Accredited

TWENTY FIRST CENTURY SCIENCE SUITE

GCSE FURTHER ADDITIONAL SCIENCE A

ACCREDITED SPECIFICATION

J246

VERSION 1

JULY 2013

WELCOME TO GCSE SCIENCES

THOUSANDS OF TEACHERS ALREADY UNLEASH THE JOY OF SCIENCE WITH OCR.

A FEW GOOD REASONS TO WORK WITH OCR

- You can enjoy the **freedom and excitement** of teaching science qualifications which have been developed to help you inspire students of all abilities.
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- Our **clear and sensible assessment** approach means that exam papers and requirements are clearly presented and sensibly structured for you and your students.
- **Pathways for choice** – we have the broadest range of science qualifications and our GCSEs provide an ideal foundation for students to progress to more advanced studies and science-related careers.
- **Working in partnership to support you** – together with teachers we've developed a range of practical help and support to save you time. We provide everything you need to teach our specifications with confidence and ensure your students get as much as possible from our qualifications.
- **A personal service** – as well as providing you with lots of support resources, we're also here to help you with specialist advice, guidance and support for those times when you simply need a more individual service.

HERE'S HOW TO CONTACT US FOR SPECIALIST ADVICE:

Phone: 01223 553998

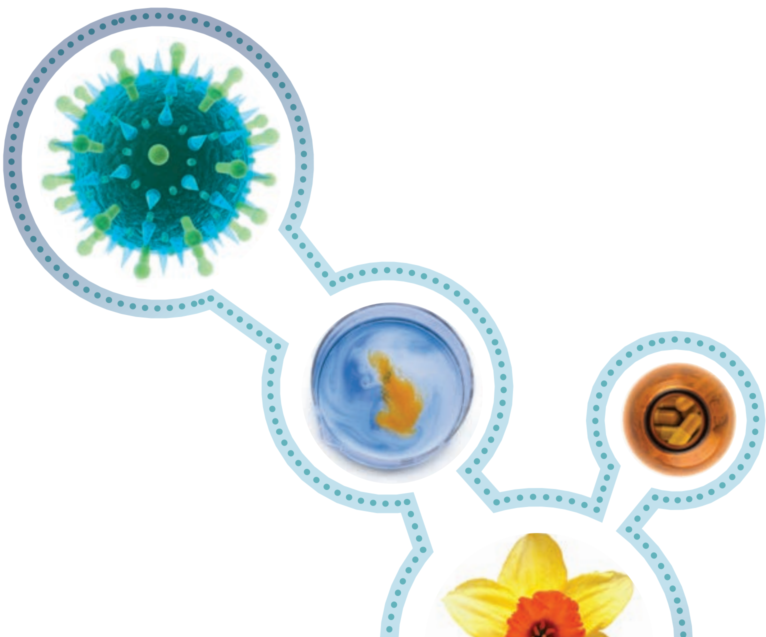
Email: science@ocr.org.uk

Online: http://answers.ocr.org.uk

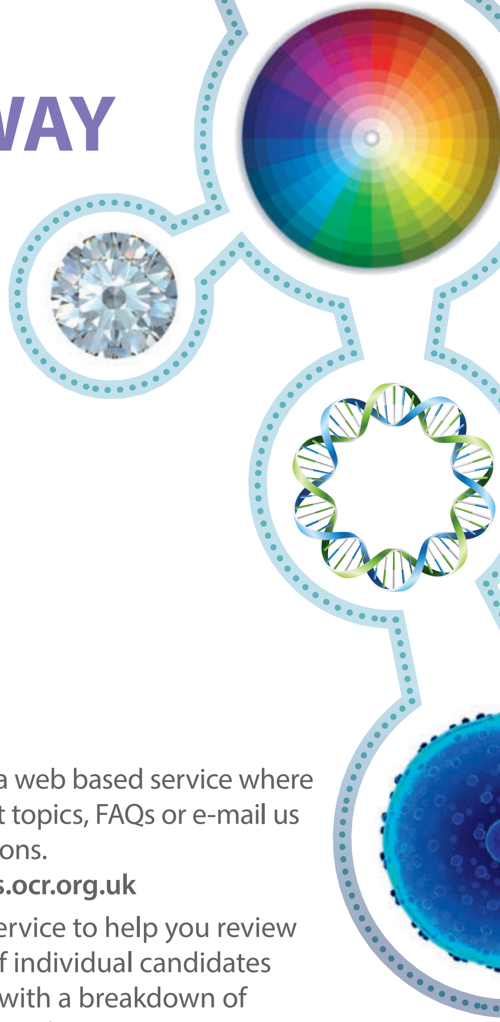
Fax: 01223 552627

Post: Customer Contact Centre, OCR, Progress House, Westwood Business Park, Coventry CV4 8JQ

DON'T FORGET
– you can download a copy of this specification and all our support materials at
ocr.org.uk/science



SUPPORTING YOU ALL THE WAY



Our aim is to help you at every stage and we work in close consultation with teachers and other experts, to provide a practical package of high quality resources and support.

Our support materials are designed to save you time while you prepare for and teach our new specifications. In response to what you have told us we are offering detailed guidance on key topics and controlled assessment.

Our essential FREE support includes:

Materials

- Specimen assessment materials and mark schemes
- Guide to controlled assessment
- Sample controlled assessment material
- Exemplar candidate work
- Marking commentaries
- Teacher's handbook
- Sample schemes of work and lesson plans
- Frequently asked questions
- Past papers.

You can access all of our support at:
ocr.org.uk/science

Science Community

Join our social network at **social.ocr.org.uk** where you can start discussions, ask questions and upload resources.

Services

- **Answers @ OCR –** a web based service where you can browse hot topics, FAQs or e-mail us with specific questions.
  Visit **http://answers.ocr.org.uk**
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- **Local cluster support networks** – supported by OCR, you can join our local clusters of centres who offer each other mutual support.

Endorsed publisher partner materials

We're working closely with our publisher partner Oxford University Press to ensure effective delivery of endorsed materials when you need them.
Find out more at: **twentyfirstcenturyscience.org**

TWENTY FIRST CENTURY SCIENCE SUITE

Science today – for scientists of tomorrow

Explore the science that underpins day-to-day life. Enthuse and motivate students using a mix of teaching strategies.

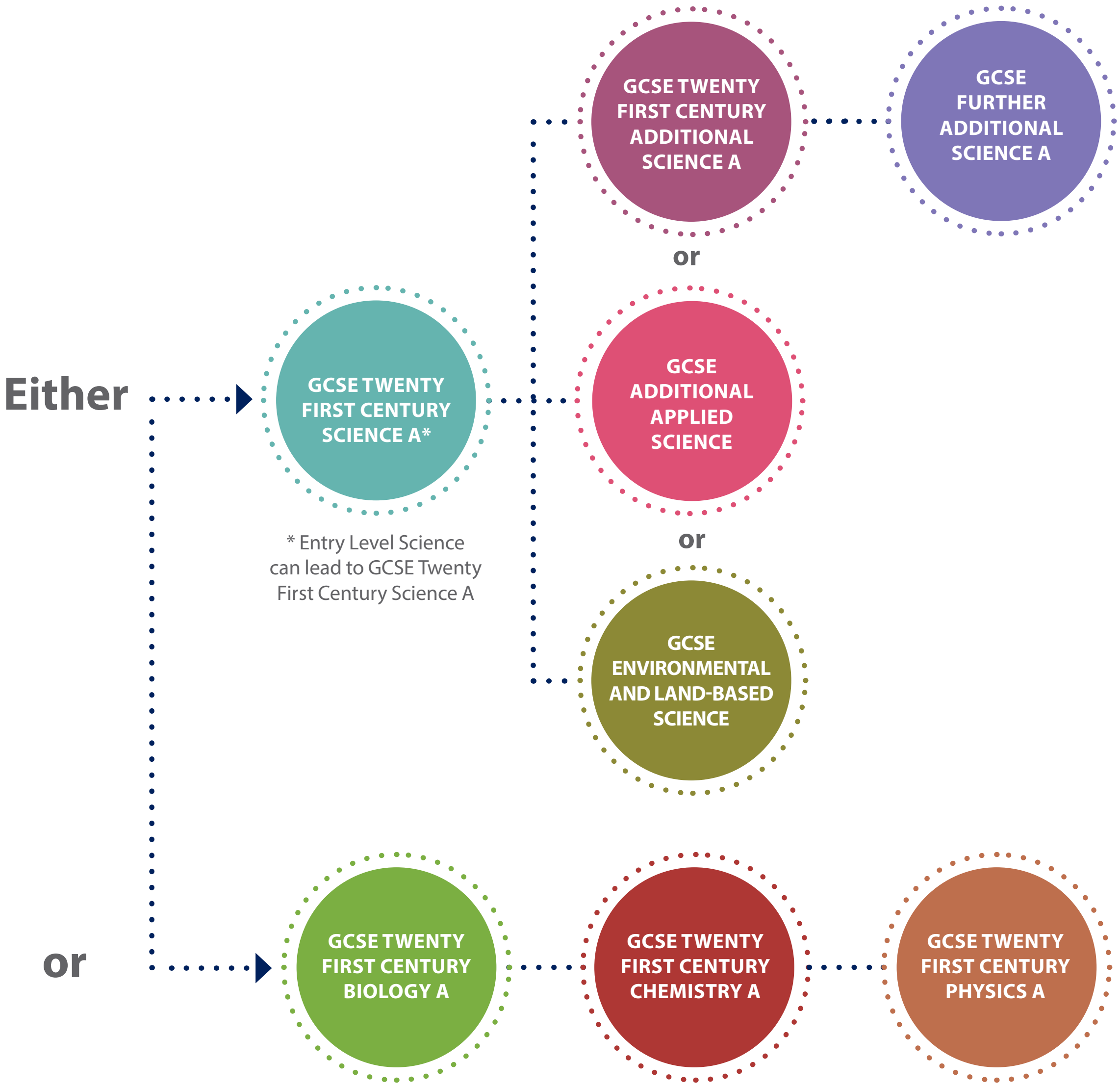
Our Twenty First Century Science suite:

- is engaging to study and motivating for you to teach
- will help your learners engage with the course rather than just study it
- gives you the flexibility to choose a delivery style to engage students.

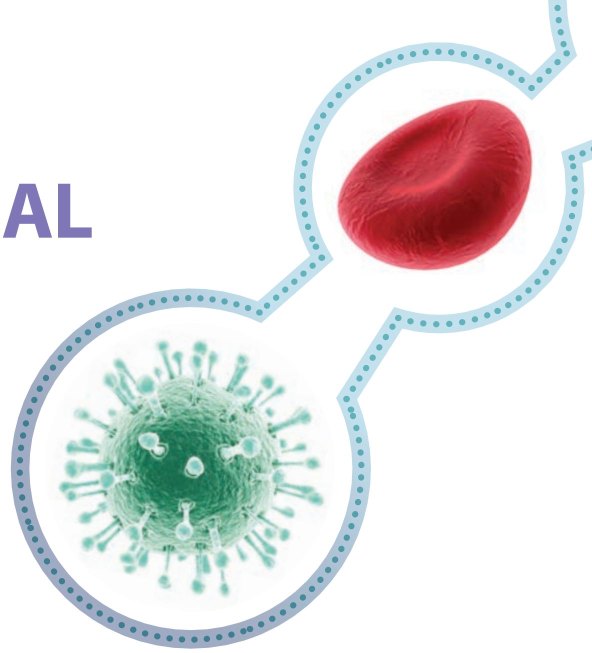
KEY FEATURES

- **How Science Works**, fully integrated into teaching and assessment.
- An **ideal foundation** for students to progress to more-advanced studies and science-related careers.
- A well regarded and proven **concept led** teaching approach to science.

POSSIBLE GCSE COMBINATIONS



GCSE FURTHER ADDITIONAL SCIENCE A



KEY FEATURES

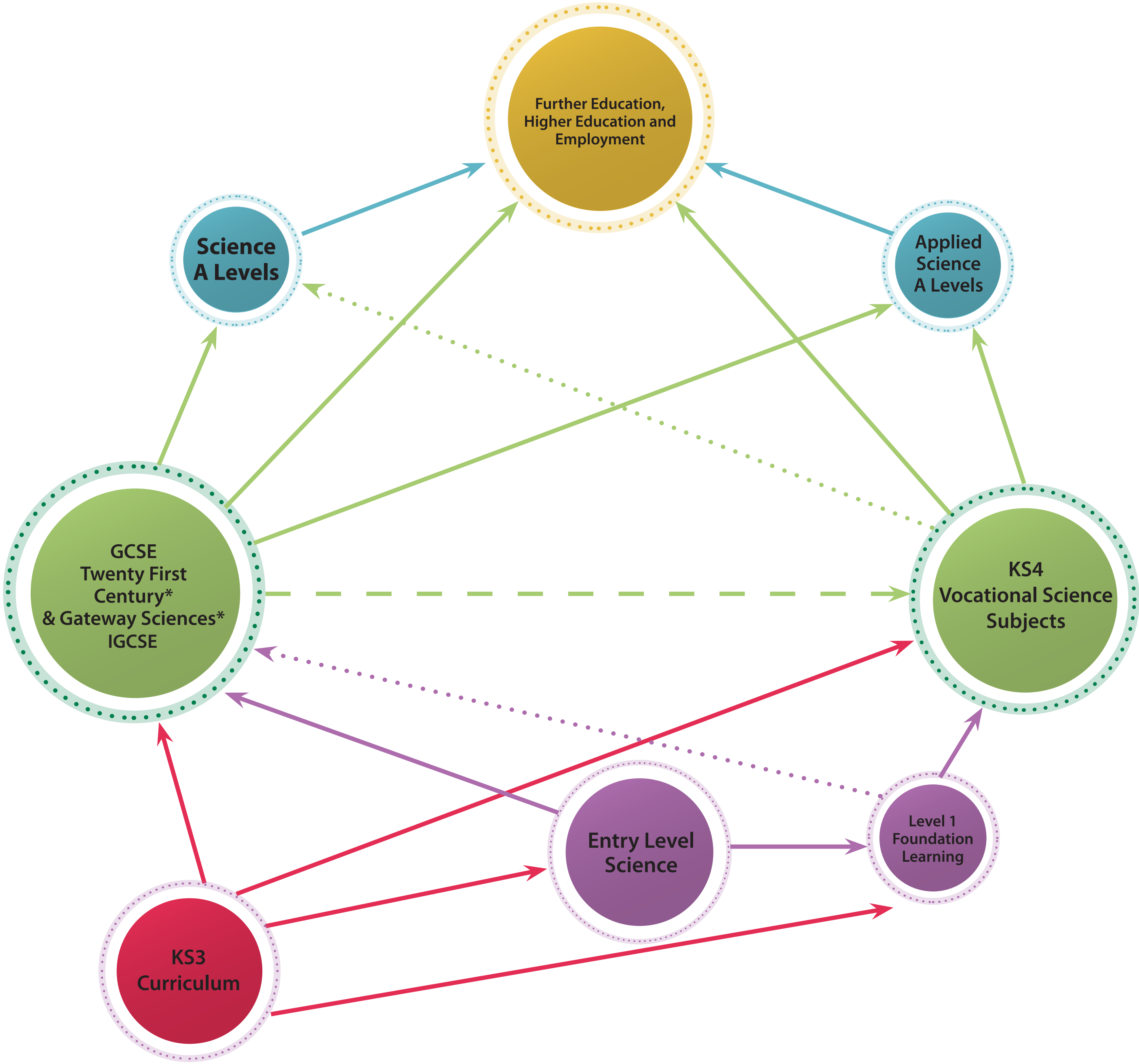
GCSE Further Additional Science A provides the opportunity to:

- develop interest in, and enthusiasm for, biology, chemistry and physics
- develop a critical approach to scientific evidence and methods
- acquire scientific skills, knowledge and understanding necessary for progression to further learning.

GCSE Further Additional Science A provides distinctive and relevant experience for students who wish to progress to Level 3 qualifications.

COURSE OVERVIEW	ASSESSMENT OVERVIEW		
Unit A163 *Module B7: Further biology*	60 marks 1 hour written paper	**25%** of total GCSE	Three written exams, assessed externally by OCR, each of which: • is offered in Foundation and Higher Tiers • uses both objective style and free response questions (there is no choice of questions) • assesses the quality of written communication.
Unit A173 *Module C7: Further chemistry*	60 marks 1 hour written paper	**25%** of total GCSE	
Unit A183 *Module P7: Further physics – studying the Universe*	60 marks 1 hour written paper	**25%** of total GCSE	
Unit A194 *Controlled assessment*	64 marks Approx 4.5–6 hours	**25%** of total GCSE	Comprises a Practical Investigation from a choice set by OCR. Assessed by teachers, internally standardised and externally moderated by OCR. Assesses the quality of written communication.

PROGRESSION PATHWAYS IN SCIENCE



This could be a progression route along a particular curriculum pathway. (Stage, not age pathways)

This could be a progression route however students would require additional support.

Alternative qualification options.

* Offered as
Science, Additional Science, Further Additional Science, Biology, Chemistry and Physics.

Contents

Contents

1 Introduction to the Twenty First Century Science suite

The Twenty First Century Science suite comprises six specifications which share a similar approach to teaching and learning, utilise common materials, use a consistent style of examination questions and have a common approach to skills assessment.

The qualifications available as part of this suite are:

- GCSE Science A
- GCSE Additional Science A
- GCSE Further Additional Science A
- GCSE Biology A
- GCSE Chemistry A
- GCSE Physics A.

GCSE Science A (J241)	which emphasises scientific literacy – the knowledge and understanding which candidates need to engage, as informed citizens, with science-based issues. As with other courses in the suite, this qualification uses contemporary, relevant contexts of interest to candidates, which can be approached through a range of teaching and learning activities.
GCSE Additional Science A (J242)	which is a concept-led course developed to meet the needs of candidates seeking a deeper understanding of basic scientific ideas. The course focuses on scientific explanations and models, and gives candidates an insight into how scientists develop scientific understanding of ourselves and the world we inhabit.
GCSE Further Additional Science A (J246)	which provides an opportunity for further developing an understanding of science explanations, with particular relevance for students who wish to progress to Level 3 qualifications.
GCSE Biology A (J243)	each of which provides an opportunity for further developing an understanding of science explanations, how science works and the study of elements of applied science, with particular relevance to professional scientists.
GCSE Chemistry A (J244)	
GCSE Physics A (J245)	

The suite emphasises explanations, theories and modelling in science along with the implications of science for society. Strong emphasis is placed on the active involvement of candidates in the learning process and each specification encourages a wide range of teaching and learning activities.

The suite is supported by the Nuffield Foundation Curriculum Programme and The University of York Science Education Group, and by resources published by Oxford University Press.

In addition, an Additional Applied Science course (J251) is available. This can be used in conjunction with Science A for candidates not following GCSE Additional Science A.

Introduction to GCSE Further Additional Science A

2.1 Overview of GCSE Further Additional Science A

Unit A163: ***Biology A** Module B7*	
This is a tiered unit offered in Foundation and Higher Tiers.	Written paper 1 hour 60 marks 25% of the qualification Candidates answer all questions. The unit uses both objective style and free response questions.

+

Unit A173: ***Chemistry A** Module C7*	
This is a tiered unit offered in Foundation and Higher Tiers.	Written paper 1 hour 60 marks 25% of the qualification Candidates answer all questions. The unit uses both objective style and free response questions.

+

Unit A183: ***Physics A** Module P7*	
This is a tiered unit offered in Foundation and Higher Tiers.	Written paper 1 hour 60 marks 25% of the qualification Candidates answer all questions. The unit uses both objective style and free response questions.

+

Unit A194: ***Further Additional Science A** Controlled assessment*	
This unit is not tiered.	Controlled assessment Approximately 4.5–6 hours 64 marks 25% of the qualification

2.2 Guided learning hours

GCSE Further Additional Science A requires 120–140 guided learning hours in total.

2.3 Aims and learning outcomes

The aims of this specification are to enable candidates to:

- develop their knowledge and understanding of biology, chemistry and physics
- develop their understanding of the effects of biology, chemistry and physics on society
- develop an understanding of the importance of scale in biology, chemistry and physics
- develop and apply their knowledge and understanding of the nature of science and of the scientific process
- develop their understanding of the relationships between hypotheses, evidence, theories and explanations
- develop their awareness of risk and the ability to assess potential risk in the context of potential benefits
- develop and apply their observational, practical, modelling, enquiry and problem-solving skills and understanding in laboratory, field and other learning environments
- develop their ability to evaluate claims based on science through critical analysis of the methodology, evidence and conclusions both qualitatively and quantitatively
- develop their skills in communication, mathematics and the use of technology in scientific contexts.

2.4 Prior learning

Candidates entering this course should have achieved a general educational level equivalent to National Curriculum Level 3, or an Entry 3 at Entry Level within the National Qualifications Framework.

Content of GCSE Further Additional Science A

3.1 Summary of content

A module defines the required teaching and learning outcomes.

The specification content is displayed as three modules. The titles of these three modules are listed below.

Modules B7, C7 and P7 are designed to be taught in approximately **one and a half terms each**, at 10% curriculum time.

Module B7: Further Biology		
• Peak performance – movement and exercise. • Peak performance – circulation.	• Peak performance – energy balance. • What can we learn from natural ecosystems?	• New technologies.
Module C7: Further Chemistry		
• Green chemistry • Alcohols, carboxylic acids and esters.	• Energy changes in chemistry. • Reversible reactions and equilibria.	• Analysis.
Module P7: Further Physics – Studying the Universe		
• Naked eye astronomy. • Light, telescopes and images.	• Mapping the Universe. • The Sun, the stars and their surroundings.	• The astronomy community.

3.2 Layout of specification content

The specification content is divided into three modules that, together with Ideas about Science (see Section 3.3), are assessed across three written papers (Units A163, A173 and A183) and one unit of controlled assessment (Unit A194).

Section 3.3 describes the Ideas about Science and what candidates will need to understand and be able to do. The Ideas about Science are assessed across all units.

Sections 3.4, 3.5 and 3.6 summarise the three written paper units, A163, A173 and A183, and the associated content that can be assessed within them. Within each of these sections, a brief summary of the unit precedes the detailed description of the modules that are assessed within that unit.

Each module starts with an overview that explains the background to the module and identifies:

- a summary of the topics
- opportunities for mathematics
- opportunities for practical work
- opportunities for ICT
- examples of Ideas about Science for which there are particular opportunities for introduction or development.

Following the module overview, the module content is presented in detail.

Within the detailed content of each module, several notations are used to give teachers additional information about the assessment. The table below summarises these notations.

Notation	Explanation
Bold	**These content statements will only be assessed on Higher Tier papers.**
ⓘ	*Advisory notes for teachers to clarify depth of coverage required.*

3.3 Ideas about Science

This specifications within the Twenty First Century Science suite are unique in having interpreted and extrapolated the principles of 'How Science Works' into a series of 'Ideas about Science'. It is intended that the Ideas about Science will ensure students understand how scientific knowledge is obtained, how it is reported in the world outside the classroom, and the impacts of scientific knowledge on society.

GCSE Further Additional Science A aims to develop students' understanding of the Ideas about Science alongside their growing understanding of scientific ideas and explanations of the behaviour of the natural world.

Why are Ideas about Science important?

In order to make sense of the scientific ideas that students encounter in lessons and read or hear about outside of school, they need to develop an understanding of science itself – of how scientific knowledge is obtained, the kinds of evidence and reasoning behind it, its strengths and limitations, and how far we can therefore rely on it. They also need opportunities to reflect on the impacts of scientific knowledge on society, and how we respond individually and collectively to the new ideas, artefacts and processes that science makes possible.

Reports of scientific claims, inventions and discoveries are prolific in the media of the twenty first century, and an understanding of the Ideas about Science will ensure that students are well-equipped to critically evaluate the science stories they read and hear.

The kind of understanding of science that we would wish students to have by the end of their school science education might be summarised as follows:

How science works

The aim of science is to find explanations for the behaviour of the material world. There is no single 'method of science' that leads automatically to scientific knowledge. Scientists do, however, have characteristic ways of working. In particular, data from observations and measurements are of central importance. All data, however, have to be interpreted, and this is influenced by the ideas we bring to it. Scientific explanations do not 'emerge' automatically from data. Proposing an explanation involves creative thinking. So, it is quite possible (and may be quite reasonable) for different people to arrive at different explanations for the same data.

Causes and effects

Scientists often look for cause-effect explanations. The first step is to identify a correlation between a factor and an outcome. The factor may then be the cause, or one of the causes, of the outcome. In many situations, a factor may not always lead to the outcome, but increases the chance (or the risk) of it happening. In order to claim that the factor causes the outcome we need to identify a process or mechanism that might account for the observed correlation.

Theories, explanations and predictions

A scientific theory is a general explanation that applies to a large number of situations or examples (perhaps to all possible ones),which has been tested and used successfully, and is widely accepted by scientists. A scientific theory might propose a model involving objects (and their behaviour) that cannot be observed directly, to account for what we observe. Or it might define quantities and ways of measuring them, and state some mathematical relationships between them.

A scientific explanation of a specific event or phenomenon is often based on applying a scientific theory (or theories) to the situation in question.

A proposed scientific explanation (whether it is a very general scientific theory or a more specific explanation) is tested by comparing predictions based on it with observations or measurements. If these agree, it increases our confidence that the explanation might be correct. This can never be conclusively proved, but accumulating evidence can bring us to the point where it is hard to imagine any other possible explanation. If prediction and data disagree, then one or the other must be wrong. Data can never be relied on completely because observations may be incorrect and all measurements are subject to uncertainty, arising from the inevitable limitations of the measuring equipment or the person using it. If we believe the data are accurate, then the prediction must be wrong, lowering our confidence in the proposed explanation.

Science and scientists

The scientific community has established robust procedures for testing and checking the claims of individual scientists, and reaching an agreed view. Scientists report their findings to other scientists at conferences and in peer-reviewed journals. Claims are not accepted until they have survived the critical scrutiny of the scientific community. In some areas of enquiry, it has proved possible to eliminate all the explanations we can think of but one – which then becomes the accepted explanation (until, if ever, a better one is proposed).

Where possible, scientists choose to study simple situations in order to gain understanding. This, however, can make it difficult to apply this understanding to complex, real-world situations. So there can be legitimate disagreements about scientific explanations of particular phenomena or events, even though there is no dispute about the fundamental scientific knowledge involved.

Science and society

The application of scientific knowledge, in new technologies, materials and devices, greatly enhances our lives, but can also have unintended and undesirable side-effects. Often we need to weigh up the benefits against the disadvantages – and also consider who gains and who loses. An application of science may have social, economic and political implications, and sometimes also ethical ones. Personal and social decisions require an understanding of the science involved, but also involve knowledge and values that go beyond science.

How can Ideas about Science be developed in teaching?

Within this Section all of the Ideas about Science are listed together, in an order that shows clearly how they relate to one another and build up the understanding of science that we would like students to develop.

In addition to this Section, specific Ideas about Science are identified at the start of each module within the specification, to indicate that there are good opportunities within the content of the module to introduce and develop them. The OCR scheme of work for GCSE Further Additional Science A (published separately) will also highlight teaching opportunities for specific Ideas about Science.

What are the Ideas about Science?

The following pages set out in detail the Ideas about Science and what candidates should be able to do to demonstrate their understanding of them. The statements in the left-hand column specify the understandings candidates are expected to develop; the entries in the right-hand column are suggestions about some of the ways in which evidence of their understanding can be demonstrated.

How are the Ideas about Science assessed?

All Ideas about Science can be assessed in all units of assessment. Those that will only be assessed in Higher Tier papers are indicated in **bold**.

In order to assist with curriculum planning, Ideas about Science that could be linked to each module are suggested in the overview of each module (see Sections 3.4, 3.5 and 3.6). Taking all of the modules together, suggested links to **all** of the Ideas about Science are identified in this way. However, it is not intended that understanding and application of the Ideas about Science should be limited to any particular context, so these links are provided as suggestions only. There is freedom to develop links between modules and the Ideas about Science in any way, providing that all have been covered prior to assessment.

1 Data: their importance and limitations

Data are the starting point for scientific enquiry – and the means of testing scientific explanations. But data can never be trusted completely, and scientists need ways of evaluating how good their data are.

	Candidates should understand that:	A candidate who understands this can, for example:
1.1	• data are crucial to science. The search for explanations starts from data; and data are collected to test proposed explanations.	• use data rather than opinion if asked to justify an explanation • outline how a proposed scientific explanation has been (or might be) tested, referring appropriately to the role of data.
1.2	• we can never be sure that a measurement tells us the true value of the quantity being measured.	• suggest reasons why a given measurement may not be the true value of the quantity being measured.
1.3	• if we make several measurements of any quantity, these are likely to vary.	• suggest reasons why several measurements of the same quantity may give different values • when asked to evaluate data, make reference to its repeatability **and/or reproducibility**.
1.4	• the mean of several repeat measurements is a good estimate of the true value of the quantity being measured.	• calculate the mean of a set of repeated measurements • from a set of repeated measurements of a quantity, use the mean as the best estimate of the true value • explain why repeating measurements leads to a better estimate of the quantity.
1.5	• from a set of repeated measurements of a quantity, it is possible to estimate a range within which the true value probably lies.	• from a set of repeated measurements of a quantity, make a sensible suggestion about the range within which the true value probably lies **and explain this** • **when discussing the evidence that a quantity measured under two different conditions has (or has not) changed, make appropriate reference both to the difference in means and to the variation within each set of measurements.**
1.6	• if a measurement lies well outside the range within which the others in a set of repeats lie, or is off a graph line on which the others lie, this is a sign that it may be incorrect. If possible, it should be checked. If not, it should be used unless there is a specific reason to doubt its accuracy.	• identify any outliers in a set of data • treat an outlier as data unless there is a reason for doubting its accuracy • **discuss and defend the decision to discard or to retain an outlier.**

2 Cause-effect explanations

Scientists look for patterns in data, as a means of identifying correlations that might suggest possible cause-effect links – for which an explanation might then be sought.

	Candidates should understand that:	A candidate who understands this can, for example:
2.1	• it is often useful to think about processes in terms of factors which may affect an outcome (or input variables which may affect an outcome variable).	• in a given context, identify the outcome and factors that may affect it • in a given context, suggest how an outcome might alter when a factor is changed.
2.2	• to investigate the relationship between a factor and an outcome, it is important to control all the other factors which we think might affect the outcome (a so-called 'fair test').	• identify, in a plan for an investigation of the effect of a factor on an outcome, the fact that other factors are controlled as a positive design feature, or the fact that they are not as a design flaw • explain why it is necessary to control all the factors that might affect the outcome other than the one being investigated.
2.3	• if an outcome occurs when a specific factor is present, but does not when it is absent, or if an outcome variable increases (or decreases) steadily as an input variable increases, we say that there is a correlation between the two.	• suggest and explain an example from everyday life of a correlation between a factor and an outcome • identify where a correlation exists when data are presented as text, as a graph, or in a table. ⓘ *Examples may include both positive and negative correlations, but candidates will not be expected to know these terms.*
2.4	• a correlation between a factor and an outcome does not necessarily mean that the factor causes the outcome; both might, for example, be caused by some other factor.	• use the ideas of correlation and cause when discussing data and show awareness that a correlation does not necessarily indicate a causal link • identify, and suggest from everyday experience, examples of correlations between a factor and an outcome where the factor is (or is not) a plausible cause of the outcome • explain why an observed correlation between a given factor and outcome does not necessarily mean that the factor causes the outcome.
2.5	• in some situations, a factor alters the chance (or probability) of an outcome, but does not invariably lead to it. We also call this a correlation.	• suggest factors that might increase the chance of a particular outcome in a given situation, but do not invariably lead to it • explain why individual cases do not provide convincing evidence for or against a correlation.

	Candidates should understand that:	A candidate who understands this can, for example:
2.6	• to investigate a claim that a factor increases the chance (or probability) of an outcome, scientists compare samples (e.g. groups of people) that are matched on as many other factors as possible, or are chosen randomly so that other factors are equally likely in both samples. The larger the samples, the more confident we can be about any conclusions drawn.	• discuss whether given data suggest that a given factor does/does not increase the chance of a given outcome • evaluate critically the design of a study to test if a given factor increases the chance of a given outcome, by commenting on sample size and how well the samples are matched.
2.7	• **even when there is evidence that a factor is correlated with an outcome, scientists are unlikely to accept that it is a cause of the outcome, unless they can think of a plausible mechanism linking the two.**	• **identify the presence (or absence) of a plausible mechanism as reasonable grounds for accepting (or rejecting) a claim that a factor is a cause of an outcome.**

3 Developing scientific explanations

The aim of science is to develop good explanations for natural phenomena. Initially, an explanation is a hypothesis that might account for the available data. As more evidence becomes available, it may become an accepted explanation or theory. Scientific explanations and theories do not 'emerge' automatically from data, and cannot be deduced from the data. Proposing an explanation or theory involves creative thinking. It can then be tested – by comparing its predictions with data from observations or measurements.

	Candidates should understand that:	A candidate who understands this can, for example:
3.1	• scientific hypotheses, explanations and theories are not simply summaries of the available data. They are based on data but are distinct from them.	• in a given account of scientific work, identify statements which report data and statements of explanatory ideas (hypotheses, explanations, theories) • recognise that an explanation may be incorrect even if the data agree with it.
3.2	• an explanation cannot simply be deduced from data, but has to be thought up creatively to account for the data.	• identify where creative thinking is involved in the development of an explanation.
3.3	• a scientific explanation should account for most (ideally all) of the data already known. It may explain a range of phenomena not previously thought to be linked. It should also enable predictions to be made about new situations or examples.	• recognise data or observations that are accounted for by, or conflict with, an explanation • give good reasons for accepting or rejecting a proposed scientific explanation • identify the better of two given scientific explanations for a phenomenon, and give reasons for the choice.
3.4	• scientific explanations are tested by comparing predictions based on them with data from observations or experiments.	• draw valid conclusions about the implications of given data for a given scientific explanation, in particular: — understand that agreement between a prediction and an observation increases confidence in the explanation on which the prediction is based but does not prove it is correct — understand that disagreement between a prediction and an observation indicates that one or the other is wrong, and decreases our confidence in the explanation on which the prediction is based.

4 The scientific community

Findings reported by an individual scientist or group are carefully checked by the scientific community before being accepted as scientific knowledge.

	Candidates should understand that:	A candidate who understands this can, for example:
4.1	• scientists report their claims to other scientists through conferences and journals. Scientific claims are only accepted once they have been evaluated critically by other scientists.	• describe in broad outline the 'peer review' process, in which new scientific claims are evaluated by other scientists • recognise that there is less confidence in new scientific claims that have not yet been evaluated by the scientific community than there is in well-established ones.
4.2	• scientists are usually sceptical about claims that cannot be repeated by anyone else, and about unexpected findings until they have been replicated (by themselves) or reproduced (by someone else).	• identify the fact that a finding has not been reproduced by another scientist as a reason for questioning a scientific claim • explain why scientists see this as important.
4.3	• if explanations cannot be deduced from the available data, two (or more) scientists may legitimately draw different conclusions about the same data. A scientist's personal background, experience or interests may influence his/her judgments.	• show awareness that the same data might be interpreted, quite reasonably, in more than one way • suggest plausible reasons why scientists in a given situation disagree(d).
4.4	• an accepted scientific explanation is rarely abandoned just because some new data disagree with its predictions. It usually survives until a better explanation is available.	• discuss the likely consequences of new data that disagree with the predictions of an accepted explanation • **suggest reasons why scientists should not give up an accepted explanation immediately if new data appear to conflict with it.**

5 Risk

Every activity involves some risk. Assessing and comparing the risks of an activity, and relating these to the benefits we gain from it, are important in decision making.

	Candidates should understand that:	A candidate who understands this can, for example:
5.1	• everything we do carries a certain risk of accident or harm. Nothing is risk free. New technologies and processes based on scientific advances often introduce new risks.	• explain why it is impossible for anything to be completely safe • identify examples of risks which arise from a new scientific or technological advance • suggest ways of reducing a given risk.
5.2	• we can sometimes assess the size of a risk by measuring its chance of occurring in a large sample, over a given period of time.	• interpret and discuss information on the size of risks, presented in different ways.
5.3	• to make a decision about a particular risk, we need to take account both of the chance of it happening and the consequences if it did.	• discuss a given risk, taking account of both the chance of it occurring and the consequences if it did.
5.4	• to make a decision about a course of action, we need to take account of both its risks and benefits, to the different individuals or groups involved.	• identify risks and benefits in a given situation, to the different individuals and groups involved • discuss a course of action, with reference to its risks and benefits, taking account of who benefits and who takes the risks • suggest benefits of activities that are known to have risk.
5.5	• people are generally more willing to accept the risk associated with something they choose to do than something that is imposed, and to accept risks that have short-lived effects rather than long-lasting ones.	• offer reasons for people's willingness (or reluctance) to accept the risk of a given activity.
5.6	• **people's perception of the size of a particular risk may be different from the statistically estimated risk. People tend to over-estimate the risk of unfamiliar things (like flying as compared with cycling), and of things whose effect is invisible or long-term (like ionising radiation).**	• **distinguish between perceived and calculated risk, when discussing personal choices** • **suggest reasons for given examples of differences between perceived and measured risk.**
5.7	• governments and public bodies may have to assess what level of risk is acceptable in a particular situation. This decision may be controversial, especially if those most at risk are not those who benefit.	• discuss the public regulation of risk, **and explain why it may in some situations be controversial.**

6 Making decisions about science and technology

To make sound decisions about the applications of scientific knowledge, we have to weigh up the benefits and costs of new processes and devices. Sometimes these decisions also raise ethical issues. Society has developed ways of managing these issues, though new developments can pose new challenges to these.

	Candidates should understand that:	A candidate who understands this can, for example:
6.1	• science-based technology provides people with many things that they value, and which enhance the quality of life. Some applications of science can, however, have unintended and undesirable impacts on the quality of life or the environment. Benefits need to be weighed against costs.	• in a particular context, identify the groups affected and the main benefits and costs of a course of action for each group • **suggest reasons why different decisions on the same issue might be appropriate in view of differences in social and economic context.**
6.2	• scientists may identify unintended impacts of human activity (including population growth) on the environment. They can sometimes help us to devise ways of mitigating this impact and of using natural resources in a more sustainable way.	• identify, and suggest, examples of unintended impacts of human activity on the environment • explain the idea of sustainability, and apply it to specific situations • use data (for example, from a Life Cycle Assessment) to compare the sustainability of alternative products or processes.
6.3	• in many areas of scientific work, the development and application of scientific knowledge are subject to official regulations.	• in contexts where this is appropriate, show awareness of, **and discuss**, the official regulation of scientific research and the application of scientific knowledge.
6.4	• some questions, such as those involving values, cannot be answered by science.	• distinguish questions which could in principle be answered using a scientific approach, from those which could not.
6.5	• some forms of scientific research, and some applications of scientific knowledge, have ethical implications. People may disagree about what should be done (or permitted).	• where an ethical issue is involved: — say clearly what this issue is — summarise different views that may be held.
6.6	• in discussions of ethical issues, one common argument is that the right decision is one which leads to the best outcome for the greatest number of people involved. Another is that certain actions are considered right or wrong whatever the consequences.	• in a given context, identify, **and develop**, arguments based on the ideas that: — the right decision is the one which leads to the best outcome for the greatest number of people involved — certain actions are considered right or wrong whatever the consequences.

3.4 Summary of Unit A163: *Biology A Module B7*

Unit A163 is the unit within GCSE Further Additional Science A where the biology content is assessed. It assesses the content of *Module B7* together with the Ideas about Science.

Unit A163 includes content to enhance progression and to give a greater understanding of the subjects concerned. This unit continues the emphasis on 'science for the scientist' in preparation for further study, and provides a stimulating bridge to advanced level studies in science.

3.4.1 Module B7: Further Biology

Overview

More than ever before, Biology in the Twenty First Century is at the forefront of science. In this module, candidates draw together and develop their understanding of some of the major science explanations they have studied during Modules B1 – B3 (Unit A161) and Modules B4 – B6 (Unit A162). Throughout *Module B7* candidates have opportunities to employ Ideas about Science from IaS1 (Data: their importance and limitations), IaS5 (Risk), and IaS6 (Making decisions about science and technology).

Medicine and health, and production of food and other resources such as fuels are important areas involving biological sciences. In 'Peak performance' pupils learn more about how human bodies work and how to keep fit and healthy.

Humans cannot live without consideration of their place in the natural world. We are part of the natural world and dependent on it for our survival. In 'What can we learn from natural ecosystems?' pupils find out how the natural world provides humans with a model for sustainable systems.

In 'New technologies' pupils discover more about the fast-moving world of modern biological techniques. Many of these have implications for human food production and production of medicines and other useful products.

Topics
B7.1 Peak performance – movement and exercise
Skeletal system; health and fitness
B7.2 Peak performance – circulation
Components of blood; the circulatory system
B7.3 Peak performance – energy balance
Maintaining constant body temperature and blood sugar; diabetes
B7.4 What can we learn from natural ecosystems?
Closed loop systems; sustainability
B7.5 New technologies
DNA technology; genetic modification; nanotechnology; stem cells

Opportunities for mathematics

This module offers opportunities to develop mathematics skills. For example:

- develop a sense of scale in the context of DNA, cells, organs, organisms and ecosystems
- develop a sense of scale in the context of nanotechnology
- carry out calculations using experimental data on heart rate and recovery period after exercise
- carry out calculations to find the percentage increase in measured values including muscle length and heart rate
- use ideas of proportion in the context of gel electrophoresis of DNA fragments
- plot, draw, and interpret graphs and charts from candidates' own and secondary data in the context of seed germination, injury recovery times, body mass index, and enzyme activity
- use ideas about correlation in the context of blood sugar and insulin levels
- use ideas about uncertainty and probability in the context of the risks and benefits of genetically modified organisms
- use the equation for calculating BMI including appropriate units for physical quantities.

Opportunities for practical work

This module offers opportunities for practical work in teaching and learning. For example:

- find out how muscles and bones enable humans and other animals to move, both by self-observation and by dissecting a chicken wing
- investigate the physiology of fitness
- investigate the energy content of oil from different seeds
- investigate the role of microorganisms in recycling
- investigate the effect of temperature on enzyme activity
- investigate the conditions required for seed germination
- heart dissection
- model an ecosystem on a small scale
- use a model to investigate the role of blood in maintaining a constant body temperature.

Opportunities for ICT

This module offers opportunities to illustrate the use of ICT in science. For example:

- log, store and display data for analysis and evaluation
- the integral role of ICT in DNA technologies
- animations of movement at a joint
- animations of the heart
- animations of valves in veins
- investigate the structures in a chicken leg

Use of ICT in teaching and learning can include:

- video clips of physiotherapy
- video clips showing behaviour of living things in response to extreme temperatures
- a data logger to monitor body temperature over 12 or 24 hours
- video clips of Easter Island
- video clips of Masai people
- video clips of biodigester in use
- video clips of desert
- animations of genetic modification
- animations to illustrate the change in surface area as material is divided up
- using the internet to research new technologies.

Opportunities for teaching the Ideas about Science

Examples of Ideas about Science for which there are particular opportunities for introduction or development in this module include:

Data: their importance and limitations

IaS 1.1 – 1.6

Cause-effect explanations

IaS 2.3 – 2.5

Developing scientific explanations

IaS 3.4

Risk

IaS 5.1 – 5.3

Making decisions about science and technology

IaS 6.1 – 6.6

Module B7: Further Biology

B7.1 Peak performance – movement and exercise

1. understand that the internal skeleton of vertebrates is needed for support and movement
2. understand that muscles can only move bones at a joint by contraction, and thus operate in antagonistic pairs
3. recall the structure and function of the components of a joint, to include:
    a. smooth layer of cartilage and synovial fluid to reduce friction between bones
    b. elastic ligaments to stabilise joints while allowing movement
    c. tendons to transmit the forces between muscle and bones
4. understand how the specific properties of ligaments, cartilage and tendons enable them to function effectively
5. explain why certain factors in a person's medical or lifestyle history need to be disclosed before an exercise regime is started (for example: symptoms, current medication, alcohol and tobacco consumption, level of physical activity, family medical history and previous treatments)
6. interpret data obtained when monitoring a person during and after exercise, including change in heart rate, change in blood pressure and the recovery period
7. use proportion of body fat and body mass index (BMI) as measurements of fitness
8. use the equation:

$$\text{BMI} = \frac{\text{body mass (kg)}}{[\text{height (m)}]^2}$$

9. **understand that any assessment of progress needs to take into account the accuracy of the monitoring technique and the repeatability of the data obtained**
10. recall common injuries that can be caused by excessive exercise, to include sprains, dislocations, and torn ligaments or tendons
11. recall symptoms and basic treatments for a sprain
12. describe the role of the physiotherapist in treatment of skeletal-muscular injury.

Module B7: Further Biology

B7.2 Peak performance – circulation

1. explain what is meant by a double circulatory system
2. understand that the blood carries glucose molecules and oxygen to the muscles, and waste products such as carbon dioxide away from muscles
3. relate the components of the blood to their functions, including:
    a. red blood cells – transport oxygen
    b. white blood cells – fighting infections
    c. platelets – blood clotting at injury sites
    d. plasma – transporting nutrients (e.g. glucose and amino acids), antibodies, hormones and waste (carbon dioxide and urea)
4. understand how red blood cells are adapted to their function, limited to:
    a. packed with haemoglobin (to bind oxygen)
    b. no nucleus (more space for haemoglobin)
    c. biconcave shape (increased surface area for oxygen exchange)
5. describe and name the main structures and blood vessels of the heart including the left and right atria and ventricles, vena cava, aorta, pulmonary vein, pulmonary artery, coronary arteries and valves
6. describe the function of valves in the heart and veins
7. **understand how tissue fluid is formed in capillary beds and that it assists the exchange of chemicals by diffusion between capillaries and tissues, to include oxygen, carbon dioxide, glucose and urea.**

Module B7: Further Biology

B7.3 Peak performance – energy balance

1. understand that to maintain a constant body temperature, heat gained (including heat released during respiration) is balanced by heat lost
2. recall that temperature receptors in the skin detect external temperature
3. recall that temperature receptors in the brain (**hypothalamus**) detect the temperature of the blood
4. understand that the brain (**hypothalamus**) acts as a processing centre, receiving information from the temperature receptors, and sending instructions to trigger the effectors automatically
5. recall that effectors include sweat glands and muscles
6. understand that at high body temperatures:
    a. more sweat is produced by sweat glands which cools the body when it evaporates
    b. blood vessels supplying the capillaries of the skin dilate (vasodilation) allowing more blood to flow through skin capillaries which increases heat loss
7. explain how exercise produces increased sweating, and can produce dehydration, which may lead to reduced sweating and further increase of core body temperature
8. understand that at low body temperatures:
    a. the increased rate of respiration stimulated when muscles contract rapidly (shivering) results in some of the energy transferred in respiration warming the surrounding tissues
    b. blood vessels supplying the capillaries of the skin constrict (vasoconstriction) restricting blood flow through skin capillaries which reduces heat loss
9. **understand that some effectors work antagonistically, which allows a more sensitive and controlled response**
10. understand that high levels of sugar, common in some processed foods, are quickly absorbed into the blood stream, causing a rapid rise in the blood sugar level
11. recall that there are two types of diabetes (type 1 and type 2), and that it is particularly late-onset diabetes (type 2) which is more likely to arise because of poor diet or obesity
12. understand that type 1 diabetes arises when the pancreas stops producing enough of the hormone, insulin, but that type 2 diabetes develops when the body no longer responds to its own insulin or does not make enough insulin
13. recall that type 1 diabetes is controlled by insulin injections and that type 2 diabetes can be controlled by diet and exercise
14. explain how a diet high in fibre and complex carbohydrates can help to maintain a constant blood sugar level
15. interpret data on risks associated with an unhealthy lifestyle (limited to poor diet and lack of exercise), including obesity, heart disease, diabetes and some cancers.

Module B7: Further Biology

B7.4 What can we learn from natural ecosystems?

1. recall that a perfect closed loop system is a system that has no waste because the output from one part of the system becomes the input to another part
2. understand that an ecosystem is a type of closed loop system since most waste materials are not lost but are used as food or reactants
3. name examples of waste products in natural ecosystems, to include oxygen (from photosynthesis), carbon dioxide (from respiration), and dead organic matter such as fallen petals, leaves and fruits, and faeces
4. understand how these waste products may become food or reactants for animals, plants and microorganisms in the ecosystem, including the role of the digestive enzymes of microorganisms
5. interpret closed loop system diagrams and data on the storage and movement of chemicals through an ecosystem, including water, carbon, nitrogen and oxygen

   ⓘ *Candidates will not be expected to recall details of the nutrient cycles*

6. understand that no ecosystem is a perfect closed loop system since some output is always lost, e.g. migration of organisms and loss of nutrients transferred by air or water
7. understand that in stable ecosystems, including rainforests, the output (losses) is balanced by gains
8. understand why the production of large quantities of reproductive structures, including eggs, sperm, pollen, flowers and fruit, is a necessary strategy for successful reproduction
9. understand that, in stable ecosystems, the production of large quantities of these reproductive structures is not wasteful, since the surplus is recycled in the ecosystem
10. recall that vegetation in stable ecosystems, such as rain forests, prevents soil erosion and extremes of temperature, and promotes cloud formation
11. understand that vegetation reduces soil erosion since foliage protects the soil from direct rainfall and roots help to bind the soil together
12. understand that humans depend on natural ecosystems to provide ‘ecosystem services’, for example providing clean air, water, soil, mineral nutrients, pollination, fish and game
13. understand that human systems are not closed loop systems because some waste leaves the system, including non-recycled waste from households, agriculture and industry, and emissions from burning fossil fuels
14. understand that some non-recycled waste can build up to harmful levels, **including bioaccumulation in food chains**
15. understand that human activity can unbalance natural ecosystems by altering the inputs and outputs, and that this leads to change
16. **describe and explain the process of eutrophication**
17. describe the environmental impact of removing biomass from natural closed loop systems for human use, to include unsustainable timber harvesting and fishing

B7.4 What can we learn from natural ecosystems?

18. explain the impact of replacing vegetation in natural ecosystems with agricultural crops and livestock, to include the loss of biodiversity, silting of rivers and desertification
19. understand that the use of natural resources by humans can only be sustainable if used at a rate at which they can be replaced
20. understand why the use of crude oil does not fulfil the requirements of a closed loop system, including:
    a. crude oil takes millions of years to form from the decay of dead organisms
    b. energy released from burning crude oil originated from the Sun when these organisms were alive ('fossil sunlight energy')
21. recall and understand solutions to allow sustainable harvesting of natural resources such as timber and fish, including the use of quotas and restocking/replanting
22. describe the role of sunlight as a sustainable source of energy for natural ecosystems and sustainable agriculture
23. understand the tensions between conserving natural ecosystems and the needs of local human communities.

Module B7: Further Biology

B7.5 New technologies

1. recall the features of bacteria that make them ideal for industrial and genetic processes to include:
   a. rapid reproduction
   b. presence of plasmids
   c. simple biochemistry
   d. ability to make complex molecules
   e. lack of ethical concerns in their culture
2. understand that bacteria and fungi can be grown on a large scale (fermentation) to include production of:
   a. antibiotics and other medicines
   b. single-cell protein
   c. enzymes for food processing, for example chymosin as a vegetarian substitute for rennet
   d. enzymes for commercial products, such as washing powders and to make biofuels
3. recall that genetic modification is where a gene from one organism is transferred to another and continues to work
4. recall the main steps in genetic modification as:
   a. isolating and replicating the required gene
   b. putting the gene into a suitable vector (virus or plasmid)
   c. using the vector to insert the gene into a new cell
   d. selecting the modified individuals
5. recall examples of the application of genetic modification, to include:
   a. bacterial synthesis of medicines, for example insulin
   b. herbicide resistance in crop plants
6. **understand and explain the use of DNA technology in genetic testing, to include:**
   a. isolation of a DNA sample from white blood cells
   b. production of a gene probe labelled with a fluorescent chemical
   c. addition of the labelled gene probe (marker) to the DNA sample
   d. use of UV to detect the marker and therefore indicate the position of the gene or the presence of a specific allele in the DNA sample
7. recall that nanotechnology involves structures that are about the same size as some molecules
8. describe the application of nanotechnology in the food industry, including food packaging which can increase shelf life and detect contaminants
9. describe applications of stem cell technology in tissue and organ culture, including the treatment of leukaemia and the potential to treat spinal cord injuries
10. describe the role of biomedical engineering in pacemakers and the replacement of faulty heart valves.

3.5 Summary of Unit A173: *Chemistry A Module C7*

Unit A173 is the unit within GCSE Further Additional Science A where the chemistry content is assessed. It assesses the content of *Module C7* together with the Ideas about Science.

Unit A173 includes content to enhance progression and to give a greater understanding of the subjects concerned. This unit continues the emphasis on 'science for the scientist' in preparation for further study, and provides a stimulating bridge to advanced level studies in science.

3.5.1 Module C7: Further Chemistry

Overview

The five topics in this longer module introduce new chemical ideas while illustrating important features of the applications of chemistry and exploring Ideas about Science from IaS1: Data and their limitations, IaS3: Developing explanations, and IaS6: Making decisions about science and technology.

The module starts with an introduction to green chemistry and describes how the chemical industry is reinventing processes so that the manufacture of bulk and fine chemicals is more sustainable. The theme of green chemistry runs through the module, presenting several opportunities to see how the principles are applied in real life.

The second topic covers introductory organic chemistry taking alcohols and carboxylic acids as the main examples. This builds on the coverage of hydrocarbon molecules in Modules C1 and C2.

The third and fourth topics lay the foundations for more advanced study of physical chemistry by exploring chemical concepts on a molecular scale including the connection between energy changes and bond breaking, as well as the notion of dynamic equilibrium.

The fifth topic introduces concepts of valid analytical measurements in contexts where the results of analysis matter. The two main analytical methods featured are chromatography and volumetric analysis.

Topics
C7.1 Green chemistry
The chemical industry The characteristics of green chemistry
C7.2 Alcohols, carboxylic acids and esters
Organic molecules and functional groups Alcohols Carboxylic acids Esters
C7.3 Energy changes in chemistry
Why are there energy changes during chemical reactions?
C7.4 Reversible reactions and equilibria
Introducing dynamic equilibrium
C7.5 Analysis
Analytical procedures Chromatography Quantitative analysis by titration

Opportunities for mathematics

This module offers opportunities to develop mathematics skills. For example:

- carry out calculations using experimental data, including finding the mean and the range
- carry out calculations to find percentage yield and atom economy
- plot, draw and interpret graphs and charts from candidates' own and secondary data
- use an equation to calculate Rf values in chromatography
- use an equation to calculate concentration using appropriate units for physical quantities
- calculate reacting masses
- extract information from charts, graphs and tables including comparing data about nitrogen fixation processes
- balance equations
- calculate energy changes using bond energies.

Opportunities for practical work

This module offers opportunities for practical work in teaching and learning. For example:

- reactions of alkanes, alcohols, and carboxylic acids
- synthesis of an ester
- exothermic and endothermic reactions
- reversible reactions
- chromatography
- acid alkali titrations
- experiments to investigate catalysts.

Opportunities for ICT

This module offers opportunities to illustrate the use of ICT in science. For example:

- modelling the structures of molecules
- the integral role of ICT in chemical instrumentation.

Use of ICT in teaching and learning can include:

- using modelling software to explore the shapes of organic molecules
- video clips to illustrate the manufacture of chemicals on large and small scales
- video clips to illustrate gas chromatography and other analytical techniques
- using the internet to research current developments in green chemistry.

Opportunities for teaching the Ideas about Science

Examples of Ideas about Science for which there are particular opportunities for introduction or development in this module include:

Data: their importance and limitations

IaS 1.2 – 1.6

Developing scientific explanations

IaS 3.1, 3.2

Making decisions about science and technology

IaS 6.1, 6.2

Module C7: Further Chemistry

C7.1 Green chemistry

The chemical industry

1. understand and use the terms ‘bulk’ (made on a large scale) and ‘fine’ (made on a small scale) in the context of the chemical industry
2. recall examples of chemicals made on a large scale (ammonia, sulfuric acid, sodium hydroxide, phosphoric acid) and examples of chemicals made on a small scale (drugs, food additives, fragrances)
3. interpret information about the work done by people who make chemicals

   ⓘ *Candidates are not expected to recall any specific details*
4. understand that the development of new chemical products or processes requires an extensive programme of research and development (for example, catalysts for new processes)
5. recall that governments have strict regulations to control chemical processes as well as the storage and transport of chemicals to protect people and the environment

What are the characteristics of green chemistry?

6. understand that the production of useful chemicals involves several stages to include:
   a. the preparation of feedstocks
   b. synthesis
   c. separation of products
   d. handling of by-products and wastes
   e. the monitoring of purity
7. understand that sustainability of any chemical process depends on:
   a. whether or not the feedstock is renewable
   b. the atom economy
   c. the nature and amount of by-products or wastes and what happens to them
   d. the energy inputs or outputs
   e. the environmental impact
   f. the health and safety risks
   g. the social and economic benefits
8. understand the term activation energy in terms of the energy needed to break bonds to start a reaction
9. understand that a catalyst provides an alternative route for a reaction with a lower activation energy
10. understand that some industrial processes use enzyme catalysts, and the restrictions this places on the conditions that are used
11. use the Periodic Table to obtain the relative atomic masses of elements and use these to calculate relative formula masses
12. **calculate the masses of reactants and products from balanced equations.**

Module C7: Further Chemistry

C7.2 Alcohols, carboxylic acids and esters

Organic molecules and functional groups

1. recall that there is a family of hydrocarbons called alkanes
2. recall the names and molecular formulae of the alkanes: methane, ethane, propane and butane
3. translate between molecular, structural and ball-and-stick representations of simple organic molecules
4. understand that alkanes burn in plenty of air to give carbon dioxide and water
5. understand that alkanes are unreactive towards aqueous reagents because they contain only C—C and C—H bonds, which are difficult to break and therefore unreactive
6. recall that in saturated compounds, such as alkanes, all the carbon to carbon bonds are single, C—C, but that in unsaturated compounds there are carbon to carbon double bonds, C=C
7. represent chemical reactions by word equations
8. interpret symbol equations, including the number of atoms of each element, the number of molecules of each element or covalent compound and the number of 'formulas' of ionic compounds, in reactants and products

   ⓘ *In this context, 'formula' is used in the case of ionic compounds as an equivalent to molecules in covalent compounds; the concept of the mole is not covered in the specification*

9. **represent chemical reactions by balanced equations, including state symbols**

Alcohols

10. recall the names, molecular formulae and structural formulae of methanol and ethanol
11. recall two uses of methanol and two uses of ethanol
12. recognise the formulae of alcohols
13. understand that the characteristic properties of alcohols are due to the presence of the –OH functional group
14. recall how ethanol compares in its physical properties with water and with alkanes
15. understand that alcohols burn in air to produce carbon dioxide and water because of the presence of a hydrocarbon chain
16. **recall the reaction of alcohols with sodium and how this compares with the reactions of water and alkanes with sodium**
17. understand why there is a limit to the concentration of ethanol solution that can be made by fermentation
18. understand how ethanol solution can be concentrated by distillation and that this can be used to make products such as whisky and brandy
19. understand the optimum conditions for making ethanol by fermentation of sugar with yeast, taking into consideration temperature and pH
20. understand how genetically modified E. coli bacteria can be used to convert waste biomass from a range of sources into ethanol and recall the optimum conditions for the process

C7.2 Alcohols, carboxylic acids and esters

21. recall in outline the synthetic route for converting ethane (from oil or natural gas) into ethanol (via ethene)
22. interpret data about the different processes involved in the production of ethanol, and evaluate their sustainability

Carboxylic acids

23. understand that the characteristic properties of carboxylic acids are due to the presence of the –COOH functional group
24. recall the names, molecular formulae and structural formulae of methanoic acid and ethanoic acid
25. recognise the formulae of carboxylic acids
26. recall that many carboxylic acids have unpleasant smells and tastes and are responsible for the smell of sweaty socks and the taste of rancid butter
27. understand that carboxylic acids show the characteristic reactions of acids with metals, alkalis and carbonates
28. recall that vinegar is a dilute solution of ethanoic acid
29. understand that carboxylic acids are called weak acids because they are less reactive than strong acids such as hydrochloric acid, sulfuric acid and nitric acid
30. understand that dilute solutions of weak acids have higher pH values than dilute solutions of strong acids

Esters

31. understand that carboxylic acids react with alcohols, in the presence of a strong acid catalyst, to produce esters
32. recall that esters have distinctive smells
33. recall that esters are responsible for the smells and flavours of fruits
34. recall the use of esters as food flavourings, solvents and plasticizers, and in perfumes
35. **understand the procedure for making an ester (such as ethyl ethanoate) from a carboxylic acid and an alcohol**
36. **understand the techniques used to make a liquid ester, limited to:**
    - **a. heating under reflux**
    - **b. distillation**
    - **c. purification by treatment with reagents in a tap funnel**
    - **d. drying**
37. recall that fats are esters of glycerol and fatty acids
38. recall that living organisms make fats and oils as an energy store
39. recall that animal fats are mostly saturated molecules and that vegetable oils are mostly unsaturated molecules.

Module C7: Further Chemistry

C7.3 Energy changes in chemistry

Why are there energy changes during chemical reactions?

1. understand the terms exothermic and endothermic
2. use and interpret energy level diagrams for exothermic and endothermic reactions
3. understand that energy is needed to break chemical bonds and that energy is given out when chemical bonds form
4. **use given data on the energy needed to break covalent bonds to estimate the overall energy change in simple examples (for example, the formation of steam or hydrogen halides from their elements)**
5. understand the term activation energy in terms of the energy needed to break bonds to start a reaction.

Module C7: Further Chemistry

C7.4 Reversible reactions and equilibria

Introducing dynamic equilibrium

1. understand that some chemical reactions are reversible and are shown by the symbol $\rightleftharpoons$
2. understand that reversible reactions can reach a state of equilibrium
3. **understand the dynamic equilibrium explanation for chemical equilibrium**
4. understand why fixing nitrogen by the Haber process is important
5. recall that the feedstocks of nitrogen and hydrogen for the Haber process are made from air, natural gas and steam

   ⓘ *Candidates do not need to know the details of the processes involved*
6. in the context of the Haber process:
   a. understand that the reaction between hydrogen and nitrogen to form ammonia is a reversible reaction
   b. understand how the yield of ammonia is increased by recycling unreacted hydrogen and nitrogen
   c. explain the effect of changing temperature and pressure on the yield of ammonia at equilibrium
   d. understand that the gases do not stay in the reactor long enough to reach equilibrium
   e. understand that a catalyst is used to increase the rate of reaction in the Haber process
   f. understand that the efficiency of the process can be improved by using a different catalyst
   g. explain how the conditions used for the process are a compromise to produce an economically viable yield of ammonia
7. understand that some living organisms ‘fix’ nitrogen at room temperature and pressure using enzymes as catalysts
8. understand why chemists are interested in producing new catalysts that mimic natural enzymes
9. understand the impact on the environment of the large scale manufacture of ammonia and the widespread use of fertilisers made from it
10. interpret data about nitrogen fixation processes and evaluate their sustainability.

Module C7: Further Chemistry

C7.5 Analysis

Analytical procedures

1. understand the difference between qualitative and quantitative methods of analysis
2. understand that an analysis must be carried out on a sample that represents the bulk of the material under test
3. recall that many analytical methods are based on samples in solution
4. understand the need for standard procedures for the collection, storage and preparation of samples for analysis

Chromatography

5. understand that in chromatography, substances are separated by movement of a mobile phase through a stationary phase
6. understand and use the terms aqueous and non-aqueous as applied to solvents
7. understand that for each component in a sample there is a dynamic equilibrium between the stationary and mobile phases
8. understand how a separation by chromatography depends on the distribution of the components in the sample between the mobile and stationary phases
9. understand the use of standard reference materials in chromatography
10. describe and compare paper and thin-layer chromatography
11. use the formula:

$$Rf = \frac{\text{distance travelled by solute}}{\text{distance travelled by solvent}}$$

    and understand the use of Rf values

12. understand the use of locating agents in paper and thin-layer chromatography
13. recall in outline the procedure for separating a mixture by gas chromatography (gc)
14. understand the term retention time as applied to gc
15. interpret print-outs from gc analyses, limited to retention times and peak heights

C7.5 Analysis

Quantitative analysis by titration

16. understand the main stages of a quantitative analysis:
    a. measuring out accurately a specific mass or volume of the sample
    b. working with replicate samples
    c. dissolving the samples quantitatively
    d. measuring a property of the solution quantitatively
    e. calculating a value from the measurements (IaS 1.4)
    f. estimating the degree of uncertainty in the results (IaS 1.5–1.6)
17. understand that concentrations of solutions can be measured in g/dm^3
18. recall the procedure for making up a standard solution
19. **calculate the concentration of a given volume of solution given the mass of solute**
20. **calculate the mass of solute in a given volume of solution with a specified concentration**
21. recall the procedure for carrying out an acid-base titration using a pipette and burette
22. substitute results in a given formula to interpret titration results quantitatively
23. **use the balanced equation and relative formula masses to interpret the results of a titration**
24. use values from a series of titrations to assess the degree of uncertainty in a calculated value.

3.6 Summary of Unit A183: *Physics A Module P7*

Unit A183 is the unit within GCSE Further Additional Science A where the physics content is assessed. It assesses the content of *Module P7* together with the Ideas about Science.

Unit A183 includes content to enhance progression and to give a greater understanding of the subjects concerned. This unit continues the emphasis on 'science for the scientist' in preparation for further study, and provides a stimulating bridge to advanced level studies in science.

3.6.1 Module P7: Further Physics – Studying the Universe

Overview

Astronomy is one of the most publicly visible and appealing areas of scientific research. It is inextricably linked with physics, and is the context used in this module to introduce and develop understanding of a breadth of fundamental concepts in physics. Explanations of the design and operation of telescopes, the analysis of radiation to deduce information about remote objects, and theories about star formation and evolution are used to develop understanding of the behaviour of waves, fundamentals of optics, spectra, estimation of astronomical distances, the gas laws, temperature scales, nuclear fusion and mass-energy equivalence ($E = mc^2$).

The module begins with naked eye astronomy and explains some observations of the Moon, stars and planets, including eclipses (shadows) and twinkling stars (refraction). Attention then turns to telescopes, to the formation of images by a pinhole, by lenses and by curved mirrors, and to the use of prisms and gratings to produce spectra. A study of modern observatories explores the scientific reasons for building large telescopes (to collect a lot of radiation and minimise diffraction) and for placing them at high, remote sites (to minimise atmospheric absorption and to avoid 'noise' from Earth-based sources), and highlights other factors that influence the siting of observatories and the ways astronomers work.

Next, the module addresses the question of distance measurement. Trigonometric parallax is introduced, and the parsec as a unit of distance. The variation of intensity with distance is then explored, with particular reference to the use of Cepheid variable stars. This leads into a discussion of the historical controversy about the nature of 'spiral nebulae' and its resolution, then to Hubble's observation of receding galaxies and its explanation in terms of the expanding Universe.

Questions about the nature of the Sun lead first to a study of thermal radiation and temperature, then to line spectra and their interpretation. The Sun's energy output is explained in terms of nuclear fusion. The Sun is then compared with other stars, using the Hertzsprung-Russell diagram to display luminosity and temperature and to characterise main sequence, giant, and white dwarf stars. An overview of interstellar regions (gas clouds) introduces a study of gases, including the Kelvin temperature scale. Ideas about gas behaviour are then used to explain how stars and planets can form as a cloud collapses under its own gravity. The story continues with main sequence stars, which are explained in terms of nuclear fusion and energy transport. Post-main-sequence evolution involves further fusion, eventually ending with the formation of a white dwarf, or with a supernova explosion and the formation of a neutron star or black hole and the ejection of material that might form new stars and planets.

Modern professional astronomy is high-profile, big-impact science, involving large, often multinational, teams of people and expensive specialised instruments. Case studies in this module illustrate ideas about the scientific community (IaS 4) and how we make decisions about science and technology (IaS 6).

Topics	
P7.1	**Naked eye astronomy**
	Observations of Moon, stars, planets
	Angular size, angular coordinates
	Twinkling stars/refraction
P7.2	**Light, telescopes and images**
	Real image formation by pinhole, lens
	Diffraction by aperture, image blurring
	Atmospheric windows
	Background 'noise'
	Mirror, simple telescope
	Image processing
	Spectra from prism, grating
P7.3	**Mapping the Universe**
	Parallax, parsec
	Brightness, luminosity and distance
	Cepheids
	Nebulae
	Recession of galaxies
	Hubble constant
P7.4	**The Sun, the stars and their surroundings**
	Thermal radiation and temperature
	Line spectra
	Nuclear fusion
	Types of stars
	Interstellar gas clouds
	Gas laws, kinetic theory, absolute zero
	Star formation, gravity and gas behaviour
	Main sequence, nuclear fusion, energy transport
	End points
	Exoplanets and SETI
P7.5	**The astronomy community**
	Organisation of astronomy
	Choice of observing sites
	Observing from the Earth and in space

Opportunities for mathematics

This module offers opportunities to develop mathematics skills. For example:

- develop a sense of scale in the context of the solar system, galaxies and the Universe
- carry out calculations using experimental data, including finding the mean and the range
- use ideas of proportion in the context of the gas laws
- plot, draw and interpret graphs and charts from candidates' own and secondary data
- use equations, including appropriate units for physical quantities
- extract information from charts, graphs and tables
- use ideas about correlation in the context of Hubble's Law.

Opportunities for practical work

This module offers opportunities for practical work in teaching and learning. For example:

- record positions and appearance of astronomical objects over a day (or night) and over a month or longer
- measure the focal length of lenses and relate this to their shape
- build simple telescopes and measure the magnification
- investigate diffraction of light and microwaves
- investigate the use of diffraction gratings and prisms to produce spectra
- use parallax methods to measure distances
- use robotic telescopes to observe astronomical objects
- investigate the relationship between temperature, pressure and volume of a gas
- observe the spectra of a range of elements and link this to spectra of stars.

Opportunities for ICT

This module offers opportunities to illustrate the use of ICT in science. For example:

- remote control of telescopes
- the collection, storage and analysis of astronomical data.

Use of ICT in teaching and learning can include:

- using the internet to find out about astronomy done at telescopes around the world, and to view astronomical images
- processing of astronomical images
- learning from simulations and applets showing star processes.

Opportunities for teaching the Ideas about Science

Examples of Ideas about Science for which there are particular opportunities for introduction or development in this module include:

The scientific community

IaS 4.1 – 4.4

Making decisions about science and technology

IaS 6.1

Module P7: Further Physics – Studying the Universe

P7.1 Naked eye astronomy

1. recall that the Sun appears to travel east–west across the sky once every 24 hours, that the stars appear to travel east–west across the sky once in a very slightly shorter time period, and that the Moon appears to travel east–west across the sky once in a slightly longer time period

2. explain why a sidereal day, a rotation of 360° of the Earth, is different from a solar day due to the orbital movement of the Earth and that a sidereal day is 4 minutes less than a solar day

3. understand that the planets Mercury, Venus, Mars, Jupiter and Saturn can be seen with the naked-eye and that all the planets appear to move with the stars but also to change their position relative to the fixed stars

4. explain the apparent motions of the Sun, stars, Moon **and planets** in terms of rotation of the Earth and the orbits of the Earth, Moon **and planets**

5. explain the phases of the Moon in terms of the relative positions of the Sun, Moon and Earth

6. explain both solar and lunar eclipses in terms of the positions of the Sun and Moon **and explain the low frequency of eclipses in terms of the relative tilt of the orbits of the Moon about the Earth and the Earth about the Sun**

7. explain why different stars are seen in the night sky at different times of the year, in terms of the movement of the Earth round the Sun

8. recall that, **and explain why,** planets sometimes appear to move with retrograde motion relative to the 'fixed' stars

9. understand that the positions of astronomical objects are described in terms of two angles (e.g. right ascension and declination) **and understand how the angles relate to the celestial sphere.**

Module P7: Further Physics – Studying the Universe

P7.2 Light, telescopes and images

1. understand that the speed of waves is affected by the medium they are travelling through and that the wave speed will change if a wave moves from one medium into another
2. understand that a change in the speed of a wave causes a change in wavelength since the frequency of the waves cannot change, and that this may cause a change in direction
3. understand that the refraction of light waves can be explained by a change in their speed when they pass into a different medium
4. describe how refraction leads to the formation of an image by a convex/converging lens
5. understand and draw diagrams to show how convex/converging lenses bring parallel light to a focus
6. **draw and** interpret ray diagrams for convex/converging lenses gathering light from distant point sources (stars), off the principal axis of the lens **and extended sources (planets or moons in our solar system, galaxies)**
7. understand that a lens with a more curved surface is more powerful than a lens with a less curved surface made of the same material
8. calculate the power of a lens from:

$$\underset{\text{(dioptres)}}{\text{power}} = \underset{(\text{metres}^{-1})}{\frac{1}{\text{focal length}}}$$

9. understand that astronomical objects are so distant that light from them reaches the Earth as effectively parallel sets of rays
10. recall that a simple optical telescope has two converging lenses of different powers, with the more powerful lens as the eyepiece
11. understand that a telescope has two optical elements:
    a. an objective lens or mirror to collect light from the object being observed and form an image of it
    b. an eyepiece which produces a magnified image of the image from the objective that we can view
12. **calculate the angular magnification of a telescope from the powers of the two lenses using:**

$$\textbf{magnification} = \frac{\textbf{focal length of objective lens}}{\textbf{focal length of eyepiece lens}}$$

13. explain why most astronomical telescopes have concave mirrors, not converging lenses, as their objectives
14. understand how concave mirrors bring a parallel beam of light to a focus
15. explain why large telescopes are needed to collect the weak radiation from faint or very distant sources
16. recall that waves can spread out from a narrow gap and that this is called diffraction
17. draw and interpret diagrams showing wave diffraction through gaps

P7.2 Light, telescopes and images

18. recall that light can be diffracted, and that the effect is most noticeable when light travels through a very small gap, comparable to the wavelength of the wave

19. understand that radiation is diffracted by the aperture of a telescope, and that the aperture must be very much larger than the wavelength of the radiation detected by the telescope to produce sharp images

20. explain how a spectrum can be produced by refraction in a prism

21. recall that a spectrum can be produced by a diffraction grating.

Module P7: Further Physics – Studying the Universe

P7.3 Mapping the Universe

1. explain how parallax makes closer stars seem to move relative to more distant ones over the course of a year
2. define the parallax angle of a star as half the angle moved against a background of very distant stars in 6 months
3. understand that a smaller parallax angle means that the star is further away
4. define a parsec (pc) as the distance to a star with a parallax angle of one second of arc
5. calculate distances in parsecs for simple parallax angles expressed as fractions of a second of arc
6. recall that a parsec is similar in magnitude to a light-year and is the unit used by astronomers to measure distance
7. recall that typical interstellar distances are a few parsecs
8. recall that the luminosity of a star depends on its temperature and its size
9. explain qualitatively why the observed intensity of light from a star (as seen on Earth) depends on the star's luminosity and its distance from Earth
10. recall that Cepheid variable stars pulse in brightness, with a period related to their luminosity
11. recall that **and explain qualitatively how** this relationship enables astronomers to estimate the distance to Cepheid variable stars
12. understand the role of observations of Cepheid variable stars in establishing the scale of the Universe and the nature of most spiral nebulae as distant galaxies
13. recall that telescopes revealed that the Milky Way consists of millions of stars and led to the realisation that the Sun was a star in the Milky Way galaxy
14. recall that telescopes revealed the existence of many fuzzy objects in the night sky, and that these were originally called nebulae
15. recall the main issue in the Curtis-Shapley debate: whether spiral nebulae were objects within the Milky Way or separate galaxies outside it
16. recall that Hubble's observations of Cepheid variables in one spiral nebula indicated that it was much further away than any star in the Milky Way, and so he concluded that this nebula was a separate galaxy
17. recall that intergalactic distances are typically measured in megaparsecs (Mpc)
18. recall that data on Cepheid variable stars in distant galaxies has given better values of the Hubble constant
19. use the following equation to calculate, given appropriate data, the speed of recession of a distant galaxy, **the Hubble constant or the distance to the galaxy:**

speed of recession	=	Hubble constant	×	distance
(km/s)		(s^{-1})		(km)
(km/s)		(km/s per Mpc)		(Mpc)

20. understand how the motions of galaxies suggests that space itself is expanding

21. recall that scientists believe the Universe began with a 'big bang' about 14 thousand million years ago.

Module P7: Further Physics – Studying the Universe

P7.4 The Sun, the stars and their surroundings

1. recall that all hot objects (including stars) emit a continuous range of electromagnetic radiation, whose luminosity and peak frequency increases with temperature
2. recall that the removal of electrons from atoms is called ionisation and **explain how electron energy levels within atoms give rise to line spectra**
3. recall that specific spectral lines in the spectrum of a star provide evidence of the chemical elements present in it
4. use data on the spectrum of a star, together with data on the line spectra of elements, to identify elements present in it
5. understand that the volume of a gas is inversely proportional to its pressure at a constant temperature and explain this using a molecular model
6. explain why the pressure and volume of a gas vary with temperature using a molecular model
7. understand that both the pressure and the volume of a gas are proportional to the absolute temperature
8. interpret absolute zero using a molecular model and kinetic theory
9. recall that –273°C is the absolute zero of temperature, and convert temperatures in K to temperatures in °C (and vice versa)
10. use the relationships:
    a. $\text{pressure} \times \text{volume} = \text{constant}$
    b. $\dfrac{\text{pressure}}{\text{temperature}} = \text{constant}$
    c. $\dfrac{\text{volume}}{\text{temperature}} = \text{constant}$
11. explain the formation of a protostar in terms of the effects of gravity on a cloud of gas, which is mostly hydrogen and helium
12. understand that as the cloud of gas collapses its temperature increases, and relate this to the volume, pressure and behaviour of particles in a protostar
13. understand that nuclear processes discovered in the early 20th century provided a possible explanation of the Sun's energy source
14. understand that, if brought close enough together, hydrogen nuclei can fuse into helium nuclei releasing energy, and that this is called nuclear fusion
15. complete and interpret nuclear equations relating to fusion in stars to include the emission of positrons to conserve charge
16. understand that energy is liberated when light nuclei fuse to make heavier nuclei with masses up to that of the iron nucleus

P7.4 The Sun, the stars and their surroundings

17. **understand that Einstein's equation $E = mc^2$ is used to calculate the energy released during nuclear fusion and fission (where E is the energy produced, m is the mass lost and c is the speed of light in a vacuum)**

18. recall that the more massive the star, the hotter its core and the heavier the nuclei it can create by fusion

19. recall that the core (centre) of a star is where the temperature and density are highest and where most nuclear fusion takes place

20. understand that energy is transported from core to surface by photons of radiation and by convection

21. recall that energy is radiated into space from the star's surface (photosphere)

22. recall that the Hertzsprung-Russell diagram is a plot of temperature and luminosity and identify regions on the graph where supergiants, giants, main sequence and white dwarf stars are located

23. recall that in a main sequence star, hydrogen fusion to helium takes place in the core

24. recall that a star leaves the main sequence when its core hydrogen runs out; it swells to become a red giant or supergiant and its photosphere cools

25. recall that in a red giant or supergiant star, helium nuclei fuse to make carbon, followed by further reactions that produce heavier nuclei such as nitrogen and oxygen

26. recall that a low-mass star (similar to the Sun) becomes a red giant, which lacks the mass to compress the core further at the end of helium fusion; it then shrinks to form a white dwarf

27. recall that in a white dwarf star there is no nuclear fusion; the star gradually cools and fades

28. recall that in a high-mass star (several times the mass of the Sun) nuclear fusion can produce heavier nuclei up to and including iron; when the core is mostly iron, it explodes as a supernova creating nuclei with masses greater than iron and leaving a dense neutron star or a black hole.

29. understand that astronomers have found convincing evidence of planets around hundreds of nearby stars

30. understand that, if even a small proportion of stars have planets, many scientists think that it is likely that life exists elsewhere in the Universe

31. recall that no evidence of extraterrestrial life (at present or in the past) has so far been detected.

Module P7: Further Physics – Studying the Universe

P7.5 The astronomy community

1. recall that major optical and infrared astronomical observatories on Earth are mostly situated in Chile, Hawaii, Australia and the Canary Islands
2. describe factors that influence the choice of site for major astronomical observatories including:
   a. high elevation
   b. frequent cloudless nights
   c. low atmospheric pollution and dry air
   d. sufficient distance from built-up areas that cause light pollution
3. describe ways in which astronomers work with local or remote telescopes
4. explain the advantages of computer control of telescopes including:
   a. being able to work remotely
   b. continuous tracking of objects
   c. more precise positioning of the telescope
   d. computer recording and processing of data collected
5. explain the main advantages and disadvantages of using telescopes outside the Earth's atmosphere including:
   a. avoids absorption and refraction effects of atmosphere
   b. can use parts of electromagnetic spectrum that the atmosphere absorbs
   c. cost of setting up, maintaining and repairing
   d. uncertainties of space programme
6. understand the reasons for international collaboration in astronomical research in terms of economy and pooling of expertise
7. describe two examples showing how international cooperation is essential for progress in astronomy
8. understand that non-astronomical factors are important considerations in planning, building, operating, and closing down an observatory including:
   a. cost
   b. environmental and social impact near the observatory
   c. working conditions for employees.

4 Assessment of GCSE Further Additional Science A

4.1 Overview of the assessment in GCSE Further Additional Science A

For GCSE Further Additional Science A candidates must take units A163, A173, A183 and A194.

GCSE Further Additional Science A J246	
Unit A163: *Biology A Module B7*	
25% of the total GCSE 1 hour written paper 60 marks	This question paper: • is offered in Foundation and Higher Tiers • assesses *Module B7* • uses both objective style and free response questions (there is no choice of questions) • assesses the quality of written communication.
Unit A173: *Chemistry A Module C7*	
25% of the total GCSE 1 hour written paper 60 marks	This question paper: • is offered in Foundation and Higher Tiers • assesses *Module C7* • uses both objective style and free response questions (there is no choice of questions) • assesses the quality of written communication.
Unit A183: *Physics A Module P7*	
25% of the total GCSE 1 hour written paper 60 marks	This question paper: • is offered in Foundation and Higher Tiers • assesses *Module P7* • uses both objective style and free response questions (there is no choice of questions) • assesses the quality of written communication.
Unit A194: *Further Additional Science A Controlled assessment*	
25% of the total GCSE Controlled assessment Approximately 4.5–6 hours 64 marks	This unit: • comprises a Practical Investigation • is assessed by teachers, internally standardised and then externally moderated by OCR • assesses the quality of written communication.

4.2 Tiers

All written papers are offered in one of two tiers: Foundation Tier and Higher Tier. Foundation Tier papers assess grades G to C and Higher Tier papers assess Grades D to A*. An allowed grade E may be awarded on the Higher Tier components.

In Units A163, A173 and A183, candidates are entered for an option in either the Foundation Tier or the Higher Tier. Unit A194 (controlled assessment) is not tiered.

Candidates may enter for either the Foundation Tier or Higher Tier in each of the externally assessed units. So a candidate may take, for example, A163/F and A173/H.

4.3 Assessment objectives (AOs)

Candidates are expected to demonstrate their ability to:

AO1	Recall, select and communicate their knowledge and understanding of science.
AO2	Apply skills, knowledge and understanding of science in practical and other contexts.
AO3	Analyse and evaluate evidence, make reasoned judgements and draw conclusions based on evidence.

4.3.1 AO weightings – GCSE Further Additional Science A

The relationship between the units and the assessment objectives of the scheme of assessment is shown in the following grid:

Unit	% of GCSE			
	AO1	AO2	AO3	Total
Units A163, A173 and A183	30	34	11	75
Unit A194: Controlled assessment	2	5	18	25
Total	**32**	**39**	**29**	**100**

4.4 Grading and awarding grades

GCSE results are awarded on the scale A* to G. Units are awarded a* to g. Grades are indicated on certificates. However, results for candidates who fail to achieve the minimum grade (G or g) will be recorded as *unclassified* (U or u) and this is **not** certificated.

Most GCSEs are unitised schemes. When working out candidates' overall grades OCR needs to be able to compare performance on the same unit in different series when different grade boundaries may have been set, and between different units. OCR uses a Uniform Mark Scale to enable this to be done.

A candidate's uniform mark for each unit is calculated from the candidate's raw mark on that unit. The raw mark boundary marks are converted to the equivalent uniform mark boundary. Marks between grade boundaries are converted on a pro rata basis.

When unit results are issued, the candidate's unit grade and uniform mark are given. The uniform mark is shown out of the maximum uniform mark for the unit, e.g. 60/100.

The specification is graded on a Uniform Mark Scale. The uniform mark thresholds for each of the assessments are shown below:

(GCSE) Unit Weighting	Maximum Unit Uniform Mark	Unit Grade								
		a*	a	b	c	d	e	f	g	u
25% F	69	–	–	–	60	50	40	30	20	0
25% H	100	90	80	70	60	50	45	–	–	0
25%	100	90	80	70	60	50	40	30	20	0

Higher Tier candidates who fail to gain a 'd' grade may achieve an "allowed e". Higher Tier candidates who miss the allowed grade 'e' will be graded as 'u'.

A candidate's uniform marks for each unit are aggregated and grades for the specification are generated on the following scale:

Qualification	Max Uniform Mark	Qualification Grade								
		A*	A	B	C	D	E	F	G	U
J246	400	360	320	280	240	200	160	120	80	0

The written papers will have a total weighting of 75% and controlled assessment a weighting of 25%.

A candidate's uniform mark for each paper will be combined with the uniform mark for the controlled assessment to give a total uniform mark for the specification. The candidate's grade will be determined by the total uniform mark.

4.5 Grade descriptions

Grade descriptions are provided to give a general indication of the standards of achievement likely to have been shown by candidates awarded particular grades. The descriptions must be interpreted in relation to the content in the specification; they are not designed to define that content. The grade awarded will depend in practice upon the extent to which the candidate has met the assessment objectives overall. Shortcomings in some aspects of the assessment may be balanced by better performance in others.

The grade descriptors have been produced by the regulatory authorities in collaboration with the awarding bodies.

4.5.1 Grade F

Candidates recall, select and communicate their limited knowledge and understanding of science. They recognise simple inter-relationships between science and society. They show a limited understanding that scientific advances may have ethical implications, benefits and risks. They use limited scientific and technical knowledge, terminology and conventions, showing some understanding of scale in terms of time, size and space.

They apply skills, including limited communication, mathematical, technical and observational skills, knowledge and understanding in practical and some other contexts. They recognise and use hypotheses, evidence and explanations and can explain straightforward models of phenomena, events and processes. They use a limited range of methods, sources of information and data to address straightforward scientific questions, problems and hypotheses.

Candidates interpret and evaluate limited quantitative and qualitative data and information from a narrow range of sources. They can draw elementary conclusions having collected limited evidence.

4.5.2 Grade C

Candidates recall, select and communicate secure knowledge and understanding of science. They demonstrate understanding of the nature of science and its principles and applications and the relationship between science and society. They understand that scientific advances may have ethical implications, benefits and risks. They use scientific and technical knowledge, terminology and conventions appropriately, showing understanding of scale in terms of time, size and space.

They apply appropriate skills, including communication, mathematical, technical and observational skills, knowledge and understanding in a range of practical and other contexts. They show understanding of the relationships between hypotheses, evidence, theories and explanations and use models, including mathematical models, to describe abstract ideas, phenomena, events and processes. They use a range of appropriate methods, sources of information and data, applying their skills to address scientific questions, solve problems and test hypotheses.

Candidates analyse, interpret and evaluate a range of quantitative and qualitative data and information. They understand the limitations of evidence and use evidence and information to develop arguments with supporting explanations. They draw conclusions based on the available evidence.

4.5.3 Grade A

Candidates recall, select and communicate precise knowledge and detailed understanding of science. They demonstrate a comprehensive understanding of the nature of science, its principles and applications and the relationship between science and society. They understand the relationships between scientific advances, their ethical implications and the benefits and risks associated with them. They use scientific and technical knowledge, terminology and conventions appropriately and consistently, showing a detailed understanding of scale in terms of time, size and space.

They apply appropriate skills, including communication, mathematical, technical and observational skills, knowledge and understanding effectively in a wide range of practical and other contexts. They show a comprehensive understanding of the relationships between hypotheses, evidence, theories and explanations and make effective use of models, including mathematical models, to explain abstract ideas, phenomena, events and processes. They use a wide range of appropriate methods, sources of information and data consistently, applying relevant skills to address scientific questions, solve problems and test hypotheses.

Candidates analyse, interpret and critically evaluate a broad range of quantitative and qualitative data and information. They evaluate information systematically to develop arguments and explanations taking account of the limitations of the available evidence. They make reasoned judgments consistently and draw detailed, evidence-based conclusions.

4.6 Quality of written communication

Quality of written communication is assessed in all units and is integrated in the marking criteria.

Candidates are expected to:

- ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
- present information in a form that suits its purpose
- use an appropriate style of writing and, where applicable, specialist terminology.

Questions assessing quality of written communication will be indicated by the icon of a pencil (✎).

Controlled assessment in GCSE Further Additional Science A

This section provides general guidance on controlled assessment: what controlled assessment tasks are, when and how they are available; how to plan and manage controlled assessment and what controls must be applied throughout the process. More support can be found on the OCR website.

Teaching and Learning

Controlled assessment is designed to be an integral part of teaching and learning. There are many opportunities in teaching and learning to develop skills and use a variety of appropriate materials and equipment. These opportunities allow students to practise a wide range of tasks, and teachers can discuss and comment on performance as appropriate.

When all necessary teaching and learning has taken place and teachers feel that candidates are ready for assessment, candidates can be given the appropriate controlled assessment task.

5.1 Introduction to controlled assessment tasks

All controlled assessment tasks are set by OCR and will be available for submission only in June examination series. Each year a choice of six tasks will be offered; two for each subject area of biology, chemistry and physics. These will correspond to the same tasks available for submission for Biology A (Unit A164), Chemistry A (Unit A174) and Physics A (Unit A184). Within each subject area, one of the tasks will always be based on the Further Additional Science A Modules B7, C7 and P7.

Each task will be valid for submission in a single examination series only, but may be undertaken at any point between release of the task by OCR and the examination series for which the task must be submitted. Centres must ensure that candidates undertake a task that is valid for submission in the year in which the candidate intends to submit it. The series in which each task can be submitted will be clearly marked on the front cover of the task. Tasks will not be valid for submission in any examination series other than that indicated.

Every year, six new controlled assessment tasks will be made available on OCR Interchange from 1 June, two years ahead of the examination series for which the tasks are to be submitted. These will be removed upon expiry. Guidance on how to access controlled assessment tasks from OCR Interchange is available on the OCR website: www.ocr.org.uk.

It is not necessary for all candidates from a centre to carry out the same task from the choice of six provided. Staff at each centre can choose whether:

- all candidates from the centre complete the same task
- all candidates in any teaching group carry out the same task, but different groups use different tasks
- candidates complete tasks on an individual basis.

The number of tasks attempted is at the discretion of the centre, but the results of only one complete task may be submitted.

5.2 Nature of controlled assessment tasks

5.2.1 Introduction to skills assessment

The controlled assessment for GCSE Further Additional Science A comprises one element: a Practical Investigation.

Investigations are central to the nature of science as an evidence-based activity and Practical Investigations provide an effective and valid assessment instrument for a course which is both a basis for further studies and for possible future careers in science. The ability of a candidate to formulate a hypothesis and to explain patterns in results will be related to their knowledge and understanding of the topic.

Controlled assessment tasks for GCSE Further Additional Science A Practical Investigations require candidates to:

- develop hypotheses and plan practical ways to test them including risk assessment
- manage risks when carrying out practical work
- collect, process, analyse and interpret primary and secondary data, including the use of appropriate technology to draw evidence-based conclusions
- review methodology to assess fitness for purpose
- review hypotheses in the light of outcomes.

Practical Investigations therefore draw together the skills of predicting and planning, and collecting, interpreting, evaluating and reviewing primary and secondary data within the context of a whole investigation. Candidates should be familiar with these requirements before starting any controlled assessment task.

It is expected that candidates will be involved in a variety of practical work during the course that will prepare them for this assessment. This should include developing their abilities to handle equipment and carry out practical procedures safely, illustrating science principles with real experiences and learning how to carry out and evaluate investigations.

In addition, candidates' abilities to devise and evaluate suitable methods, to decide on suitable data ranges and to offer explanations will be closely linked to their understanding of some Ideas about Science, particularly:

- IaS1: Data: their importance and limitations
- IaS2: Cause-effect explanations
- IaS3: Developing scientific explanations
- IaS5: Risk.

Candidates should be encouraged to use ideas and vocabulary related to these Ideas about Science in their reports and it is therefore important that candidates are familiar with these ideas before attempting the investigation. Ideas about Science are detailed in Section 3.3.

The tasks to be used for the controlled assessment that are set by OCR will be presented in a way which leaves some freedom for each centre to vary the approach as appropriate, to allow for candidates of different abilities and interests, or for differences in the materials, equipment and facilities at different centres.

The tasks provided will be open-ended and investigative in nature. The information provided with each task will include:

- *Information for candidates (1)*: an introduction to the topic of the investigation, to be issued to candidates at the start of the task, placing the work into an appropriate wider context
- *Information for candidates (2)*: secondary data for analysis, to be issued to candidates only on completion of the data collection part of their Practical Investigation
- *Information for teachers*: an overview of the investigation including notes on possible approaches and assessment issues and guidance for technicians.

At the start of a controlled assessment, candidates will use the information provided to plan how to collect data, including any preliminary work required, and to develop a testable hypothesis before carrying out the investigation. After collecting primary data and interpreting and evaluating the results, candidates will be expected to engage with relevant secondary data to develop and evaluate their conclusions further and review their original hypothesis. Sources of secondary data can include experimental results from other candidates in the class or school, as well as text books and web sites on the internet. In addition, OCR will provide some secondary data relevant to the task set for each Practical Investigation.

The completed work will be presented for assessment as a written report.

5.2.2 Summary of tasks in Unit A194

Assessment Task	Task Marks	Weighting
Practical Investigation	64	25%

5.3 Planning and managing controlled assessment

Controlled assessment tasks will be available up to two years ahead of the examination series for which they are valid, to allow planning time. It is anticipated that candidates will spend a total of about 4.5–6 hours in producing the work for this unit. Candidates should be allowed sufficient time to complete the task.

When supervising tasks, teachers are expected to:

- exercise continuing supervision of work in order to monitor progress and to prevent plagiarism
- provide guidance on the use of information from other sources to ensure that confidentiality and intellectual property rights are maintained
- exercise continuing supervision of practical work to ensure essential compliance with Health and Safety requirements
- ensure that the work is completed in accordance with the specification requirements and can be assessed in accordance with the specified marking criteria and procedures.

Teachers must not provide templates, model answers or feedback on drafts. Candidates must produce their own individual responses to each stage and work independently to produce the report on the final stage (analysis, evaluation and review).

Suggested steps and timings are included below, with guidance on regulatory controls at each stage of the process. Teachers must ensure that control requirements indicated below are met throughout the process.

5.3.1 Research and planning, and collecting data

- Strategy: research and planning **1.5–2 hours**

  In the research and planning stage, a limited level of control is required. This means that candidates can undertake this part of the process without direct teacher supervision and away from the centre, as required. This may also include collection of secondary data where this informs the planning of the work. Candidates are also able to work in collaboration during this stage. During the research phase candidates can be given support and guidance. Teachers can explain the task, advise on how the task could be approached, advise on resources and alert the candidate to key things that must be included in their final piece of work. However, each candidate must develop their own individual response.

- Collecting data **1.5–2 hours**

  In the data collection stage, a limited level of control is required. Candidates will carry out practical work under direct teacher supervision to collect primary data. They may work in collaboration during this stage but all candidates must be actively involved and develop their own, individual response in determining how best to collect and record primary data.

  Secondary data may also be collected during this stage to support or extend the conclusions to the investigation. However, it is not permitted to base the assessment solely on secondary data or (computer) simulations, or on data recorded by candidates whilst watching demonstrations.

  The OCR-provided secondary data, *Information for candidates (2)*, should be given to candidates **only** after collection of primary data is completed. This can be used in addition to secondary data collection by the candidate, if appropriate. Time should be allowed for further collection of secondary data following the issue of *Information for candidates (2)*.

5.3.2 Analysis, evaluation and review

- Analysis, evaluation and review **1.5–2 hours**

  The report for this stage is produced in the centre under conditions of high control, which means that candidates work individually to complete their reports under direct teacher supervision. Teachers must be able to authenticate the work and there must be acknowledgement and referencing of any sources used. If writing up is carried out over several sessions, work must be collected in between each session, including any electronic data storage such as USB memory sticks and rewritable CDs.

5.3.3 Presentation of the final piece of work

Candidates must observe the following procedures when producing their final piece of work for the controlled assessment tasks:

- tables, graphs and spreadsheets may be produced using appropriate ICT. These should be inserted into the final report at the appropriate place
- any copied material must be suitably acknowledged
- quotations must be clearly marked and a reference provided wherever possible
- work submitted for moderation by OCR must be marked with the:
  - centre number
  - centre name
  - candidate number
  - candidate name
  - unit code and title
  - controlled assessment task title.

Work submitted on paper for moderation must be secured by treasury tags. Work submitted in digital format (CD or online) must be in a suitable file structure as detailed in Appendix A at the end of this specification.

5.4 Marking and moderating controlled assessment

All controlled assessment tasks are marked by centre assessor(s) using OCR marking criteria and guidance.

This corresponds to a medium level of control.

5.4.1 Applying the marking criteria

The starting point for marking the tasks is the marking criteria (see section 5.4.5 *Marking criteria for controlled assessment tasks*). These identify levels of performance for the skills, knowledge and understanding that the candidate is required to demonstrate. Some further guidance for each specific task will be provided, if appropriate, in the *Information for teachers* for each task. Before the start of the course, and for use at INSET training events, OCR will provide exemplification through real or simulated candidate work which will help to clarify the level of achievement that assessors should be looking for when awarding marks.

5.4.2 Using the hierarchical marking criteria

A standard method of marking is used for the controlled assessment tasks for Twenty First Century Science GCSE Further Additional Science A, based on a grid of hierarchical marking criteria. The marking criteria indicate levels of response and are generic, so can be used for marking any OCR-issued Practical Investigation. They define the performance for the skills, knowledge and understanding that the candidate is expected to demonstrate at each level. For each task set by OCR, further guidance on applying the marking criteria in the context of the task may also be given in the *Information for teachers*, if appropriate.

Candidates' progress through a task is assessed in five strands, each of which corresponds to a different type of performance by the candidate. Three of the five strands include two different aspects of the work. Thus, marking is based on a total of eight aspects, each of which is shown as a different row in the grid of marking criteria.

For each aspect, a hierarchical set of four marking criteria shows typical performance for candidates working at 1–2, 3–4, 5–6 and 7–8 marks. This provides a level of response mark scheme where achievement is divided into four non-overlapping bands, each covering a range of two marks.

Award of marks in each row of the grid is based on the professional judgement of the teacher and is hierarchical. This means that each of the criteria is considered in turn, working up from the lowest band to the highest band that is fully matched by the candidate's performance. Once a band has been reached which is not fully matched by the work seen, no higher bands can be considered.

Within each two-mark band, the higher mark is available where the performance fully matches the criterion for that mark band (and all preceding, lower mark bands). The lower mark is awarded where the candidate has partially, but not fully, matched this criterion and has exceeded the criteria in the preceding, lower mark bands.

Where there is no evidence of engagement with an aspect of the work, or if the response is not sufficient to merit award of one mark, a mark of zero is awarded for the aspect.

This method of marking can be used even where there is wide variation in performance between different aspects of the work. Weak performance on one aspect need not limit marks in other aspects.

In Strand A, two alternative routes to credit are provided. One row of criteria is used for investigations where the candidate uses graphical display or charts to reveal patterns in the data. The other row is used where the candidate has used statistical or algebraic methods to identify patterns. Only the row which gives the highest mark is counted. However, the requirements of the hierarchical marking criteria can be satisfied by crossing from one row to the other to demonstrate continuous progression through this strand.

The level awarded in each aspect is recorded on a marking grid, which also serves as a cover sheet if the work is called for moderation.

The total for the assessment is the sum of all the aspect marks, giving a maximum possible mark of 64.

5.4.3 Annotation of candidates' work

Each piece of internally assessed work should show how the marks have been awarded in relation to the marking criteria.

The writing of comments on candidates' work, and coversheet, provides a means of communication between teachers during internal standardisation and with the moderator if the work forms part of the moderation sample.

5.4.4 Overview of marking criteria for controlled assessment tasks

The five strands in the marking criteria are designed to match five main stages in the investigation. However, candidates do not always follow this sequence strictly when writing their investigation reports, and positive achievement should be credited in the appropriate strand wherever it is found in the report.

Strand	Aspect	Notes
S strategy	S(a) – formulating a hypothesis or prediction	Candidates review factors that might affect their results (this may include preliminary tests of these effects) and use their scientific knowledge to choose an effect to study, based on a prediction or testable hypothesis (IaS3). Responses in this aspect will be in extended writing and should be assessed for quality of written communication of the content.
	S(b) – design of techniques and choice of equipment	Candidates test different experimental methods or apparatus, and justify the choices they make (IaS1). They show awareness of safe working practices and the hazards associated with materials (IaS1–3, IaS5). At the highest level, a full risk assessment is included.
C collecting data	C – range and quality of primary data	Candidates make decisions about the amount of data to be collected, the range of values covered, and effective checking for repeatability (IaS1).
A analysis	A – revealing patterns in data	To allow access to a wider range of activities, this strand has two alternative sets of criteria. One is for the quality of graphical display. The alternative row can be used to award credit for statistical or numerical analysis of data, e.g. species distribution surveys.
E evaluation	E(a) – evaluation of apparatus and procedures	Candidates show awareness of any limitations imposed by the apparatus or techniques used and suggest improvements to the method.
	E(b) – evaluation of primary data	Candidates consider carefully the repeatability of their data, recognise outliers and treat them appropriately (IaS1).
R review	R(a) – collection and use of secondary data	Candidates collect secondary data, which can be considered together with their own primary data, to give a broader basis for confirmation, adaptation or extension of the initial hypothesis or prediction.
	R(b) – reviewing confidence in the hypothesis	Candidates make an overall review of the evidence in relation to the underlying scientific theory and consider how well it supports the hypothesis, and what extra work might help to improve confidence in the hypothesis (IaS2 and IaS3). Quality of written communication should be taken into account in assessing this aspect of the work.

5.4.5 Marking criteria for controlled assessment tasks

Marking criteria are to be applied hierarchically (see section 5.4.2).

Strand/ Aspect	0	1–2 marks	3–4 marks	5–6 marks	7–8 marks	AO
S a	*	Make a prediction to test, but without any justification. The response may be simplistic, with frequent errors of spelling, punctuation or grammar and have little or no use of scientific vocabulary.	Suggest a testable prediction and justify it by reference to common sense or previous experience. Some relevant scientific terms are used, but spelling, punctuation and grammar are of variable quality.	Consider major factors and refer to scientific knowledge to make a testable hypothesis about how one factor will affect the outcome. Information is effectively organised with generally sound spelling, punctuation and grammar. Specialist terms are used appropriately.	After consideration of all relevant factors, select one and propose a testable hypothesis and quantitative prediction about how it will affect the outcomes. The report is comprehensive, relevant and logically sequenced, with full and effective use of relevant scientific terminology. There are few, if any, grammatical errors.	AO1: 2 marks AO2: 4 marks AO3: 2 marks
S b	*	Follow a given technique, but with very limited precision or accuracy. Make an appropriate comment about safe working.	Select and use basic equipment to collect a limited amount of data. Correctly identify hazards associated with the procedures used.	Select and use techniques and equipment appropriate for the range of data required, and explain the ranges chosen. Identify any significant risks and suggest some precautions.	Justify the choice of equipment and technique to achieve data which is precise and valid. Complete a full and appropriate risk assessment, identifying ways of minimising risks associated with the work.	AO2: 4 marks AO3: 4 marks
C	*	Record a very limited amount of data (e.g. isolated individual data points with no clear pattern), covering only part of the range of relevant cases/situations, with no checking for repeatability. Data is generally of low quality.	Record an adequate amount or range of data, allowing some errors in units or labelling, and with little checking for repeatability. Data is of variable quality, with some operator error apparent.	Collect and correctly record data to cover the range of relevant cases/situations, with regular repeats or checks for repeatability. Data is of generally good quality.	Choose an appropriate range of values to test across the range, with regular repeats and appropriate handling of any outliers. Checks or preliminary work are included to confirm or adapt the range and number of measurements to ensure data of high quality.	AO1: 1 mark AO2: 3 marks AO3: 4 marks

* 0 marks = no response or no response worthy of credit

Strand/ Aspect	0	1–2 marks	3–4 marks	5–6 marks	7–8 marks	AO
A	*	Display limited numbers of results in tables, charts or graphs, using given axes and scales.	Construct simple charts or graphs to display data in an appropriate way, allowing some errors in scaling or plotting.	Correctly select scales and axes and plot data for a graph, including an appropriate line of best fit, or construct complex charts or diagrams e.g. species distribution maps.	Indicate the spread of data (e.g. through scatter graphs or range bars) or give clear keys for displays involving multiple data-sets.	AO3: 8 marks
		Select individual results as a basis for conclusions.	Carry out simple calculations e.g. correct calculation of averages from repeated readings.	Use mathematical comparisons between results to support a conclusion.	Use complex processing to reveal patterns in the data e.g. statistical methods, use of inverse relationships, or calculation of gradient of graphs.	
E a	*	Make relevant comments about problems encountered whilst collecting the data.	Describe the limitations imposed by the techniques and equipment used.	Suggest (in outline) improvements to apparatus or techniques, or alternative ways to collect the data; or explain why the method used gives data of sufficient quality to allow a conclusion.	Describe in detail improvements to the apparatus or techniques, or alternative ways to collect the data, and explain why they would be an improvement; or explain fully why no further improvement could reasonably be achieved.	AO3: 8 marks
E b	*	Make a claim for accuracy or repeatability, but without appropriate reference to the data.	Correctly identify individual results which are beyond the range of experimental error (are outliers), or justify a claim that there are no outliers.	Use the general pattern of results or degree of scatter between repeats as a basis for assessing accuracy and repeatability and explain how this assessment is made.	Consider critically the repeatability of the evidence, accounting for any outliers.	AO3: 8 marks
R a	*	Compare own experimental results with at least one piece of secondary data and make basic comments on similarities and/ or differences. Secondary data collected is limited in amount and not always relevant to the investigation.	Identify in detail similarities and differences between the secondary data and primary data. Secondary data collected is relevant to the investigation and sources are referenced, although these may be incomplete.	Describe and explain the extent to which the secondary data supports, extends and/ or undermines the primary data, and identify any areas of incompleteness. A range of relevant secondary data is collected from several fully referenced sources.	Assess the levels of confidence that can be placed on the available data, and explain the reasons for making these assessments. Comment on the importance of any similarities or differences.	AO1: 1 mark AO2: 1 mark AO3: 6 marks

Strand/ Aspect	0	1–2 marks	3–4 marks	5–6 marks	7–8 marks	AO
R b	*	Correctly state whether or not the original prediction or hypothesis is supported, with reference only to common sense or previous experience. The response is simplistic, with frequent errors in spelling, punctuation or grammar and has little or no use of scientific vocabulary.	Comment on whether trends or correlations in the data support the prediction or hypothesis and suggest why by reference to appropriate science. Some relevant scientific terms are used correctly, but spelling, punctuation and grammar are of variable quality.	Explain the extent to which the hypothesis can account for the pattern(s) shown in the data. Use relevant science knowledge to conclude whether the hypothesis has been supported or to suggest how it should be modified to account for the data more completely. Information is organised effectively with generally sound spelling, punctuation and grammar. Specialist terms are used appropriately.	Give a detailed account of what extra data could be collected to increase confidence in the hypothesis. The report is comprehensive, relevant and logically sequenced, with full and effective use of relevant scientific terminology. There are few, if any, grammatical errors.	AO1: 2 marks AO3: 6 marks

* 0 marks = no response or no response worthy of credit

5.4.6 Assessment Objectives (AOs)

Each of the aspects to be assessed addresses one or more of the assessment objectives and these are shown in the marking criteria. The overall balance is shown in the table below:

Assessment Objective	TOTAL
AO1: Recall, select and communicate their knowledge and understanding of science.	6
AO2: Apply skills, knowledge and understanding of science in practical and other contexts.	12
AO3: Analyse and evaluate evidence, make reasoned judgments and draw conclusions based on evidence.	46
TOTAL	64

5.4.7 Authentication of work

Teachers must be confident that the work they mark is the candidate's own. This does not mean that a candidate must be supervised throughout the completion of all work but the teacher must exercise sufficient supervision, or introduce sufficient checks, to be in a position to judge the authenticity of the candidate's work.

Wherever possible, the teacher should discuss work-in-progress with candidates. This will not only ensure that work is underway in a planned and timely manner but will also provide opportunities for assessors to check authenticity of the work and provide general feedback.

Candidates must not plagiarise. Plagiarism is the submission of another's work as one's own and/or failure to acknowledge the source correctly. Plagiarism is considered to be malpractice and could lead to the candidate being disqualified. Plagiarism sometimes occurs innocently when candidates are unaware of the need to reference or acknowledge their sources. It is therefore important that centres ensure that candidates understand that the work they submit must be their own and that they understand the meaning of plagiarism and what penalties may be applied. Candidates may refer to research, quotations or evidence but they must list their sources. The rewards from acknowledging sources, and the credit they will gain from doing so, should be emphasised to candidates as well as the potential risks of failing to acknowledge such material.

Both candidates and teachers must declare that the work is the candidate's own.

- **Each candidate** must sign a declaration before submitting their work to their teacher. A candidate authentication statement that can be used is available to download from the OCR website. These statements should be retained within the centre until all enquiries about results, malpractice and appeals issues have been resolved. **A mark of zero must be recorded if a candidate cannot confirm the authenticity of their work.**

- **Teachers** are required to declare that the work submitted for internal assessment is the candidate's own work by sending the moderator a centre authentication form (CCS160) for each unit at the same time as the marks. If a centre fails to provide evidence of authentication, **we will set the mark for that candidate(s) to Pending (Q) for that component until authentication can be provided.**

5.5 Internal standardisation

It is important that all internal assessors of this controlled assessment work to common standards. Centres must ensure that the internal standardisation of marks across assessors 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 centres' own standardisation. In subsequent years, this, or centres' own archive material, may be used. Centres are advised to hold preliminary meetings of staff involved to compare standards through cross-marking a small sample of work. After most marking has been completed, a further meeting at which work is exchanged and discussed will enable final adjustments to be made.

Centres with entries for both unit A194: Further Additional Science A Controlled Assessment and for unit A154: Additional Science A Controlled Assessment must ensure internal standardisation takes place across all work for both these units as these units will be moderated together.

5.6 Submitting marks and authentication

All work for controlled assessment is marked by the teacher and internally standardised by the centre. Marks are then submitted to OCR **and** your moderator: refer to the OCR website for submission dates of the marks to OCR.

There should be clear evidence that work has been attempted and some work produced. If a candidate submits no work for an internally assessed component, then the candidate should be indicated as being absent from that component. If a candidate completes any work at all for an internally assessed component, then the work should be assessed according to the internal assessment objectives and marking instructions and the appropriate mark awarded, which may be zero.

The centre authentication form (CCS160) must be sent to the moderator with the marks.

5.7 Submitting samples of candidate work

5.7.1 Sample requests

Once you have submitted your marks, your exams officer will receive an email requesting a moderation sample. Samples will include work from across the range of attainment of the candidates' work.

The sample of work which is presented to the moderator for moderation must show how the marks have been awarded in relation to the marking criteria defined in Section 5.4.5. Each candidate's work should have a cover sheet attached to it with a summary of the marks awarded for the task.

When making your entries, the entry option specifies how the sample for each unit is to be submitted. For unit A194: Further Additional Science A Controlled Assessment, all candidate work must be submitted **using the same entry option**. It is not possible for centres to offer both options for a unit within the same series. Please see the section 8.4.1 for entry codes.

Where centres have entries for both unit A194: Further Additional Science A Controlled Assessment and for unit A154: Additional Science A Controlled Assessment these units will be moderated together. Centres must use the same submission method and entry option across both units. The sample request will be for a combined sample across these two units.

5.7.2 Submitting moderation samples via post

The sample of candidate work must be posted to the moderator within three days of receiving the request. You should use one of the labels provided to send the candidate work.

We would advise you to keep evidence of work submitted to the moderator, e.g. copies of written work or photographs of practical work. You should also obtain a certificate of posting for all work that is posted to the moderator.

5.7.3 Submitting the moderation samples via the OCR Repository

The OCR Repository is a secure website for centres to upload candidate work and for assessors to access this work digitally. Centres can use the OCR Repository for uploading marked candidate work for moderation.

Centres can access the OCR Repository via OCR Interchange, find their candidate entries in their area of the Repository, and use the Repository to upload files (singly or in bulk) for access by their moderator.

The OCR Repository allows candidates to send evidence in electronic file types that would normally be difficult to submit through postal moderation; for example multimedia or other interactive unit submissions.

The OCR GCSE Further Additional Science A unit A194 can be submitted electronically to the OCR Repository via Interchange: please check section 8.4.1 for unit entry codes for the OCR Repository.

There are three ways to load files to the OCR Repository:

1. Centres can load multiple files against multiple candidates by clicking on ‘Upload candidate files’ in the Candidates tab of the Candidate Overview screen.

2. Centres can load multiple files against a specific candidate by clicking on ‘Upload files’ in the Candidate Details screen.

3. Centres can load multiple administration files by clicking on ‘Upload admin files’ in the Administration tab of the Candidate Overview screen.

The OCR Repository is seen as a faster, greener and more convenient means of providing work for assessment. It is part of a wider programme bringing digital technology to the assessment process, the aim of which is to provide simpler and easier administration for centres.

Instructions for how to upload files to OCR using the OCR Repository can be found on the OCR website.

5.8 External moderation

The purpose of moderation is to ensure that the standard of the award of marks for work is the same for each centre and that each teacher has applied the standards appropriately across the range of candidates within the centre.

At this stage, if necessary, centres may be required to provide an additional sample of candidate work (if marks are found to be in the wrong order) or carry out some re-marking. If you receive such a request, please ensure that you respond as quickly as possible to ensure that your candidates’ results are not delayed.

Where a centre has entries for both unit A194: Further Additional Science A Controlled Assessment and for unit A154: Additional Science A Controlled Assessment these units will be moderated together.

Support for GCSE Further Additional Science A

6.1 Free support and training from OCR

Working in close consultation with teachers, publishers and other experts, centres can expect a high level of support, services and resources for OCR qualifications.

Essential FREE support materials including:

- specimen assessment materials and mark schemes
- guide to controlled assessment
- sample controlled assessment materials
- exemplar candidate work and marking commentaries
- teachers' handbook
- sample schemes of work and lesson plans
- guide to curriculum planning.

Essential support services including:

- INSET training – for information visit www.gcse-science.com
- Interchange – a completely secure, free website to help centres reduce administrative tasks at exam time
- Active Results – detailed item level analysis of candidate results
- Answers@OCR – a free online service providing answers to frequently asked questions about GCSE science.

6.2 OCR endorsed resources

OCR works with publishers to ensure centres can access a choice of quality, 'Official Publisher Partner' and 'Approved publication,' resources, endorsed by OCR for use with individual specifications.

You can be confident that resources branded with 'Official Publisher Partner' or 'Approved publication' logos have undergone OCR's thorough quality assurance process and are endorsed for use with the relevant specification.

These endorsements do not mean that the materials are the only suitable resources available or necessary to achieve an OCR qualification. All responsibility for the content of the published resources rests with the publisher.

6.2.1 Publisher partner

We have been working closely with Oxford University Press, our publisher partner for OCR GCSE Twenty First Century Science, to help ensure their new resources match the new specifications and are available when you need them.

Oxford University Press is working with our science team, the Nuffield Foundation and University of York Science Education Group to publish new editions of the popular Twenty First Century Science resources. These resources are lively, engaging and make science relevant to every student.

The second editions of these resources are packed with up-to-date science together with the familiar topics you enjoy teaching, step by step guidance for answering all types of exam questions (including extended response questions) and support for the new controlled assessment.

To order an Evaluation Pack, or for further details, please visit the Oxford University Press website at www.oxfordsecondary.co.uk/twentyfirstcenturyscience.

6.2.2 Endorsed publishers

Other endorsed resources available for this specification include OCR GCSE Twenty First Century Science from Collins.

Collins is working with a team of experienced authors to provide resources which will help you deliver the new OCR GCSE Twenty First Century Science specifications. The Science, Additional Science and Separate Science components build on each other so your department can buy as needed and use them with all students taking different GCSE science routes.

Reduce planning time – the student books, teacher packs, homework activities, interactive books and assessment package are fully integrated and matched to the Collins GCSE Twenty First Century Science scheme of work so you can get started straight away.

For further details and to order an Evaluation Pack visit www.collinseducation.com/gcsescience2011.

6.3 Training

OCR will offer a range of support activities for all practitioners throughout the lifetime of the qualification to ensure they have the relevant knowledge and skills to deliver the qualification.

Please see Event Booker for further information.

6.4 OCR support services

6.4.1 Active Results

Active Results is available to all centres offering the OCR GCSE Further Additional Science A specification.

activeresults

Active Results is a free results analysis service to help teachers review the performance of individual candidates or whole schools.

Data can be analysed using filters on several categories such as gender and other demographic information, as well as providing breakdowns of results by question and topic.

Active Results allows you to look in greater detail at your results:

- richer and more granular data will be made available to centres, including question-level data available from e-marking
- you can identify the strengths and weaknesses of individual candidates and your centre's cohort as a whole
- our systems have been developed in close consultation with teachers so that the technology delivers what you need.

Further information on Active Results can be found on the OCR website.

6.4.2 OCR Interchange

OCR Interchange has been developed to help you to carry out day-to-day administration functions online, quickly and easily. The site allows you to register and enter candidates online. In addition, you can gain immediate and free access to candidate information at your convenience. Sign up on the OCR website.

7 Equality and inclusion in GCSE Further Additional Science A

7.1 Equality Act information relating to GCSE Further Additional Science A

GCSEs often require assessment of a broad range of competences. This is because they are general qualifications and, as such, prepare candidates for a wide range of occupations and higher level courses.

The revised GCSE qualification and subject criteria were reviewed by the regulators in order to identify whether any of the competences required by the subject presented a potential barrier to any disabled candidates. If this was the case, the situation was reviewed again to ensure that such competences were included only where essential to the subject. The findings of this process were discussed with disability groups and with disabled people.

Reasonable adjustments are made for disabled candidates in order to enable them to access the assessments and to demonstrate what they know and can do. For this reason, very few candidates will have a complete barrier to the assessment. Information on reasonable adjustments is found in *Access Arrangements, Reasonable Adjustments and Special Consideration* by the Joint Council www.jcq.org.uk.

Candidates who are unable to access part of the assessment, even after exploring all possibilities through reasonable adjustments, may still be able to receive an award based on the parts of the assessment they have taken.

The access arrangements permissible for use in this specification are in line with Ofqual's GCSE subject criteria equalities review and are as follows:

	Yes/No	Type of Assessment
Readers	Yes	All assessments
Scribes	Yes	All assessments
Practical assistants	Yes	All controlled assessments. The practical assistant may assist with assessed practical experiments under instruction from the candidate.
Word processors	Yes	All assessments
Transcripts	Yes	All assessments
Oral language modifiers	Yes	All assessments
BSL signers	Yes	All assessments
Modified question papers	Yes	All assessments
Extra time	Yes	All assessments

7.2 Arrangements for candidates with particular requirements (including Special Consideration)

All candidates with a demonstrable need may be eligible for access arrangements to enable them to show what they know and can do. The criteria for eligibility for access arrangements can be found in the JCQ document *Access Arrangements, Reasonable Adjustments and Special Consideration.*

Candidates who have been fully prepared for the assessment but who have been affected by adverse circumstances beyond their control at the time of the examination may be eligible for special consideration. As above, centres should consult the JCQ document *Access Arrangements, Reasonable Adjustments and Special Consideration.*

8 Administration of GCSE Further Additional Science A

GCSE Further Additional Science A certification will be available for the first time in June 2014.

8.1 Availability of assessment

There is one examination series available each year in June (all units are available each year in June).

GCSE Further Additional Science A certification is available in June 2014 and each June thereafter.

	Unit A163	Unit A173	Unit A183	Unit A194	Certification availability
June 2014	✓	✓	✓	✓	✓
June 2015	✓	✓	✓	✓	✓

8.2 Certification rules

For GCSE Further Additional Science A, a 100% terminal rule applies. Candidates must enter for all their units in the series in which the qualification is certificated.

8.3 Rules for re-taking a qualification

Candidates may enter for the qualification an unlimited number of times.

Where a candidate re-takes a qualification, **all** units must be re-entered and all externally assessed units must be re-taken in the same series as the qualification is re-certificated. The new results for these units will be used to calculate the new qualification grade. Any results previously achieved cannot be re-used.

For the controlled assessment unit, candidates who are re-taking a qualification can choose either to re-take that controlled assessment unit or to carry forward the result for that unit that was used towards the previous certification of the same qualification.

- Where a candidate decides to re-take the controlled assessment, the new result will be the one used to calculate the new qualification grade. Any results previously achieved cannot be re-used.
- Where a candidate decides to carry forward a result for controlled assessment, they must be entered for the controlled assessment unit in the re-take series using the entry code for the carry forward option (see section 8.4).

8.4 Making entries

8.4.1 Unit entries

Centres must be approved to offer OCR qualifications before they can make any entries, including estimated entries. It is recommended that centres apply to OCR to become an approved centre well in advance of making their first entries. Centres must have made an entry for a unit in order for OCR to supply the appropriate forms and administrative materials.

It is essential that correct unit entry codes are used when making unit entries.

For the externally assessed units A163, A173 and A183 candidates must be entered for either component 01 (Foundation Tier) or 02 (Higher Tier) using the appropriate unit entry code from the table below. It is not possible for a candidate to take both components for a particular unit within the same series; however, different units may be taken at different tiers.

For the controlled assessment unit, centres can decide whether they want to submit candidates' work for moderation through the OCR Repository or by post. Candidates submitting controlled assessment must be entered for the appropriate unit entry code from the table below. Candidates who are re-taking the qualification and who want to carry forward the controlled assessment should be entered using the unit entry code for the carry forward option.

Centres should note that controlled assessment tasks can still be completed at a time which is appropriate to the centre/candidate. However, where tasks change from year to year, centres would have to ensure that candidates had completed the correct task(s) for the year of entry.

Unit entry code	Component code	Assessment method	Unit titles
A163F	01	Written Paper	Unit A163: *Biology A Module B7* (Foundation Tier)
A163H	02	Written Paper	Unit A163: *Biology A Module B7* (Higher Tier)
A173F	01	Written Paper	Unit A173: *Chemistry A Module C7* (Foundation Tier)
A173H	02	Written Paper	Unit A173: *Chemistry A Module C7* (Higher Tier)
A183F	01	Written Paper	Unit A183: *Physics A Module P7* (Foundation Tier)
A183H	02	Written Paper	Unit A183: *Physics A Module P7* (Higher Tier)
A194A	01	Moderated via OCR Repository	Unit A194: *Further Additional Science A* Controlled assessment
A194B	02	Moderated via postal moderation	Unit A194: *Further Additional Science A* Controlled assessment
A194C	80	Carried forward	Unit A194: *Further Additional Science A* Controlled assessment

8.4.2 Certification entries

Candidates must be entered for qualification certification separately from unit assessment(s). If a certification entry is **not** made, no overall grade can be awarded.

Centres must enter candidates for:

- GCSE Further Additional Science A certification code J246.

8.5 Enquiries about results

Under certain circumstances, a centre may wish to query the result issued to one or more candidates. Enquiries about results for GCSE units must be made immediately following the series in which the relevant unit was taken and by the relevant enquiries about results deadline for that series.

Please refer to the JCQ *Post-Results Services* booklet and the OCR *Admin Guide: 14–19 Qualifications* for further guidance on Enquiries about results and deadlines. Copies of the latest versions of these documents can be obtained from the OCR website at www.ocr.org.uk.

8.6 Prohibited qualifications and classification code

Every specification is assigned a national classification code indicating the subject area to which it belongs. The classification code for this specification is 1320.

Centres should be aware that candidates who enter for more than one GCSE qualification with the same classification code will have only one grade (the highest) counted for the purpose of the School and College Performance Tables.

Centres may wish to advise candidates that, if they take two specifications with the same classification code, colleges are very likely to take the view that they have achieved only one of the two GCSEs. The same view may be taken if candidates take two GCSE specifications that have different classification codes but have significant overlap of content. Candidates who have any doubts about their subject combinations should seek advice, either from their centre or from the institution to which they wish to progress.

Candidates who are entered for J246 GCSE Further Additional Science A may not also enter for J243 GCSE Biology A, or J244 GCSE Chemistry A or J245 GCSE Physics A in the same examination series.

9 Other information about GCSE Further Additional Science A

9.1 Overlap with other qualifications

This specification has been developed alongside GCSE Science A, GCSE Additional Science A, GCSE Biology A, GCSE Chemistry A, GCSE Physics A and GCSE Additional Applied Science.

This specification includes the content of Modules B7, C7 and P7 of GCSE Biology A, GCSE Chemistry A and GCSE Physics A.

Aspects of the controlled assessment of skills are common across GCSE Additional Science A, GCSE Biology A, GCSE Chemistry A and GCSE Physics A.

9.2 Progression from this qualification

GCSE qualifications are general qualifications which enable candidates to progress either directly to employment, or to proceed to further qualifications.

Progression to further study from GCSE will depend upon the number and nature of the grades achieved. Broadly, candidates who are awarded mainly Grades D to G at GCSE could either strengthen their base through further study of qualifications at Level 1 within the National Qualifications Framework or could proceed to Level 2. Candidates who are awarded mainly Grades A* to C at GCSE would be well prepared for study at Level 3 within the National Qualifications Framework.

9.3 Avoidance of bias

OCR has taken great care in preparation of this specification and assessment materials to avoid bias of any kind. Special focus is given to the 9 strands of the Equality Act with the aim of ensuring both direct and indirect discrimination is avoided.

9.4 Regulatory requirements

This specification complies in all respects with the current: *General Conditions of Recognition; GCSE, GCE, Principal Learning and Project Code of Practice; GCSE Controlled Assessment regulations* and the *GCSE subject criteria for Science.* All documents are available on the Ofqual website.

9.5 Language

This specification and associated assessment materials are in English only. Only answers written in English will be assessed.

9.6 Spiritual, moral, ethical, social, legislative, economic and cultural issues

This specification offers opportunities which can contribute to an understanding of these issues.

The table below gives some examples which could be used when teaching the course.

Issue	Opportunities for teaching the issues during the course
Moral issues The commitment of scientists to publish their findings and subject their ideas to testing by others.	Practical Investigation: reviewing the strategy and procedures.
Ethical issues The ethical implications of selected scientific issues.	B7: Ethical issues arising from implications of new technologies. C7: Green chemistry.
Social issues Risk and the factors which decide the level of risk people are willing to accept in different circumstances.	B7: Data on exercise and risks associated with an unhealthy lifestyle.
Economic issues The range of factors which have to be considered when weighing the costs and benefits of scientific activity.	B7: Evaluating the costs and benefits associated with new technologies. C7: Evaluating the costs and benefits of bulk and fine processing in the chemical industry.
Cultural issues Scientific explanations which give insight into the local and global environment.	B7: What can be learnt from natural ecosystems. P7: Study of the life history of stars, the possible futures for the Universe, and the possibility of life in other parts of the Universe.

9.7 Sustainable development, health and safety considerations and European developments, consistent with international agreements

This specification supports these issues, consistent with current EU agreements, as outlined below.

The specification incorporates specific modules on health and welfare and on the environment within its content. These modules encourage candidates to develop environmental responsibility based upon a sound understanding of the principle of sustainable development.

9.8 Key Skills

This specification provides opportunities for the development of the Key Skills of *Communication, Application of Number, Information and Communication Technology, Working with Others, Improving Own Learning and Performance and Problem Solving* at Levels 1 and/or 2. However, the extent to which this evidence fulfils the Key Skills criteria at these levels will be totally dependent on the style of teaching and learning adopted for each unit.

The following table indicates where opportunities may exist for at least some coverage of the various Key Skills criteria at Levels 1 and/or 2 for each unit.

Unit	C		AoN		ICT		WwO		IoLP		PS	
	1	2	1	2	1	2	1	2	1	2	1	2
A163	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
A173	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
A183	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
A194	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

9.9 ICT

In order to play a full part in modern society, candidates need to be confident and effective users of ICT. This specification provides candidates with a wide range of appropriate opportunities to use ICT in order to further their study of biology.

Opportunities for ICT include:

- using videos clips to provide the context for topics studied and to illustrate the practical importance of the scientific ideas
- gathering information from the internet and CD-ROMs
- gathering data using sensors linked to data-loggers or directly to computers
- using spreadsheets and other software to process data
- using animations and simulations to visualise scientific ideas
- using modelling software to explore theories
- using software to present ideas and information on paper and on screen.

Particular opportunities for the use of ICT appear in the introductions to each of the modules.

9.10 Citizenship

From September 2002, the National Curriculum for England at Key Stage 4 includes a mandatory programme of study for Citizenship.

GCSE Further Additional Science A is designed as a science education for future citizens which not only covers aspects of the Citizenship programme of study but also extends beyond that programme by dealing with important aspects of science which all people encounter in their everyday lives.

Appendix A: Guidance for the production of electronic controlled assessment

Structure for evidence

A controlled assessment portfolio is a collection of folders and files containing the candidate's evidence. Folders should be organised in a structured way so that the evidence can be accessed easily by a teacher or moderator. 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 candidate's centre number, candidate number, surname and forename, together with the unit code A194, so that the portfolio is clearly identified as the work of one candidate.

Each candidate produces an assignment for controlled assessment. The evidence should be contained within a separate folder within the portfolio. This folder may contain separate files.

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

Data formats for evidence

In order to minimise software and hardware compatibility issues it will be necessary to save candidates' work using an appropriate file format.

Candidates must use formats appropriate to the evidence that they are providing and appropriate to viewing for assessment and moderation. Open file formats or proprietary formats for which a downloadable reader or player is available are acceptable. Where this is not available, the file format is not acceptable.

Electronic controlled assessment is designed to give candidates an opportunity to demonstrate what they know, understand and can do using current technology. Candidates do not gain marks for using more sophisticated formats or for using a range of formats. A candidate who chooses to use only word documents will not be disadvantaged by that choice.

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

To ensure compatibility, all files submitted must be in the formats listed below. Where new formats become available that might be acceptable, OCR will provide further guidance. OCR advises against changing the file format that the document was originally created in. It is the centre's responsibility to ensure that the electronic portfolios submitted for moderation are accessible to the moderator and fully represent the evidence available for each candidate.

Accepted file formats

Movie formats for digital video evidence
MPEG (*.mpg)
QuickTime movie (*.mov)
Macromedia Shockwave (*.aam)
Macromedia Shockwave (*.dcr)
Flash (*.swf)
Windows Media File (*.wmf)
MPEG Video Layer 4 (*.mp4)

Audio or sound formats
MPEG Audio Layer 3 (*.mp3)

Graphics formats including photographic evidence
JPEG (*.jpg)
Graphics file (*.pcx)
MS bitmap (*.bmp)
GIF images (*.gif)

Animation formats
Macromedia Flash (*.fla)

Structured markup formats
XML (*.xml)

Text formats
Comma Separated Values (.csv)
PDF (.pdf)
Rich text format (.rtf)
Text document (.txt)

Microsoft Office suite
PowerPoint (.ppt)
Word (.doc)
Excel (.xls)
Visio (.vsd)
Project (.mpp)

B Appendix B: Mathematics skills for GCSE science qualifications

Candidates are permitted to use calculators in all assessments.

Candidates should be able to:

1 understand number size and scale and the quantitative relationship between units

2 understand when and how to use estimation

3 carry out calculations involving +, – , ×, ÷, either singly or in combination, decimals, fractions, percentages and positive whole number powers

4 provide answers to calculations to an appropriate number of significant figures

5 understand and use the symbols =, <, >, ~

6 understand and use direct proportion and simple ratios

7 calculate arithmetic means

8 understand and use common measures and simple compound measures such as speed

9 plot and draw graphs (line graphs, bar charts, pie charts, scatter graphs, histograms), selecting appropriate scales for the axes

10 substitute numerical values into simple formulae and equations using appropriate units

11 translate information between graphical and numeric form

12 extract and interpret information from charts, graphs and tables

13 understand the idea of probability

14 calculate area, perimeters and volumes of simple shapes.

In addition, Higher Tier candidates should be able to:

15 interpret, order and calculate with numbers written in standard form

16 carry out calculations involving negative powers (only –1 for rate)

17 change the subject of an equation

18 understand and use inverse proportion

19 understand and use percentiles and deciles.

Appendix C: Physical quantities and units

It is expected that candidates will show an understanding of the physical quantities and corresponding SI units listed below, and will be able to use them in quantitative work and calculations. Whenever they are required for such questions, units will be provided and, where necessary, explained.

Fundamental physical quantities

Physical quantity	Unit(s)
length	metre (m); kilometre (km); centimetre (cm); millimetre (mm); nanometre (nm)
mass	kilogram (kg); gram (g); milligram (mg)
time	second (s); millisecond (ms); year (a); million years (Ma); billion years (Ga)
temperature	degree Celsius (°C); kelvin (K)
current	ampere (A); milliampere (mA)

Derived physical quantities and units

Physical quantity	Unit(s)
area	cm^2; m^2
volume	cm^3; dm^3; m^3; litre (l); millilitre (ml)
density	kg/m^3; g/cm^3
speed, velocity	m/s; km/h
acceleration	m/s^2
momentum	kg m/s
force	newton (N)
pressure	N/m^2; pascal (Pa)
gravitational field strength	N/kg
energy	joule (J); kilojoule (kJ); megajoule (MJ); kilowatt hour (kWh); megawatt hour (MWh)
power	watt (W); kilowatt (kW); megawatt (MW)
frequency	hertz (Hz); kilohertz (kHz)
information	bytes (B); kilobytes (kB); megabytes (MB)
potential difference	volt (V)
resistance	ohm (Ω)
radiation dose	sievert (Sv)
distance (in astronomy)	light-year (ly); parsec (pc)
power of a lens	dioptre (D)

Prefixes for units			
nano (n)	one thousand millionth	0.000000001	$\times 10^{-9}$
micro (μ)	one millionth	0.000001	$\times 10^{-6}$
milli (m)	one thousandth	0.001	$\times 10^{-3}$
kilo (k)	× one thousand	1000	$\times 10^{3}$
mega (M)	× one million	1 000 000	$\times 10^{6}$
giga (G)	× one thousand million	1 000 000 000	$\times 10^{9}$
tera (T)	× one million million	1 000 000 000 000	$\times 10^{12}$

Appendix D: Health and safety

In UK law, health and safety is the responsibility of the employer. For most establishments entering candidates for GCSE, this is likely to be the local education authority or the governing body. Employees, i.e. teachers and lecturers, have a duty to cooperate with their employer on health and safety matters. Various regulations, but especially the COSHH Regulations 2002 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 provide a risk assessment.

For members, the CLEAPSS® guide, *Managing Risk Assessment in Science** offers detailed advice. Most education employers have adopted a range of nationally available publications as the basis for their Model Risk Assessments. Those commonly used include:

Safety in Science Education, DfEE, 1996, HMSO, ISBN 0 11 270915 X.

Topics in Safety, 3rd edition, 2001, ASE ISBN 0 86357 316 9;

Safeguards in the School Laboratory, 11th edition, 2006, ASE ISBN 978 0 86357 408 5;

CLEAPSS® *Hazcards,* 2007 edition and later updates*;

CLEAPSS® *Laboratory Handbook**;

Hazardous Chemicals, A Manual for Science Education, 1997, SSERC Limited ISBN 0 9531776 0 2.

Where an employer has adopted these or other publications as the basis of their 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 candidates were insufficient to attempt particular activities safely. The significant findings of such risk assessment should then be recorded, 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, although a few employers require this.

Where project work or individual investigations, sometimes linked to work-related activities, are included in specifications this may well lead to the use of novel procedures, chemicals or micro-organisms, 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® (or, in Scotland, SSERC).

*These, and other CLEAPSS® publications, are on the CLEAPSS® Science Publications CD-ROM issued annually to members. Note that CLEAPSS® publications are only available to members. For more information about CLEAPSS® go to www.cleapss.org.uk. In Scotland, SSERC (www.sserc.org.uk) has a similar role to CLEAPSS® and there are some reciprocal arrangements.

Appendix E: Periodic table

Key

relative atomic mass **atomic symbol** name atomic (proton) number

1	2											3	4	5	6	7	0
							1 **H** hydrogen 1										4 **He** helium 2
7 **Li** lithium 3	9 **Be** beryllium 4											11 **B** boron 5	12 **C** carbon 6	14 **N** nitrogen 7	16 **O** oxygen 8	19 **F** fluorine 9	20 **Ne** neon 10
23 **Na** sodium 11	24 **Mg** magnesium 12											27 **Al** aluminium 13	28 **Si** silicon 14	31 **P** phosphorus 15	32 **S** sulfur 16	35.5 **Cl** chlorine 17	40 **Ar** argon 18
39 **K** potassium 19	40 **Ca** calcium 20	45 **Sc** scandium 21	48 **Ti** titanium 22	51 **V** vanadium 23	52 **Cr** chromium 24	55 **Mn** manganese 25	56 **Fe** iron 26	59 **Co** cobalt 27	59 **Ni** nickel 28	63.5 **Cu** copper 29	65 **Zn** zinc 30	70 **Ga** gallium 31	73 **Ge** germanium 32	75 **As** arsenic 33	79 **Se** selenium 34	80 **Br** bromine 35	84 **Kr** krypton 36
85 **Rb** rubidium 37	88 **Sr** strontium 38	89 **Y** yttrium 39	91 **Zr** zirconium 40	93 **Nb** niobium 41	96 **Mo** molybdenum 42	[98] **Tc** technetium 43	101 **Ru** ruthenium 44	103 **Rh** rhodium 45	106 **Pd** palladium 46	108 **Ag** silver 47	112 **Cd** cadmium 48	115 **In** indium 49	119 **Sn** tin 50	122 **Sb** antimony 51	128 **Te** tellurium 52	127 **I** iodine 53	131 **Xe** xenon 54
133 **Cs** caesium 55	137 **Ba** barium 56	139 **La*** lanthanum 57	178 **Hf** hafnium 72	181 **Ta** tantalum 73	184 **W** tungsten 74	186 **Re** rhenium 75	190 **Os** osmium 76	192 **Ir** iridium 77	195 **Pt** platinum 78	197 **Au** gold 79	201 **Hg** mercury 80	204 **Tl** thallium 81	207 **Pb** lead 82	209 **Bi** bismuth 83	[209] **Po** polonium 84	[210] **At** astatine 85	[222] **Rn** radon 86
[223] **Fr** francium 87	[226] **Ra** radium 88	[227] **Ac*** actinium 89	[261] **Rf** rutherfordium 104	[262] **Db** dubnium 105	[266] **Sg** seaborgium 106	[264] **Bh** bohrium 107	[277] **Hs** hassium 108	[268] **Mt** meitnerium 109	[271] **Ds** darmstadtium 110	[272] **Rg** roentgenium 111	Elements with atomic numbers 112-116 have been reported but not fully authenticated						

***The lanthanoids (atomic numbers 58-71) and the actinoids (atomic numbers 90-103) have been omitted.**

The relative atomic masses of copper and chlorine have not been rounded to the nearest whole number.

YOUR CHECKLIST

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Fax: 01223 552627

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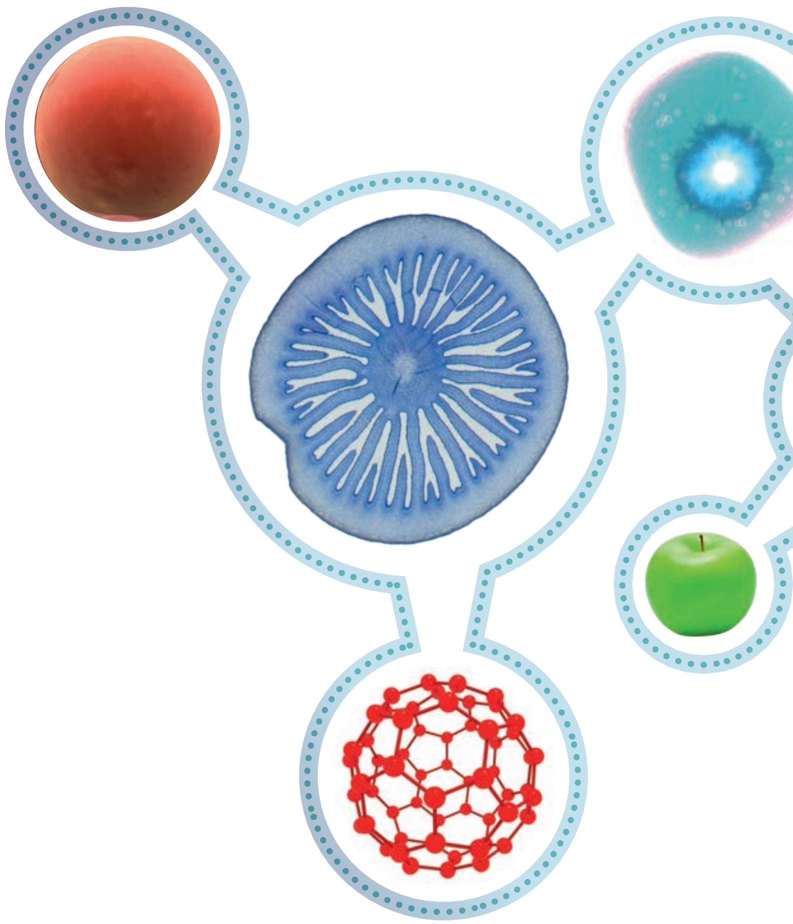

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