:</b> 1.2.2 <b>F184:</b> 1.2.1, 4.1.1
M2.4	Solve algebraic equations, including quadratic equations	e.g. solving equations for constant acceleration such as $v = u + at$	<b>F180:</b> B2.2.2, B4.1.1, C1.1.1, C2.1.1, C2.1.3, C4.1.1, C4.2.2, P1.1.1, P1.1.3, P1.1.4, P2.1.3, P2.1.4, P3.1.3, P3.1.5
<b>M3 - Graphs</b>			
M3.1	Translate information between graphical, numerical, and algebraic forms	e.g. interpreting and analysing spectra	<b>F180:</b> B3.1.3, C1.2, C4.1.1 <b>F181:</b> 2.4.1 <b>F182:</b> 3.1.1 <b>F183:</b> 1.1.1, 3.1.3 <b>F184:</b> 2.1.1, 2.2.1, 3.1.1, 5.1.1 <b>F185:</b> 3.1.2 <b>F186:</b> 1.1, 1.2, 1.4, 2.1.2, 4.3
M3.2	How to plot two variables from experimental or other data	e.g. plotting graphs of current against potential difference	<b>F180:</b> B2.1.2 <b>F183:</b> 1.1.1 <b>F184:</b> 2.2.1

M3.3	Understand that $y = mx + c$ represents a linear relationship	e.g. rearranging and comparing $v = u + at$ with $y = mx + c$ for velocity-time graphs in constant acceleration problems	<b>F180:</b> B2.1.2, C4.1.2 <b>F182:</b> 3.2.1
M3.4	The slope and intercept of a linear graph	e.g. reading off and interpreting the initial velocity in a velocity-time graph	<b>F180:</b> B2.1.2, P3.1.4 <b>F182:</b> 3.2.1
M3.5	Rate of change from a graph showing a linear relationship	e.g. calculating acceleration from a linear velocity-time graph	<b>F180:</b> B2.1.2, C4.1.2
M3.6	The slope of a tangent to a curve as a measure of rate of change	e.g. calculating the rate of a reaction from the gradient of a gas volume-time graph	<b>F180:</b> P3.1.4
M3.7	Instantaneous rate of change and average rate of change	e.g. understanding that the gradient of the tangent of a displacement-time graph gives the velocity at a point in time, which is a different measure to the average velocity	<b>F180:</b> C4.1.2, P2.1.5
M3.8	Understand the possible physical significance of the area between a curve or line and the x-axis and be able to calculate it or estimate it by graphical methods as appropriate	e.g. recognising that the area under a force-extension graph is equivalent to the energy stored	<b>F180:</b> C4.1.1, P2.1.5
M3.9	Sketch relationships for graphs	e.g. sketching the relationship between resistance and temperature for a thermistor	<b>F180:</b> C4.1.1, C4.1.2, C4.2.1, P1.1.4
<b>M4 – Geometry and trigonometry</b>			
M4.1	Use angles in regular 2D and 3D structures	e.g. measuring angles in force diagrams to solve problems for work done	<b>F180:</b> P2.1.2 <b>F186:</b> 2.2.2
M4.2	Visualise and represent 2D and 3D forms including two-dimensional representations of 3D objects	e.g. drawing different forms of isomers	<b>F180:</b> B1.2.1, B3.1.1, B3.1.3, B3.1.4, C3.1.1, C3.3.1 <b>F186:</b> 1.1
M4.3	Areas of triangles, circumferences and areas of circles, surface areas and volumes of rectangular blocks, cylinders, and spheres	e.g. calculating the surface area or volume of a cell	<b>F180:</b> B2.1.1

The questions and tasks across all units that are used to target mathematical skills will be at a level of demand that is appropriate to Level 3 Alternative Academic Qualification Cambridge Advanced National in Applied Science. The questions that assess mathematical skills will not be of a lower demand than that of questions and tasks in the assessment for the Level 1/Level 2 GCSE (9-1) in Mathematics.

The list of examples provided in the table is not exhaustive and is not limited to Level 2 examples. These skills could be developed in other areas of the specification content from those indicated.

Students will not be expected to memorise mathematical formulas. Any mathematical formulas will be provided in the examination paper on a separate data sheet. Students will not be expected to memorise the content of the Periodic Table.

Mathematical skills should be taught using both theoretical and practical contexts.

## Appendix E: Units in science

It is expected that learners will show and be able to apply understanding of the physical quantities and corresponding units, and SI base units and derived units listed below. The tables also include symbols commonly used for these quantities; use of symbols by learners is optional. Learners will be able to use them in qualitative work and calculations.

Physical quantity	Common symbol(s) (use of these symbols is optional)	SI base unit	Unit abbreviation
Length	$d$ – diameter $h$ – height (e.g. height raised above ground level to calculate gravitational potential energy) $l$ – length (e.g. of a wire) $s$ – displacement (e.g. displacement of a force) $x$ – extension (e.g. of a spring) or distance travelled (e.g. for attenuation of X-rays through a medium) $\lambda$ (lambda) – wavelength	metre	m
Mass	$m$	kilogram	kg
Time	$t$ $t_E$ – effective half-life $t_{1/2}$ – physical half-life $t_B$ – biological half-life $T$ – time period	second	s
Temperature	$T$ – for Kelvin temperature $\Delta T$ – for change in Kelvin temperature	kelvin	K
Current	$I$	ampere	A
Amount of a substance	$n$	mole	mol

The following table includes SI derived or SI accepted units for quantities which will be commonly used across the qualification:

Physical quantity	Common symbol(s) (use of these symbols is optional)	SI derived / accepted unit	Unit abbreviation
Angle	$\theta$ (theta)	degree	$^\circ$
Area	$A$	squared metre	$\text{m}^2$
Acceleration	$a$	metre per squared second	$\text{m s}^{-2}$
Acoustic impedance	$Z$	kilogram per squared metre per second	$\text{kg m}^{-2} \text{s}^{-1}$
Activity	$A$	becquerel; per second	$\text{Bq; s}^{-1}$
Concentration	$c$	mole per cubic decimetre; gram per cubic decimetre	$\text{mol dm}^{-3}; \text{g dm}^{-3}$
Density	$\rho$ (rho)	kilogram per cubic metre; kilogram per cubic centimetre	$\text{kg m}^{-3}; \text{kg cm}^{-3}$

Energy	$E$ – energy $W$ – work done $Q$ – (thermal) energy	joule; electron volt	J; eV
Enthalpy change of combustion	$\Delta_c H$	kilojoule per mole	$\text{kJ mol}^{-1}$
Electric charge	$Q$	coulomb	C
Electric potential difference	$V$	volt	V
Electric resistance	$R$	ohm	$\Omega$
Force	$F$	newton	N
Frequency	$f$	hertz	Hz
Gravitational field strength	$g$	newton per kilogram	$\text{N kg}^{-1}$
Intensity	$I$	watt per squared metre	$\text{W m}^{-2}$
Intensity reflection coefficient	$\alpha$ (alpha)	no units	no units
Linear attenuation coefficient	$\mu$ (mu)	per metre; per centimetre	$\text{m}^{-1}$ ; $\text{cm}^{-1}$
Magnification	$M$	no units	no units
Molar mass	$M$	grams per mole	$\text{g mol}^{-1}$
Mass attenuation coefficient	$\mu_m$ (mu)	squared metre per kilogram; squared centimetre per gram	$\text{m}^2 \text{kg}^{-1}$ ; $\text{cm}^2 \text{g}^{-1}$
Power	$P$	watt	W
Pressure	$p$	Pascal; newton per squared metre	$\text{Pa}$ ; $\text{N m}^{-2}$
Radioactive decay constant	$\lambda$	per second	$\text{s}^{-1}$
Specific heat capacity	$c$	Joule per kilogram per degree Celsius; Joule per kilogram per Kelvin	$\text{J kg}^{-1} \text{ }^{\circ}\text{C}^{-1}$ ; $\text{J kg}^{-1} \text{ K}^{-1}$
Speed of sound	$c$	metre per second	$\text{m s}^{-1}$
Spring constant	$k$	newton per metre	$\text{N m}^{-1}$
Temperature	$\theta$ (theta) – for Celsius temperature $\Delta\theta$ (theta) – for change in Celsius temperature	degree Celsius	$^{\circ}\text{C}$
Velocity	$v$ – final velocity (also speed) $u$ – initial velocity	metre per second	$\text{m s}^{-1}$
Volume	$V$	cubic metre; litre; cubic decimetre; cubic centimetre	$\text{m}^3$ ; L; $\text{dm}^3$ ; $\text{cm}^3$

## **Appendix F: Data, Formulae and Relationships Booklet**

### **OCR Level 3 Alternative Academic Qualification Cambridge Advanced National in Applied Science (Certificate)**

**H051**

### **OCR Level 3 Alternative Academic Qualification Cambridge Advanced National in Applied Science (Extended Certificate)**

**H151**

**Data, Formulae and Relationships Booklet**

**The Periodic Table of the Elements**

(1)	(2)	Key	
1	2	atomic number name	relative atomic mass
1 <b>H</b> hydrogen 1.0	2 <b>He</b> beryllium 9.0	3 <b>Li</b> lithium 6.9	4 <b>Be</b> beryllium 9.0
5 <b>Na</b> sodium 23.0	6 <b>Mg</b> magnesium 24.3	7 <b>Al</b> aluminum 27.0	8 <b>Si</b> silicon 28.1
9 <b>K</b> potassium 39.1	10 <b>Ca</b> calcium 40.1	11 <b>Sc</b> scandium 45.0	12 <b>Cr</b> chromium 52.0
13 <b>Rb</b> rubidium 85.5	14 <b>Sr</b> strontium 87.6	15 <b>Ti</b> titanium 47.9	16 <b>V</b> vanadium 50.9
17 <b>Cs</b> caesium 132.9	18 <b>Ba</b> barium 137.3	19 <b>Sc</b> scandium 45.0	20 <b>Cr</b> chromium 52.0
21 <b>Fr</b> francium 223.0	22 <b>Ra</b> radium 226.0	23 <b>Tl</b> titanium 47.9	24 <b>Mn</b> manganese 54.9
25 <b>La</b> lanthanum 138.9	26 <b>Th</b> thorium 232.0	27 <b>Fe</b> iron 55.8	28 <b>Co</b> cobalt 58.9
29 <b>Ac</b> actinium 227.0	30 <b>Pa</b> protactinium 231.0	31 <b>Ni</b> nickel 58.7	32 <b>Ga</b> gallium 69.7
33 <b>Fr</b> francium 223.0	34 <b>Sc</b> scandium 45.0	35 <b>Zn</b> zinc 65.4	36 <b>Ge</b> germanium 72.6
36 <b>Rn</b> radon 222.0	37 <b>Sc</b> scandium 45.0	38 <b>Al</b> aluminum 27.0	39 <b>As</b> arsenic 74.9
40 <b>Fr</b> francium 223.0	41 <b>Sc</b> scandium 45.0	42 <b>Al</b> aluminum 27.0	43 <b>Si</b> silicon 28.1
44 <b>Fr</b> francium 223.0	45 <b>Sc</b> scandium 45.0	46 <b>Al</b> aluminum 27.0	47 <b>Ge</b> germanium 72.6
48 <b>Fr</b> francium 223.0	49 <b>Sc</b> scandium 45.0	50 <b>Al</b> aluminum 27.0	51 <b>Se</b> selenium 79.0
52 <b>Fr</b> francium 223.0	53 <b>Sc</b> scandium 45.0	54 <b>Al</b> aluminum 27.0	55 <b>Kr</b> krypton 83.8
56 <b>Fr</b> francium 223.0	57 <b>Sc</b> scandium 45.0	58 <b>Al</b> aluminum 27.0	59 <b>Xe</b> xenon 131.3
59 <b>Fr</b> francium 223.0	60 <b>Sc</b> scandium 45.0	61 <b>Al</b> aluminum 27.0	62 <b>Br</b> bromine 79.9
63 <b>Fr</b> francium 223.0	64 <b>Sc</b> scandium 45.0	65 <b>Al</b> aluminum 27.0	66 <b>Ar</b> argon 39.9
67 <b>Fr</b> francium 223.0	68 <b>Sc</b> scandium 45.0	69 <b>Al</b> aluminum 27.0	70 <b>Ne</b> neon 20.2
71 <b>Fr</b> francium 223.0	72 <b>Sc</b> scandium 45.0	73 <b>Al</b> aluminum 27.0	74 <b>O</b> oxygen 16.0
75 <b>Fr</b> francium 223.0	76 <b>Sc</b> scandium 45.0	77 <b>Al</b> aluminum 27.0	78 <b>F</b> fluorine 19.0
79 <b>Fr</b> francium 223.0	80 <b>Sc</b> scandium 45.0	81 <b>Al</b> aluminum 27.0	82 <b>S</b> sulfur 32.1
83 <b>Fr</b> francium 223.0	84 <b>Sc</b> scandium 45.0	85 <b>Al</b> aluminum 27.0	86 <b>Rn</b> radon 222.0
87 <b>Fr</b> francium 223.0	88 <b>Sc</b> scandium 45.0	89 <b>Al</b> aluminum 27.0	90 <b>Fr</b> francium 223.0
91 <b>Fr</b> francium 223.0	92 <b>Sc</b> scandium 45.0	93 <b>Al</b> aluminum 27.0	94 <b>Fr</b> francium 223.0
95 <b>Fr</b> francium 223.0	96 <b>Sc</b> scandium 45.0	97 <b>Al</b> aluminum 27.0	98 <b>Fr</b> francium 223.0
99 <b>Fr</b> francium 223.0	100 <b>Sc</b> scandium 45.0	101 <b>Al</b> aluminum 27.0	102 <b>Fr</b> francium 223.0
103 <b>Fr</b> francium 223.0	104 <b>Sc</b> scandium 45.0	105 <b>Al</b> aluminum 27.0	106 <b>Fr</b> francium 223.0
107 <b>Fr</b> francium 223.0	108 <b>Sc</b> scandium 45.0	109 <b>Al</b> aluminum 27.0	110 <b>Fr</b> francium 223.0
111 <b>Fr</b> francium 223.0	112 <b>Sc</b> scandium 45.0	113 <b>Al</b> aluminum 27.0	114 <b>Fr</b> francium 223.0
115 <b>Fr</b> francium 223.0	116 <b>Sc</b> scandium 45.0	117 <b>Al</b> aluminum 27.0	118 <b>Fr</b> francium 223.0
119 <b>Fr</b> francium 223.0	120 <b>Sc</b> scandium 45.0	121 <b>Al</b> aluminum 27.0	122 <b>Fr</b> francium 223.0
123 <b>Fr</b> francium 223.0	124 <b>Sc</b> scandium 45.0	125 <b>Al</b> aluminum 27.0	126 <b>Fr</b> francium 223.0
127 <b>Fr</b> francium 223.0	128 <b>Sc</b> scandium 45.0	129 <b>Al</b> aluminum 27.0	130 <b>Fr</b> francium 223.0
131 <b>Fr</b> francium 223.0	132 <b>Sc</b> scandium 45.0	133 <b>Al</b> aluminum 27.0	134 <b>Fr</b> francium 223.0
135 <b>Fr</b> francium 223.0	136 <b>Sc</b> scandium 45.0	137 <b>Al</b> aluminum 27.0	138 <b>Fr</b> francium 223.0
139 <b>Fr</b> francium 223.0	140 <b>Sc</b> scandium 45.0	141 <b>Al</b> aluminum 27.0	142 <b>Fr</b> francium 223.0
143 <b>Fr</b> francium 223.0	144 <b>Sc</b> scandium 45.0	145 <b>Al</b> aluminum 27.0	146 <b>Fr</b> francium 223.0
147 <b>Fr</b> francium 223.0	148 <b>Sc</b> scandium 45.0	149 <b>Al</b> aluminum 27.0	150 <b>Fr</b> francium 223.0
151 <b>Fr</b> francium 223.0	152 <b>Sc</b> scandium 45.0	153 <b>Al</b> aluminum 27.0	154 <b>Fr</b> francium 223.0
155 <b>Fr</b> francium 223.0	156 <b>Sc</b> scandium 45.0	157 <b>Al</b> aluminum 27.0	158 <b>Fr</b> francium 223.0
159 <b>Fr</b> francium 223.0	160 <b>Sc</b> scandium 45.0	161 <b>Al</b> aluminum 27.0	162 <b>Fr</b> francium 223.0
163 <b>Fr</b> francium 223.0	164 <b>Sc</b> scandium 45.0	165 <b>Al</b> aluminum 27.0	166 <b>Fr</b> francium 223.0
167 <b>Fr</b> francium 223.0	168 <b>Sc</b> scandium 45.0	169 <b>Al</b> aluminum 27.0	170 <b>Fr</b> francium 223.0
171 <b>Fr</b> francium 223.0	172 <b>Sc</b> scandium 45.0	173 <b>Al</b> aluminum 27.0	174 <b>Fr</b> francium 223.0
175 <b>Fr</b> francium 223.0	176 <b>Sc</b> scandium 45.0	177 <b>Al</b> aluminum 27.0	178 <b>Fr</b> francium 223.0
179 <b>Fr</b> francium 223.0	180 <b>Sc</b> scandium 45.0	181 <b>Al</b> aluminum 27.0	182 <b>Fr</b> francium 223.0
183 <b>Fr</b> francium 223.0	184 <b>Sc</b> scandium 45.0	185 <b>Al</b> aluminum 27.0	186 <b>Fr</b> francium 223.0
187 <b>Fr</b> francium 223.0	188 <b>Sc</b> scandium 45.0	189 <b>Al</b> aluminum 27.0	190 <b>Fr</b> francium 223.0
191 <b>Fr</b> francium 223.0	192 <b>Sc</b> scandium 45.0	193 <b>Al</b> aluminum 27.0	194 <b>Fr</b> francium 223.0
195 <b>Fr</b> francium 223.0	196 <b>Sc</b> scandium 45.0	197 <b>Al</b> aluminum 27.0	198 <b>Fr</b> francium 223.0
199 <b>Fr</b> francium 223.0	200 <b>Sc</b> scandium 45.0	201 <b>Al</b> aluminum 27.0	202 <b>Fr</b> francium 223.0
203 <b>Fr</b> francium 223.0	204 <b>Sc</b> scandium 45.0	205 <b>Al</b> aluminum 27.0	206 <b>Fr</b> francium 223.0
207 <b>Fr</b> francium 223.0	208 <b>Sc</b> scandium 45.0	209 <b>Al</b> aluminum 27.0	210 <b>Fr</b> francium 223.0
211 <b>Fr</b> francium 223.0	212 <b>Sc</b> scandium 45.0	213 <b>Al</b> aluminum 27.0	214 <b>Fr</b> francium 223.0
215 <b>Fr</b> francium 223.0	216 <b>Sc</b> scandium 45.0	217 <b>Al</b> aluminum 27.0	218 <b>Fr</b> francium 223.0
219 <b>Fr</b> francium 223.0	220 <b>Sc</b> scandium 45.0	221 <b>Al</b> aluminum 27.0	222 <b>Fr</b> francium 223.0
223 <b>Fr</b> francium 223.0	224 <b>Sc</b> scandium 45.0	225 <b>Al</b> aluminum 27.0	226 <b>Fr</b> francium 223.0
227 <b>Fr</b> francium 223.0	228 <b>Sc</b> scandium 45.0	229 <b>Al</b> aluminum 27.0	230 <b>Fr</b> francium 223.0
231 <b>Fr</b> francium 223.0	232 <b>Sc</b> scandium 45.0	233 <b>Al</b> aluminum 27.0	234 <b>Fr</b> francium 223.0
235 <b>Fr</b> francium 223.0	236 <b>Sc</b> scandium 45.0	237 <b>Al</b> aluminum 27.0	238 <b>Fr</b> francium 223.0
239 <b>Fr</b> francium 223.0	240 <b>Sc</b> scandium 45.0	241 <b>Al</b> aluminum 27.0	242 <b>Fr</b> francium 223.0
243 <b>Fr</b> francium 223.0	244 <b>Sc</b> scandium 45.0	245 <b>Al</b> aluminum 27.0	246 <b>Fr</b> francium 223.0
247 <b>Fr</b> francium 223.0	248 <b>Sc</b> scandium 45.0	249 <b>Al</b> aluminum 27.0	250 <b>Fr</b> francium 223.0
251 <b>Fr</b> francium 223.0	252 <b>Sc</b> scandium 45.0	253 <b>Al</b> aluminum 27.0	254 <b>Fr</b> francium 223.0
255 <b>Fr</b> francium 223.0	256 <b>Sc</b> scandium 45.0	257 <b>Al</b> aluminum 27.0	258 <b>Fr</b> francium 223.0
259 <b>Fr</b> francium 223.0	260 <b>Sc</b> scandium 45.0	261 <b>Al</b> aluminum 27.0	262 <b>Fr</b> francium 223.0
263 <b>Fr</b> francium 223.0	264 <b>Sc</b> scandium 45.0	265 <b>Al</b> aluminum 27.0	266 <b>Fr</b> francium 223.0
267 <b>Fr</b> francium 223.0	268 <b>Sc</b> scandium 45.0	269 <b>Al</b> aluminum 27.0	270 <b>Fr</b> francium 223.0
271 <b>Fr</b> francium 223.0	272 <b>Sc</b> scandium 45.0	273 <b>Al</b> aluminum 27.0	274 <b>Fr</b> francium 223.0
275 <b>Fr</b> francium 223.0	276 <b>Sc</b> scandium 45.0	277 <b>Al</b> aluminum 27.0	278 <b>Fr</b> francium 223.0
279 <b>Fr</b> francium 223.0	280 <b>Sc</b> scandium 45.0	281 <b>Al</b> aluminum 27.0	282 <b>Fr</b> francium 223.0
283 <b>Fr</b> francium 223.0	284 <b>Sc</b> scandium 45.0	285 <b>Al</b> aluminum 27.0	286 <b>Fr</b> francium 223.0
287 <b>Fr</b> francium 223.0	288 <b>Sc</b> scandium 45.0	289 <b>Al</b> aluminum 27.0	290 <b>Fr</b> francium 223.0
291 <b>Fr</b> francium 223.0	292 <b>Sc</b> scandium 45.0	293 <b>Al</b> aluminum 27.0	294 <b>Fr</b> francium 223.0
295 <b>Fr</b> francium 223.0	296 <b>Sc</b> scandium 45.0	297 <b>Al</b> aluminum 27.0	298 <b>Fr</b> francium 223.0
299 <b>Fr</b> francium 223.0	300 <b>Sc</b> scandium 45.0	301 <b>Al</b> aluminum 27.0	302 <b>Fr</b> francium 223.0
303 <b>Fr</b> francium 223.0	304 <b>Sc</b> scandium 45.0	305 <b>Al</b> aluminum 27.0	306 <b>Fr</b> francium 223.0
307 <b>Fr</b> francium 223.0	308 <b>Sc</b> scandium 45.0	309 <b>Al</b> aluminum 27.0	310 <b>Fr</b> francium 223.0
311 <b>Fr</b> francium 223.0	312 <b>Sc</b> scandium 45.0	313 <b>Al</b> aluminum 27.0	314 <b>Fr</b> francium 223.0
315 <b>Fr</b> francium 223.0	316 <b>Sc</b> scandium 45.0	317 <b>Al</b> aluminum 27.0	318 <b>Fr</b> francium 223.0
319 <b>Fr</b> francium 223.0	320 <b>Sc</b> scandium 45.0	321 <b>Al</b> aluminum 27.0	322 <b>Fr</b> francium 223.0
323 <b>Fr</b> francium 223.0	324 <b>Sc</b> scandium 45.0	325 <b>Al</b> aluminum 27.0	326 <b>Fr</b> francium 223.0
327 <b>Fr</b> francium 223.0	328 <b>Sc</b> scandium 45.0	329 <b>Al</b> aluminum 27.0	330 <b>Fr</b> francium 223.0
331 <b>Fr</b> francium 223.0	332 <b>Sc</b> scandium 45.0	333 <b>Al</b> aluminum 27.0	334 <b>Fr</b> francium 223.0
335 <b>Fr</b> francium 223.0	336 <b>Sc</b> scandium 45.0	337 <b>Al</b> aluminum 27.0	338 <b>Fr</b> francium 223.0
339 <b>Fr</b> francium 223.0	340 <b>Sc</b> scandium 45.0	341 <b>Al</b> aluminum 27.0	342 <b>Fr</b> francium 223.0
343 <b>Fr</b> francium 223.0	344 <b>Sc</b> scandium 45.0	345 <b>Al</b> aluminum 27.0	346 <b>Fr</b> francium 223.0
347 <b>Fr</b> francium 223.0	348 <b>Sc</b> scandium 45.0	349 <b>Al</b> aluminum 27.0	350 <b>Fr</b> francium 223.0
351 <b>Fr</b> francium 223.0	352 <b>Sc</b> scandium 45.0	353 <b>Al</b> aluminum 27.0	354 <b>Fr</b> francium 223.0
355 <b>Fr</b> francium 223.0	356 <b>Sc</b> scandium 45.0	357 <b>Al</b> aluminum 27.0	358 <b>Fr</b> francium 223.0
359 <b>Fr</b> francium 223.0	360 <b>Sc</b> scandium 45.0	361 <b>Al</b> aluminum 27.0	362 <b>Fr</b> francium 223.0
363 <b>Fr</b> francium 223.0	364 <b>Sc</b> scandium 45.0	365 <b>Al</b> aluminum 27.0	366 <b>Fr</b> francium 223.0
367 <b>Fr</b> francium 223.0	368 <b>Sc</b> scandium 45.0	369 <b>Al</b> aluminum 27.0	370 <b>Fr</b> francium 223.0
371 <b>Fr</b> francium 223.0	372 <b>Sc</b> scandium 45.0	373 <b>Al</b> aluminum 27.0	374 <b>Fr</b> francium 223.0
375 <b>Fr</b> francium 223.0	376 <b>Sc</b> scandium 45.0	377 <b>Al</b> aluminum 27.0	378 <b>Fr</b> francium 223.0
379 <b>Fr</b> francium 223.0	380 <b>Sc</b> scandium 45.0	381 <b>Al</b> aluminum 27.0	382 <b>Fr</b> francium 223.0
383 <b>Fr</b> francium 223.0	384 <b>Sc</b> scandium 45.0	385 <b>Al</b> aluminum 27.0	386 <b>Fr</b> francium 223.0
387 <b>Fr</b> francium 223.0	388 <b>Sc</b> scandium 45.0	389 <b>Al</b> aluminum 27.0	390 <b>Fr</b> francium 223.0
391 <b>Fr</b> francium 223.0	392 <b>Sc</b> scandium 45.0	393 <b>Al</b> aluminum 27.0	394 <b>Fr</b> francium 223.0
395 <b>Fr</b> francium 223.0	396 <b>Sc</b> scandium 45.0	397 <b>Al</b> aluminum 27.0	398 <b>Fr</b> francium 223.0
3			

## General information

Physical constant	Symbol	Value and units
Acceleration of free fall	$g$	$9.81 \text{ m s}^{-2}$
Avogadro constant	$N_A$	$6.02 \times 10^{23} \text{ mol}^{-1}$
Elementary charge	$e$	$1.60 \times 10^{-19} \text{ C}$
Electron rest mass	$m_e$	$9.11 \times 10^{-31} \text{ kg}$
Neutron rest mass	$m_n$	$1.675 \times 10^{-27} \text{ kg}$
Planck constant	$h$	$6.63 \times 10^{-34} \text{ Js}$
Proton rest mass	$m_p$	$1.673 \times 10^{-27} \text{ kg}$
Specific heat capacity of water	$c$	$4180 \text{ J kg}^{-1} \text{ }^{\circ}\text{C}^{-1}$
Speed of light in a vacuum	$c$	$3.00 \times 10^8 \text{ m s}^{-1}$
Molar gas volume (at room temperature and pressure, RTP)	$V_m$	$24.0 \text{ dm}^3 \text{ mol}^{-1}$
Euler's number	$e$	2.718

Conversion factors:  $1 \text{ eV} = 1.60 \times 10^{-19} \text{ J}$

## Mathematical Equations

Circumference of circle =  $2\pi r$

Area of circle =  $\pi r^2$

Curved surface area of cylinder =  $2\pi r h$

Surface area of sphere =  $4\pi r^2$

Area of trapezium =  $\frac{1}{2} (a + b)h$

Volume of cylinder =  $\pi r^2 h$

Volume of sphere =  $\frac{4}{3}\pi r^3$

## Formulae and relationships for Unit F180

B1 Cell structure and microscopy	
Total magnification = magnification of objective lens $\times$ magnification of eyepiece lens	$M_T = M_O \times M_E$
Magnification = $\frac{\text{observed size}}{\text{actual size}}$	

B4 Biodiversity and ecosystems	
Percentage efficiency = $\frac{\text{useful energy transferred}}{\text{total energy transferred}} \times 100\%$	

<b>C1 Atomic Structure and the Periodic Table</b>	
Relative atomic mass = $\sum \frac{(\text{isotope mass} \times \text{isotope abundance})}{100}$	

<b>C2 Amount of substance</b>	
Amount of substance = $\frac{\text{mass of substance}}{\text{molar mass}}$	$n = \frac{m}{M}$
Concentration = $\frac{\text{amount of solute}}{\text{volume}}$	$c = \frac{n}{V}$
Concentration = $\frac{\text{mass of solute}}{\text{volume}}$	$c = \frac{m}{V}$
Amount of gas = $\frac{\text{volume of gas}}{24}$	$n = \frac{V}{24}$

<b>C4 Rates of Reaction and Enthalpy Changes</b>	
Thermal energy = mass $\times$ specific heat capacity $\times$ change in temperature	$Q = mc\Delta\theta$

<b>P1 Electricity</b>	
Charge = current $\times$ time	$Q = It$
Potential difference = current $\times$ resistance	$V = IR$
Power = current $\times$ potential difference	$P = IV$
Power = (current) <sup>2</sup> $\times$ resistance	$P = I^2R$
Power = $\frac{(\text{potential difference})^2}{\text{resistance}}$	$P = \frac{V^2}{R}$
Work done = potential difference $\times$ current $\times$ time	$W = VIt$
Work done = potential difference $\times$ charge	$W = VQ$
Total resistance in series = resistance of resistor 1 + resistance of resistor 2 + ...	$R_T = R_1 + R_2 + \dots$
$\frac{1}{\text{Total resistance in parallel}} = \frac{1}{\text{Resistance of resistor 1}} + \frac{1}{\text{Resistance of resistor 2}} + \dots$	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$

<b>P2 Forces &amp; Motion</b>	
Work done = force $\times$ displacement	$W = Fs$
Work done = force $\times$ displacement $\times \cos\theta$	$W = Fs \cos\theta$
Kinetic energy = $\frac{1}{2} \times \text{mass} \times (\text{velocity})^2$	$E = \frac{1}{2}mv^2$
Gravitational potential energy = mass $\times$ acceleration of free fall $\times$ height	$E = mg\Delta h$
Elastic potential energy = $\frac{1}{2} \times \text{force} \times \text{extension} = \frac{1}{2} \times \text{spring constant} \times (\text{extension})^2$	$E = \frac{1}{2}Fx$ $= \frac{1}{2}kx^2$
Power = $\frac{\text{work done}}{\text{time}}$	$P = \frac{W}{t}$
Efficiency = $\frac{\text{useful energy transferred}}{\text{total energy transferred}}$	
Net force = mass $\times$ acceleration	$F = ma$
Average velocity = $\frac{\text{displacement}}{\text{time taken}}$	$v = \frac{s}{t}$
Acceleration = $\frac{\text{final velocity} - \text{initial velocity}}{\text{time taken}}$	$a = \frac{v - u}{t}$
Final velocity = initial velocity + (acceleration $\times$ time taken)	$v = u + at$
Displacement = $\frac{1}{2} (\text{initial velocity} + \text{final velocity}) \times \text{time taken}$	$s = \frac{1}{2}(u + v)t$
Displacement = $(\text{initial velocity} \times \text{time taken}) + (\frac{1}{2} \times \text{acceleration} \times \text{time taken}^2)$	$s = ut + \frac{1}{2}at^2$
Final velocity <sup>2</sup> = initial velocity <sup>2</sup> + $2 \times \text{acceleration} \times \text{displacement}$	$v^2 = u^2 + 2as$

<b>P3.1 Medical Physics</b>	
Energy of a photon = Planck constant $\times$ frequency	$E = hf$
Energy of a photon = $\frac{\text{Planck constant} \times \text{speed of light in a vacuum}}{\text{wavelength}}$	$E = \frac{hc}{\lambda}$
Intensity of emergent beam = intensity of incident beam $\times e^{-\text{linear attenuation coefficient} \times \text{distance travelled through the medium}}$	$I = I_0 e^{-\mu x}$
Mass attenuation coefficient = $\frac{\text{linear attenuation coefficient}}{\text{density of medium}}$	$\mu_m = \frac{\mu}{\rho}$
Density = $\frac{\text{mass}}{\text{volume}}$	$\rho = \frac{m}{V}$

Frequency = $\frac{1}{\text{time period}}$	$f = \frac{1}{T}$
Wave speed = frequency $\times$ wavelength	$v = f\lambda$
Intensity = $\frac{\text{power}}{\text{area}}$	$I = \frac{P}{A}$
Acoustic impedance = density of medium $\times$ speed of sound in the medium	$Z = \rho c$
Intensity reflection coefficient = $\frac{\text{intensity of reflected wave}}{\text{intensity of incident wave}}$	$\alpha = \frac{I_r}{I_0}$
Intensity reflection coefficient = $(\frac{\text{acoustic impedance of second medium}}{\text{acoustic impedance of initial medium}} - \frac{\text{acoustic impedance of initial medium}}{\text{acoustic impedance of second medium}} + \text{acoustic impedance of initial medium})^2$	$\alpha = \left( \frac{Z_2 - Z_1}{Z_2 + Z_1} \right)^2$

<b>P3.2 Radioactivity</b>	
Physical half-life = $\frac{0.693}{\text{radioactive decay constant}}$	$t_{\frac{1}{2}} = \frac{0.693}{\lambda}$
$\frac{1}{\text{effective half-life}} = \frac{1}{\text{physical half-life}} + \frac{1}{\text{biological half-life}}$	$\frac{1}{t_E} = \frac{1}{t_1} + \frac{1}{t_B}$
Activity = radioactive decay constant $\times$ number of undecayed nuclei	$A = \lambda N$
Number of undecayed nuclei = initial number of undecayed nuclei $\times e^{-\text{radioactive decay constant} \times \text{time}}$	$N = N_0 e^{-\lambda t}$
Activity = initial activity $\times e^{-\text{radioactive decay constant} \times \text{time}}$	$A = A_0 e^{-\lambda t}$

Some aspects of this document may not be fully accessible. If you have any problems with the accessibility of this format, please [contact us](#).

**Contact the team at:**

- 📞 **01223 553998**
- ✉️ **science@ocr.org.uk**
- 🌐 **ocr.org.uk**
- FACEBOOK **facebook.com/ocrexams**
- TWITTER **@OCR\_science**
- INSTAGRAM **instagram.com/ocrexaminations**
- LINKEDIN **linkedin.com/company/ocr**
- YOUTUBE **youtube.com/ocrexams**

To stay up to date with all the relevant news about our qualifications, register for email updates at **ocr.org.uk/updates**

Visit our Online Support Centre at **support.ocr.org.uk**



OCR is part of Cambridge University Press & Assessment, a department of the University of Cambridge.

For staff training purposes and as part of our quality assurance programme your call may be recorded or monitored. ©OCR 2024 Oxford Cambridge and RSA Examinations is a Company Limited by Guarantee. Registered in England. Registered office The Triangle Building, Shaftesbury Road, Cambridge, CB2 8EA. Registered company number 3484466. OCR is an exempt charity.

OCR operates academic and vocational qualifications regulated by Ofqual, Qualifications Wales and CCEA as listed in their qualifications registers including A Levels, GCSEs, Cambridge Technicals and Cambridge Nationals.

Cambridge University Press & Assessment is committed to making our documents accessible in accordance with the WCAG 2.1 Standard. We're always looking to improve the accessibility of our documents. If you find any problems or you think we're not meeting accessibility requirements, please [contact us](#).

OCR acknowledges the use of the icons by appleuzr, sourced from [gettyimages.co.uk](#).