TWENTY FIRST CENTURY SCIENCE SUITE

GCSE SCIENCE A

ACCREDITED SPECIFICATION

J241

VERSION 1

MARCH 2011

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

Fax: 01223 552627

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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, controlled assessment and curriculum planning.

Our essential FREE support includes:

Materials

- Specimen assessment materials and mark schemes
- Guide to controlled assessment
- Sample controlled assessment material
- Exemplar candidate work
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- Guide to curriculum planning
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- include useful information about our specifications direct from the experts
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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.

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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.

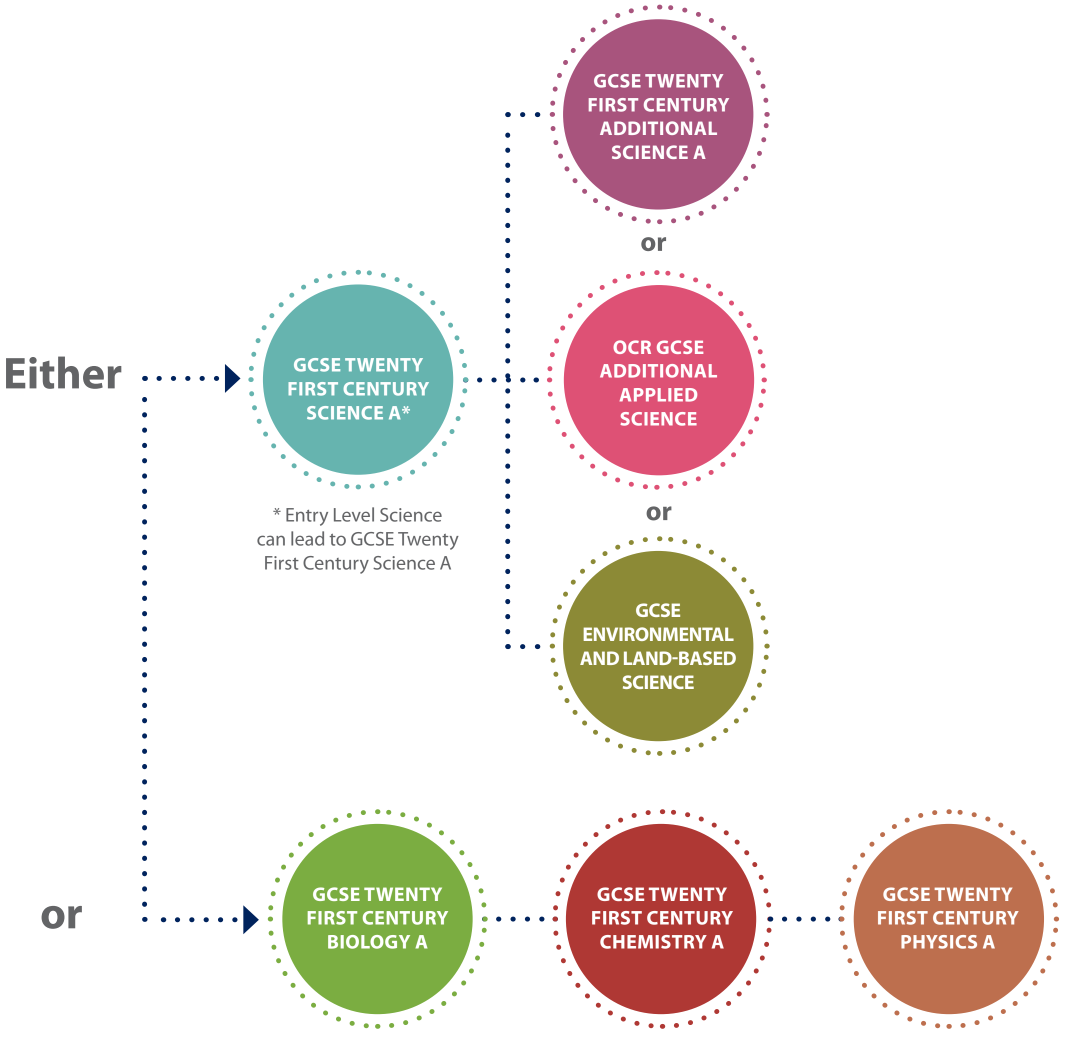
Our Twenty First Century Science suite:

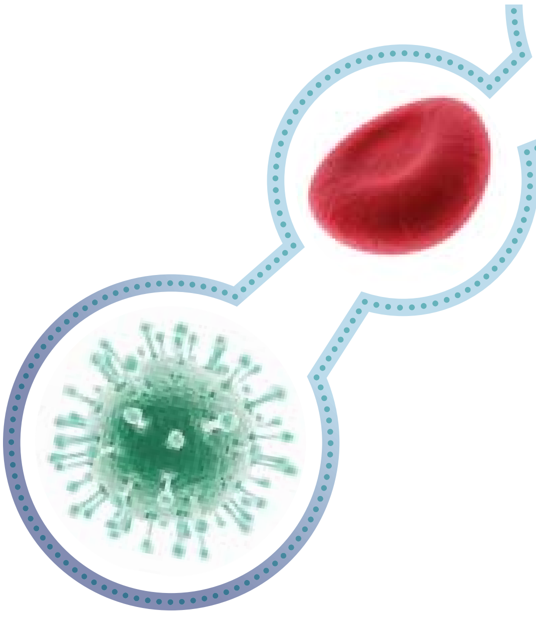
- is engaging to study and motivating for you to teach
- will help your learners engage with the course rather than just study it
- gives you the flexibility to choose a delivery style to engage students.

KEY FEATURES

- **Flexible assessments**, which can be arranged to suit your centre and your students – unit exams will be available twice a year, in January and June.
- 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 SCIENCE A

KEY FEATURES

GCSE Science A has an emphasis on scientific literacy – the knowledge and understanding that learners need to recognise the impact of science and technology on everyday life.

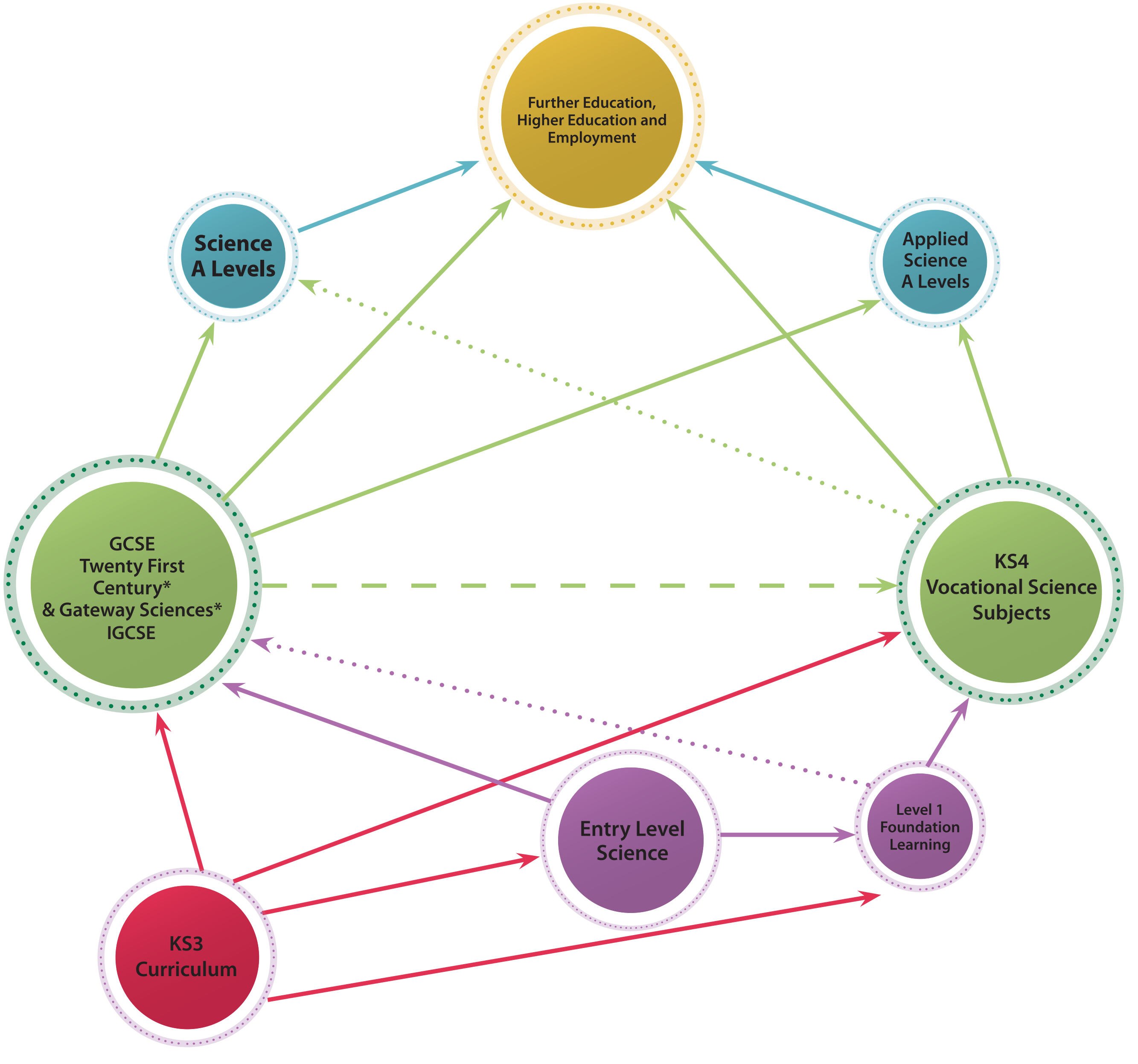
There are two alternative routes to achieve GCSE Science A:

Route 1 using Unit A161 from Biology A, Unit A171 from Chemistry A and Unit A181 from Physics A (separate science papers);

Route 2 using Units A141, A142 and A143 of Science A (mixed science papers).

COURSE OVERVIEW ROUTE 1	OR	COURSE OVERVIEW ROUTE 2	ASSESSMENT OVERVIEW (APPLIES TO BOTH ROUTE 1 AND ROUTE 2)		
A161 (BIOLOGY A) Module B1: You and your genes Module B2: Keeping healthy Module B3: Life on Earth		**A141 (SCIENCE A)** Module B1: You and your genes Module C1: Air quality Module P1: The Earth in the Universe	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
A171 (CHEMISTRY A) Module C1: Air quality Module C2: Material choices Module C3: Chemicals in our lives : risks & benefits		**A142 (SCIENCE A)** Module B2: Keeping healthy Module C2: Material choices Module P2: Radiation and life	60 marks 1 hour written paper	**25%** of total GCSE	
A181 (PHYSICS A) Module P1: The Earth in the Universe Module P2: Radiation and life Module P3: Sustainable energy		**A143 (SCIENCE A)** Module B3: Life on Earth Module C3: Chemicals in our lives : risks & benefits Module P3: Sustainable energy	60 marks 1 hour written paper	**25%** of total GCSE	
A144 (SCIENCE A) Controlled assessment		**A144 (SCIENCE A)** Controlled assessment	64 marks Approx 6–7 hours	**25%** of total GCSE	Comprises a Practical Data Analysis and Case Study of a topical issue in science 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, Biology, Chemistry and Physics.

Contents

Contents

1 Introduction to the Twenty First Century Science suite

The Twenty First Century Science suite comprises five 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 Biology A
- GCSE Chemistry A
- GCSE Physics A.

<table>
<tr><td>GCSE Science A (J241)</td><td>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.</td></tr>
<tr><td>GCSE Additional Science A (J242)</td><td>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.</td></tr>
<tr><td>GCSE Biology A (J243)</td><td rowspan="3">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.</td></tr>
<tr><td>GCSE Chemistry A (J244)</td></tr>
<tr><td>GCSE Physics A (J245)</td></tr>
</table>

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 as an alternative route to two science GCSEs, for candidates not following GCSE Additional Science A.

2 Introduction to GCSE Science A

2.1 Overview of OCR GCSE Science A

There are **two** alternative routes to achieve GCSE Science A:

- route 1 using Unit A161 from Biology A, Unit A171 from Chemistry A and Unit A181 from Physics A (separate science papers)
- route 2 using Units A141, A142 and A143 from Science A (mixed science papers).

Route 1

Biology A Unit A161: ***Modules B1, B2, B3***	
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.

+

Chemistry A Unit A171: ***Modules C1, C2, C3***	
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.

+

Physics A Unit A181: ***Modules P1, P2, P3***	
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.

+

Science A Unit A144: ***Controlled assessment***	
This unit is not tiered.	Controlled assessment Approximately 6–7 hours 64 marks 25% of the qualification

Route 2

Science A Unit A141: *Modules B1, C1, P1*

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.

+

Science A Unit A142: *Modules B2, C2, P2*

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.

+

Science A Unit A143: *Modules, B3, C3, P3*

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.

+

Science A Unit A144: *Controlled assessment*

This unit is not tiered.	Controlled assessment Approximately 6–7 hours 64 marks 25% of the qualification

2.2 What is new in OCR GCSE Science A?

	What stays the same?	What changes?
Structure	• The course can be taught as modular or linear. • Externally assessed units are tiered – Foundation and Higher Tier. • Two routes to each GCSE using either separate science papers (route 1) or Science A mixed science papers (route 2).	• Reduced from five to four units, comprising three externally assessed units and one internally assessed unit. • All four units have equal weightings of 25%. • Controlled assessment replaces coursework. • No 'Ideas in Context' paper, and no pre-release material for externally assessed units.
Content	• Content is divided into nine modules.	• New module C3 'Chemicals in our lives', replaces 'Food Matters'. • Module P3 'Radioactive materials' is reorganised, some content retained in new P3 'Sustainable energy' and the rest transferred to the new P6 'Radioactive materials'. • Parts of the original P6 'The wave model of radiation' are transferred to the updated P2 'Radiation and life'.
Assessment	• Internally assessed unit is based on a case study and practical data analysis. • Modules are externally assessed within written examination papers. • Ideas about Science (How Science Works) are written into the specification content. • January and June assessments are available for written papers. • Controlled assessment available in June series only.	• New terminal and re-sit rules apply to science GCSEs. • There will be a choice of controlled assessment tasks set by OCR, each valid for entry in a single examination series. • Controlled assessment is worth 25%, and will be simpler to mark and administer. • Ideas about Science are associated with all units. • Quality of written communication (QWC) will be assessed in all units. • Externally assessed papers are each 1 hour long, with a total of 60 marks divided between objective (worth 40%) and free-response style questions.

2.3 Guided learning hours

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

3 Content of GCSE Science A

3.1 Summary of content

GCSE Science A offers students the chance to develop the scientific literacy needed by active and informed citizens in a modern democratic society where science and technology play key roles in shaping our lives. The course content has a clear focus on scientific literacy. Teachers can use a wide range of teaching and learning styles, challenging students to consider critically the issues and choices raised by technology and science. Students will appreciate what science has to say about people, the environment and the Universe.

A module defines the required teaching and learning outcomes.

The specification content is displayed as nine modules. The titles of these nine modules are listed in the table on the next page.

Each module is designed to be taught in approximately **half a term**, in 10% of the candidates' curriculum time.

Module B1: You and your genes	Module B2: Keeping healthy	Module B3: Life on Earth
• What are genes and how do they affect the way that organisms develop? • Why can people look like their parents, brothers and sisters, but not be identical to them? • How can and should genetic information be used? How can we use our knowledge of genes to prevent disease? • How is a clone made?	• How do our bodies resist infection? • What are vaccines and antibiotics and how do they work? • What factors increase the risk of heart disease? • How do our bodies keep a healthy water balance?	• Systems in balance – how do different species depend on each other? • How has life on Earth evolved? • What is the importance of biodiversity?
Module C1: Air quality	**Module C2: Material choices**	**Module C3: Chemicals in our lives – risks and benefits**
• Which chemicals make up air, and which ones are pollutants? How do I make sense of data about air pollution? • What chemical reactions produce air pollutants? What happens to these pollutants in the atmosphere? • What choices can we make personally, locally, nationally or globally to improve air quality?	• How do we measure the properties of materials and why are the results useful? • Why is crude oil important as a source of new materials such as plastics and fibres? • Why does it help to know about the molecular structure of materials such as plastics and fibres? • What is nanotechnology and why is it important?	• What were the origins of minerals in Britain that contribute to our economic wealth? • Where does salt come from and why is it so important? • Why do we need chemicals such as alkalis and chlorine and how do we make them? • What can we do to make our use of chemicals safe and sustainable?
Module P1: The Earth in the Universe	**Module P2: Radiation and life**	**Module P3: Sustainable energy**
• What do we know about the place of the Earth in the Universe? • What do we know about the Earth and how it is changing?	• What types of electromagnetic radiation are there? What happens when radiation hits an object? • Which types of electromagnetic radiation harm living tissue and why? • What is the evidence for global warming, why might it be occurring, and how serious a threat is it? • How are electromagnetic waves used in communications?	• How much energy do we use? • How can electricity be generated? • Which energy sources should we choose?

3.2 Layout of specification content

The specification content is divided into nine modules. There are two alternative routes to achieve GCSE Science A.

Sections 3.3, 3.4 and 3.5 summarise the units and the associated content that are required for route 1. Sections 3.6, 3.7 and 3.8 summarise the units and the associated content that are required for route 2.

Within each section, a summary of the unit precedes the modules that are assessed within that unit, indicating the modules and the associated Ideas about Science that can be assessed.

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

- issues for citizens which are likely to be uppermost in the minds of citizens when considering the module topic, whatever their understanding of science
- questions about the topic that science can help to address which could reasonably be asked of a scientifically literate person
- opportunities for mathematics
- opportunities for practical work
- opportunities for ICT.

Following the module overview, the Ideas about Science that can be introduced or developed in the module are outlined. Finally, the module content is presented in detail.

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

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

3.3 Summary of Biology A Unit A161: *Modules B1, B2, B3*

Unit A161 is the unit within assessment route 1 to GCSE Science A where the biology content is assessed. It assesses the content of Modules B1, B2 and B3 together with their associated Ideas about Science. The other route 1 units are Unit A171 (Section 3.4) and Unit A181 (Section 3.5).

The modules in Unit A161 offer students the chance to develop the scientific literacy needed by active and informed citizens in a modern democratic society where science and technology play key roles in shaping our lives. The course content has a clear focus on scientific literacy. Teachers can use a wide range of teaching and learning styles, challenging students to consider critically the issues and choices raised by technology and science. Students will appreciate what science has to say about people, the environment and the Universe.

Ideas about Science in Unit A161

Modules B1, B2 and B3 present learning opportunities for a number of the Ideas about Science. The start of each module details the particular Ideas about Science that can be introduced or developed within the contexts covered in the module. Specific examples of contexts within which Ideas about Science can be taught are given in the OCR scheme of work for GCSE Science A (published separately).

However, it is not intended that understanding and application of Ideas about Science should be limited to the context in which they are taught; they should be applicable to any appropriate scientific context.

Accordingly, questions in Unit A161 can assess any of the Ideas about Science linked to Modules B1, B2 and B3, and these Ideas about Science may be assessed in the context of any of the learning outcomes covered in the three modules.

In summary, the Ideas about Science that can be assessed in Unit A161, within any of the scientific contexts introduced by Modules B1, B2 and B3, are:

Cause-effect explanations
IaS 2.3 – 2.7
Developing scientific explanations
IaS 3.1 – 3.4
The scientific community
IaS 4.1 – 4.4
Risk
IaS 5.1 – 5.7
Making decisions about science and technology
IaS 6.1 – 6.6

3.3.1 Module B1: You and your genes

Overview

The inheritance of detailed information from each generation to the next is a fundamental story in science. For each of us, inheritance also raises questions about our own development. In this module, candidates learn basic concepts of inheritance: genes as units of inheritance, the interplay between genes and environment and sexual reproduction as a source of variation.

These concepts are sufficiently detailed for candidates to make sense of related ideas in other GCSE Science modules. More complex ideas, such as mechanisms for protein synthesis and cell division, are not required; these are covered in GCSE Additional Science A.

Throughout the module, candidates are introduced to genetic technologies that open up new possibilities for individuals and society. In doing so, they present significant ethical issues for citizens. Candidates explore some of the ideas people use to make ethical decisions. This enables them to engage with issues which regularly appear in the media, such as genetic testing and cloning research.

Some of the issues covered in this module may be very sensitive for candidates.

Issues for citizens	Questions that science may help to answer
How do my genes affect my appearance, my body, and my health? How and why do people find out about their genes? What decisions do people make with this information? Can we change our genes, and should this be allowed? What is cloning, and should it be allowed?	What are genes and how do they affect the way that organisms develop? Why can people look like their parents, brothers or sisters, but not be identical to them? How can and should genetic information be used? How can we use our knowledge of genes to prevent disease? How can we use our knowledge of genes to improve treatment of disease? What are stem cells, and why could they be useful in treating some diseases?

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
- use ideas of ratios in the context of inheritance
- plot, draw and interpret graphs and charts from candidates' own and secondary data
- use ideas about probability in the context of risk.

Opportunities for practical work

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

- clone plant materials
- model fertilisation to illustrate the random nature of allele distribution in sex
- role play to discuss the ethics of genetic testing
- internet research project to investigate regulation associated with genetic information
- activity to decide if permission should be granted for embryo selection
- decision-making activity to consider different viewpoints about using embryonic stem cells.

Opportunities for ICT

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

- use of the internet to disseminate scientific findings about health issues to the public.

Use of ICT in teaching and learning can include:

- animated journey through a cell to illustrate the relationship between the nucleus, chromosomes and genes
- interactive models of genetic crosses
- video clips of media reports highlighting ethical and regulatory issues.

Module B1: You and your genes – Ideas about Science

Module B1 provides opportunities to develop candidates' understanding of these Ideas about Science

6	Making decisions about science and technology Candidates should understand that:	A candidate who understands this can, for example:
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.

Module B1: You and your genes

B1.1 What are genes and how do they affect the way that organisms develop?

1. recall that instructions to control how an organism develops and functions are found in the nucleus of its cells and are called genes
2. recall that genes are instructions for a cell that describe how to make proteins
3. recall that proteins may be structural (eg collagen) or functional (eg enzymes such as amylase)
4. recall that genes are sections of very long DNA molecules that make up chromosomes in the nuclei of cells
5. understand that some characteristics are determined by genes (eg dimples), some are determined by environmental factors (eg scars), and some are determined by a combination of genes and the environment (eg weight)
6. understand that many characteristics are determined by several genes working together (eg eye colour).

Module B1: You and your genes

B1.2 Why can people look like their parents, brothers and sisters, but not be identical to them?

1. recall that body cells contain pairs of chromosomes and that sex cells contain only one chromosome from each pair
2. understand that chromosomes in a pair carry the same genes in the same place, but that there may be different versions of genes called alleles
3. recall that an individual usually has two alleles for each gene
4. recall that in an individual the two alleles of each gene can be the same **(homozygous)** or different **(heterozygous)**
5. understand that during sexual reproduction genes from both parents come together and produce variation in the offspring
6. understand that offspring have some similarities to their parents because of the combination of maternal and paternal alleles in the fertilised egg
7. understand that different offspring from the same parents can differ from each other because they inherit a different combination of maternal and paternal alleles
8. understand that an allele can be dominant or recessive, and that:
    a. an individual with one or both dominant alleles (in a pair of alleles) will show the associated dominant characteristic
    b. an individual with one recessive allele (in a pair of alleles) will not show the associated recessive characteristic
    c. an individual with both recessive alleles (in a pair of alleles) will show the associated recessive characteristic
9. recall that human males have XY sex chromosomes and females have XX sex chromosomes
10. **understand that the sex-determining gene on the Y chromosome triggers the development of testes, and that in the absence of a Y chromosome ovaries develop**
11. use and interpret genetic diagrams (family trees and Punnett squares) showing:
    a. the inheritance of single gene characteristics with a dominant and recessive allele
    b. the inheritance of sex chromosomes
12. **understand that the term genotype describes the genetic make-up of an organism (the combination of alleles), and the term phenotype describes the observable characteristics that the organism has.**

Module B1: You and your genes

B1.3 How can and should genetic information be used? How can we use our knowledge of genes to prevent disease?

1. understand that a small number of disorders are caused by faulty alleles of a single gene, including Huntington's disease and cystic fibrosis
2. recall that disorders may be caused by dominant alleles (eg Huntington's disease) or recessive alleles (eg cystic fibrosis)
3. recall the symptoms of Huntington's disease and cystic fibrosis, to include:
    a. Huntington's disease – late onset, tremor, clumsiness, memory loss, inability to concentrate, mood changes
    b. cystic fibrosis – thick mucus, difficulty breathing, chest infections, difficulty in digesting food
4. understand that a person with one recessive allele (in a pair of alleles) will not show the symptoms of the disorder, but is a carrier and can pass the recessive allele to their children
5. interpret through genetic diagrams (family trees and Punnett squares) the inheritance of a single gene disorder, including the risk of a child being a carrier
6. describe uses of genetic testing for screening adults, children and embryos, limited to:
    a. testing embryos for embryo selection **(pre-implantation genetic diagnosis)**
    b. predictive testing for genetic diseases
    c. testing an individual before prescribing drugs
7. understand that testing adults and fetuses for alleles that cause genetic disorders has implications that need to be considered, including:
    a. risk of miscarriage as a result of cell sampling for the genetic test
    b. using results that may not be accurate, including false positives and false negatives
    c. whether or not to have children at all
    d. whether or not a pregnancy should be terminated
    e. whether other members of the family should be informed
8. **understand the implications of testing embryos for embryo selection prior to implantation**
9. understand the implications of the use of genetic testing by others (for example, for genetic screening programmes by employers and insurance companies).

Module B1: You and your genes

B1.4 How is a clone made?

1. understand that bacteria, plants and some animals can reproduce asexually to form clones (individuals with identical genes)
2. understand that any differences between clones are likely to be due only to environmental factors
3. understand that clones of plants occur naturally when plants produce bulbs or runners
4. understand that clones of animals occur:
    a. naturally, when cells of an embryo separate (identical twins)
    b. artificially, when the nucleus from an adult body cell is transferred to an empty unfertilised egg cell
5. understand that there are different types of stem cells:
    a. adult stem cells which are unspecialised cells that can develop into many, but not all, types of cells
    b. embryonic stem cells which are unspecialised cells that can develop into any type of cell
6. understand that, as a result of being unspecialised, stem cells from embryos and adults offer the potential to treat some illnesses
7. understand that the majority of cells of multicellular organisms become specialised during the early development of the organism.

3.3.2 Module B2: Keeping healthy

Overview

Keeping healthy involves maintaining a healthy lifestyle, avoiding infection, and using medication when necessary. This module illustrates these principles through prevention of infectious diseases and heart disease.

Candidates learn about the immune system, and how vaccines work to prevent infection. They also learn about the increase of 'superbugs', and how correct use of antibiotics can help to reduce their prevalence. The module explores how new drugs are developed, including the stages of testing for safety and effectiveness. Candidates also consider the causes of heart disease, and how individuals can minimise this risk. They also learn about maintaining a constant internal environment, illustrated through how our body keeps a healthy water balance.

In the contexts of vaccination policy and the study of clinical trials, candidates explore ideas of correlation and cause, and how peer review by the scientific community strengthens the confidence in scientific claims. They also consider particular ethical issues arising in modern medicine, for example the right of individual choice versus social policy, illustrated through vaccination policy.

Issues for citizens	Questions that science may help to answer
Why do I catch some diseases but not others? Why are we encouraged to have vaccinations? Why should we always finish a course of antibiotics? How do drug companies make sure a new drug is as safe as possible? How can my lifestyle affect my health?	How do our bodies resist infection? What are vaccines and antibiotics and how do they work? How are new drugs developed and tested? What factors increase the risk of heart disease? How do our bodies keep a healthy water balance?

Opportunities for mathematics

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

- develop a sense of scale in the context of microorganisms
- carry out calculations using experimental data, including finding the mean and the range
- plot, draw and interpret graphs and charts from candidates' own and secondary data
- extract information from charts, graphs and tables including data from epidemiological studies
- use ideas about correlation in the context of health risk factors
- use ideas about probability in the context of risk.

Opportunities for practical work

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

- demonstrate the rapid spread of an infection through a population using ‘contaminated’ hand contact
- role play discussion of the ethical questions arising from the need to have a high take-up of vaccination to establish effective herd immunity
- antibiotic action practical activity to demonstrate that different antibiotics have different activity against particular bacteria
- monitor blood pressure
- heart dissection.

Opportunities for ICT

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

- storing and displaying magnified images from microscopes
- storing and displaying data from studies of factors which may, or may not, cause disease
- modelling control systems which involve negative feedback.

Use of ICT in teaching and learning can include:

- animations to illustrate immune responses
- animations to illustrate development of antibiotic-resistant bacterial populations
- video clips to illustrate smallpox vaccination programmes
- video clips of interviews with patients who have heart disease
- video clips illustrating how epidemiological research is carried out and reported.

Module B2: Keeping healthy – Ideas about Science

Module B2 provides opportunities to develop candidates' understanding of these Ideas about Science

2	**Cause-effect explanations** Candidates should understand that:	A candidate who understands this can, for example:
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.
2.6	• to investigate a claim that a factor increases the chance (or probability) of an outcome, scientists compare samples (eg 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.**

4	The scientific community 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.

5	Risk	
	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**	
	Candidates should understand that:	A candidate who understands this can, for example:
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.

Module B2: Keeping healthy

B2.1 How do our bodies resist infection?

1. understand that symptoms of an infectious disease are caused by damage done to cells by microorganisms or the poisons (toxins) they produce
2. understand why, in suitable conditions such as those inside a human body, microorganisms (eg bacteria and viruses) can reproduce rapidly to produce very large numbers
3. calculate the population growth of microorganisms given appropriate data
4. understand that white blood cells are part of the body’s immune system and can destroy microorganisms by engulfing and digesting them or by producing antibodies
5. understand that antibodies recognise microorganisms by the antigens that they carry on their surface, that different microorganisms have different antigens, and that a different antibody is therefore needed to recognise each different type of microorganism
6. understand that once the body has made the antibody to recognise a particular microorganism, memory cells can make that antibody again very quickly, therefore protecting against that particular microorganism in the future (immunity).

Module B2: Keeping healthy

B2.2 What are vaccines and antibiotics and how do they work?

1. understand that vaccinations provide protection from microorganisms by establishing memory cells that produce antibodies quickly on reinfection
2. understand that a vaccine usually contains a safe form of a disease-causing microorganism
3. **understand why, to prevent epidemics of infectious diseases, it is necessary to vaccinate a high percentage of a population**
4. understand that vaccines and drugs (medicines) can never be completely risk-free, since individuals have varying degrees of side effects to them
5. understand that due to genetic differences, people react differently to drugs and vaccines
6. understand that chemicals called antimicrobials can be used to kill, **or inhibit**, bacteria, fungi and viruses
7. recall that antibiotics are a type of antimicrobial that are effective against bacteria but not viruses
8. understand that over a period of time bacteria and fungi may become resistant to antimicrobials
9. **understand that random changes (mutations) in the genes of these microorganisms sometimes lead to varieties which are less affected by antimicrobials**
10. understand that to reduce antibiotic resistance we should only use antibiotics when necessary and always complete the course
11. understand that new drugs and vaccines are first tested for safety and effectiveness using animals and human cells grown in the laboratory
12. recall that human trials may then be carried out:
    a. on healthy volunteers to test for safety
    b. on people with the illness to test for safety and effectiveness
13. **describe and explain the use of 'open-label', 'blind' and 'double-blind' human trials in the testing of a new medical treatment**
14. **understand the importance of long-term human trials**
15. understand the ethical issues related to using placebos in human trials.

Module B2: Keeping healthy

B2.3 What factors increase the risk of heart disease?

1. describe the role of the heart as a double pump in the circulatory system
2. understand why heart muscle cells need their own blood supply
3. understand how the structure of arteries, veins and capillaries is related to their function
4. understand that heart rate can be measured by recording the pulse rate
5. understand that blood pressure measurements record the pressure of the blood on the walls of the artery
6. understand that a blood pressure measurement is given as two numbers, the higher value when the heart is contracting and the lower value when the heart is relaxed
7. understand that 'normal' measurements for factors such as heart rate and blood pressure are given within a range because individuals vary
8. understand how fatty deposits in the blood vessels supplying the heart muscle can produce a 'heart attack'
9. understand that heart disease is usually caused by lifestyle factors and/or genetic factors
10. understand that lifestyle factors that can increase the risk of heart disease include:
    a. poor diet
    b. stress
    c. cigarette smoking
    d. misuse of drugs
11. understand that regular moderate exercise reduces the risk of developing heart disease
12. relate differences in lifestyle factors in the UK and non-industrialised countries to the prevalence of heart disease
13. understand how factors that can increase the risk of heart disease are identified via epidemiological and large scale genetics studies
14. assess levels of heart disease risk, and actions that could be taken to reduce risk, when provided with lifestyle and genetic data
15. understand that high blood pressure increases the risk of heart disease
16. understand that the misuse of drugs (eg Ecstasy, cannabis, nicotine and alcohol) can have an adverse effect on health, including heart rate and blood pressure, increasing the risk of a heart attack.

Module B2: Keeping healthy

B2.4 How do our bodies keep a healthy water balance?

1. understand that nervous and hormonal communication systems are involved in maintaining a constant internal environment (homeostasis)
2. understand that automatic control systems throughout the body maintain a range of factors at steady levels and that this is required for cells to function properly
3. recall that these control systems have:
   a. receptors to detect changes in the environment
   b. processing centres to receive information and coordinate responses automatically
   c. effectors to produce the response
4. **understand the principle of negative feedback**
5. **understand that negative feedback between the effector and the receptor of a control system reverses any changes to the system's steady state**
6. understand that a balanced water level is important for maintaining the concentration of cell contents at the correct level for cell activity
7. understand that water levels are controlled by balancing gains from drinks, food and respiration and losses through sweating, breathing, faeces and the excretion of urine
8. understand that the kidneys play a vital role in balancing levels of water, waste and other chemicals in the blood

   ⓘ *Candidates are not expected to recall details of kidney structure*
9. understand that the kidneys balance water levels by producing dilute or concentrated urine as a response to concentration of blood plasma, which is affected by external temperature, exercise level and intake of fluids and salt
10. **understand that concentration of urine is controlled by a hormone called ADH, which is released into the bloodstream by the pituitary gland**
11. **understand how ADH secretion is controlled by negative feedback**
12. understand that alcohol results in the production of a greater volume of more dilute urine, **due to ADH suppression**, which can lead to dehydration and adverse effects on health
13. understand that the drug Ecstasy results in a smaller volume of less dilute urine, **due to increased ADH production**.

3.3.3 Module B3: Life on Earth

Overview

Debate about theories for the evolution of life on Earth often features in the media and popular culture. Candidates consider different explanations for evolution. These contexts illustrate how explanations arise and become accepted, and the role of the scientific community in this process. Natural selection is introduced as the mechanism for evolution.

Biodiversity is recognised as an important natural resource, which is increasingly threatened by human activity. Candidates consider how ecosystems are in balance and how living organisms are dependent on their environment and each other for survival. The extinction of species is a growing concern often featured in the media. Candidates consider causes of extinction and whether extinctions should be a global concern.

The need for sustainability is frequently referred to in the press. Candidates are introduced to what this really means and how maintaining biodiversity is one of the keys to sustainability. Specific examples are used to show how sustainability can be increased.

Issues for citizens	Questions that science may help to answer
Why do some species survive whereas others do not survive? Is evolution 'just a theory'? Where do new species come from? Why do some species become extinct, and does it matter?	How do different species depend on their environment and each other? How have scientists developed explanations of evolution? How does evolution work? What is the importance of biodiversity?

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 using fractions and percentages for energy transfer
- plot, draw and interpret graphs and charts from candidates' own and secondary data
- extract information from charts, graphs and tables
- use ideas about correlation in the context of climate change.

Opportunities for practical work

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

- investigate adaptation in plants and animals
- eco-column practical investigation of food webs
- fieldwork to investigate biodiversity and environmental change in local habitats
- investigate the changes in nitrogen in an establishing aquarium over three weeks
- calculate an ecological 'footprint' that measures how great an impact an individual's lifestyle has on the environment.

Opportunities for ICT

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

- recording and displaying the results of DNA analysis
- monitoring and recording human and animal behaviour.

Use of ICT in teaching and learning can include:

- video clips to illustrate varied ecosystems
- use of the internet to research endangered plants or animals
- presentation to show how understanding of evolution develops as new evidence is discovered.

Module B3: Life on Earth – Ideas about Science

Module B3 provides opportunities to develop candidates' understanding of these Ideas about Science

3	Developing scientific explanations 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	
	Candidates should understand that:	A candidate who understands this can, for example:
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.**
6	**Making decisions about science and technology**	
	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.

Module B3: Life on Earth

B3.1 Systems in balance – how do different species depend on each other?

1. understand that a species is a group of organisms that can breed together to produce fertile offspring
2. understand that adaptation of living organisms to their environment increases the species' chance of survival by making it more likely that individuals will survive to reproduce
3. recall, and recognise when given relevant data, examples of how different organisms are adapted to their environment, and explain how the adaptations increase the organism's chance of surviving to successfully reproduce
4. understand that living organisms are dependent on the environment and other species for their survival
5. understand that there is competition for resources between different species of animals or plants in the same habitat
6. relate changes affecting one species in a food web to the impact on other species that are part of the same food web
7. **explain the interdependence of living organisms by using food webs**
8. understand that a change in the environment may cause a species to become extinct, for example, if:
    a. the environmental conditions change beyond its ability to adapt
    b. a new species that is a competitor, predator or disease organism of that species is introduced
    c. another species (animal, plant or microorganism) in its food web becomes extinct
9. understand that nearly all organisms are ultimately dependent on energy from the Sun
10. recall that plants absorb a small percentage of the Sun's energy for the process of photosynthesis
11. recall that this absorbed energy is stored in the chemicals which make up the plants' cells
12. understand that energy is transferred between organisms in an ecosystem:
    a. when organisms are eaten
    b. when dead organisms and waste materials are fed on by decay organisms (decomposers **and detritivores**)
13. explain how energy passes out of a food chain at each stage via heat, waste products and uneaten parts, limiting the length of food chains
14. calculate from given data the percentage efficiency of energy transfer at different stages of a food chain
15. understand how carbon is recycled through the environment to include the processes of combustion, respiration, photosynthesis and decomposition
16. understand the importance of the role of microorganisms in the carbon cycle

B3.1 Systems in balance – how do different species depend on each other?

17. understand how nitrogen is recycled through the environment in the processes of:
    - **a. nitrogen fixation to form nitrogen compounds including nitrates**
    - **b. conversion of nitrogen compounds to protein in plants and animals**
    - c. transfer of nitrogen compounds through food chains
    - d. excretion, death and decay of plants and animals resulting in release of nitrates into the soil
    - e. uptake of nitrates by plants
    - **f. denitrification**
    - ⓘ *Foundation tier candidates are not expected to recall details of conversion of atmospheric nitrogen to nitrates, or nitrates to atmospheric nitrogen*
18. understand the importance of the role of microorganisms in the nitrogen cycle, including decomposition, **nitrogen fixation and denitrification**
19. interpret simple diagrams of the carbon cycle and nitrogen cycle
    - ⓘ *Foundation tier candidates are not expected to recall nitrogen fixation or denitrification*
20. understand how environmental change can be measured using non-living indicators, including nitrate levels, temperature and carbon dioxide levels
21. understand how climate and environmental change can be measured using living indicators, including phytoplankton, lichens and aquatic river organisms such as mayfly nymphs
22. interpret data obtained from living and non-living indicators to investigate environmental change.

Module B3: Life on Earth

B3.2 How has life on Earth evolved?

1. recall that life on Earth began approximately 3500 million years ago
2. understand that life on Earth (including species that are now extinct) evolved from very simple living things
3. understand that there is variation between individuals of the same species and that some of this variation is genetic so can be passed on to offspring
4. understand that genetic variation is the result of changes that occur in genes (mutations)
5. understand that mutated genes in sex cells can be passed on to offspring and may occasionally produce new characteristics
6. understand the process of natural selection in terms of the effects of genetic variation and competition on survival and reproduction, leading to an increase in the number of individuals displaying beneficial characteristics in later generations
7. describe the similarities and differences between natural selection and selective breeding
8. interpret data on changes in a species in terms of natural selection
9. understand how the combined effect of mutations, environmental changes, natural selection and isolation can produce new species in the process of evolution
10. understand that evidence for evolution is provided by the fossil record and from analysis of similarities and differences in the DNA of organisms
11. understand that Darwin's theory of evolution by natural selection was the result of many observations and creative thought and why it is a better scientific explanation than Lamarck's (eg. fits with advances in understanding of genetics, no evidence or mechanism for inheritance of acquired characteristics).

Module B3: Life on Earth

B3.3 What is the importance of biodiversity?

1. understand that organisms are classified into groups according to similarities and differences in characteristics including:
   a. physical features (eg flowers in flowering plants and the skeleton in vertebrates)
   b. DNA
   ⓘ *Candidates will not be expected to give examples of characteristics of particular taxonomic groups*
2. understand that organisms are classified at different levels, and that these levels can be arranged in an order progressing from large groups containing many organisms with a small number of characteristics in common (eg kingdom) to smaller groups containing fewer organisms with more characteristics in common (eg species)
   ⓘ *Candidates will not be expected to recall the names of taxa other than kingdom and species*
3. understand that the classification of living and fossil organisms can help to:
   a. make sense of the enormous diversity of organisms on Earth
   b. show the evolutionary relationships between organisms
4. understand that biodiversity refers to the variety of life on Earth including:
   a. the number of different species
   b. the range of different types of organisms, eg plants, animals and microorganisms
   c. the genetic variation within species
5. understand why biodiversity is important for the future development of food crops and medicines
6. understand that the rate of extinction of species is increasing and why this is likely to be due to human activity
7. understand that maintaining biodiversity to ensure the conservation of different species is one of the keys to sustainability
8. understand that sustainability means meeting the needs of people today without damaging the Earth for future generations
9. understand that large-scale monoculture crop production is not sustainable because it does not maintain biodiversity
10. describe and explain how sustainability can be improved, for example in the use of packaging materials, by considering the materials used, energy used and pollution created
11. understand why it is preferable to decrease the use of some materials, including packaging materials, even when they are biodegradable, because of:
   a. use of energy in their production and transport
   b. slow decomposition in oxygen deficient landfill sites.

3.4 Summary of Chemistry A Unit A171: *Modules C1, C2, C3*

Unit A171 is the unit within assessment route 1 to GCSE Science A where the chemistry content is assessed. It assesses the content of Modules C1, C2 and C3 together with their associated Ideas about Science. The other route 1 units are Unit A161 (Section 3.3) and Unit A181 (Section 3.5).

The modules in Unit A171 offer students the chance to develop the scientific literacy needed by active and informed citizens in a modern democratic society where science and technology play key roles in shaping our lives. The course content has a clear focus on scientific literacy. Teachers can use a wide range of teaching and learning styles, challenging students to consider critically the issues and choices raised by technology and science. Students will appreciate what science has to say about people, the environment and the Universe.

Ideas about Science in Unit A171

Modules C1, C2 and C3 present learning opportunities for a number of the Ideas about Science. The start of each module details the particular Ideas about Science that can be introduced or developed within the contexts covered in the module. Specific examples of contexts within which Ideas about Science can be taught are given in the OCR scheme of work for GCSE Science A (published separately).

However, it is not intended that understanding and application of Ideas about Science should be limited to the context in which they are taught; they should be applicable to any appropriate scientific context.

Accordingly, questions in Unit A171 can assess any of the Ideas about Science linked to Modules C1, C2 and C3, and these Ideas about Science may be assessed in the context of any of the learning outcomes covered in the three modules.

In summary, the Ideas about Science that can be assessed in Unit A171, within any of the scientific contexts introduced by Modules C1, C2 and C3, are:

Data: their importance and limitations
IaS 1.1 – 1.6
Cause-effect explanations
IaS 2.1 – 2.5
Developing scientific explanations
IaS 3.3
The scientific community
IaS 4.1 – 4.4
Risk
IaS 5.1 – 5.7
Making decisions about science and technology
IaS 6.1 – 6.4

3.4.1 Module C1: Air quality

Overview

The quality of air is becoming a major world concern. In this module candidates learn about the gases that make up the Earth's atmosphere and how its composition has changed and is still changing. Candidates explore environmental and health consequences of certain air pollutants, and options for improving air quality in the future, such as the use of catalytic converters. The emphasis is on health issues arising from burning fuels rather than on global issues such as climate change, which is covered in Module P2: Radiation and life.

Candidates learn about the chemical relationship between the burning of fossil fuels and the production of air pollutants. This module introduces molecular elements and compounds to illustrate chemical explanations.

By analysing their own and given data on concentrations of pollutants, candidates learn about the way in which scientists use data, and also that all data have certain limitations.

Issues for citizens	Questions that science may help to answer
How do I make sense of data about air pollution? Where do pollutants come from? Is air pollution harmful to me, or to my environment? How can we improve air quality?	What chemicals make up air, and which ones are pollutants? What chemical reactions produce air pollutants? What happens to these pollutants in the atmosphere? What choices can we make personally, locally, nationally or globally to improve air quality?

Opportunities for mathematics

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

- develop a sense of scale in the context of atoms, molecules and particulates
- carry out calculations using experimental data, including finding the mean and the range
- carry out calculations using fractions and percentages
- plot, draw and interpret graphs and charts from candidates' own and secondary data
- use ideas about correlation in the context of air quality and health.

Opportunities for practical work

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

- experiments to calculate the proportion of air that is oxygen
- experiments to measure dust and particulates in the air
- combustion experiments.

Opportunities for ICT

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

- collecting, storing and displaying data from a large network of measuring instruments
- displaying data in a variety of charts, graphs and maps for analysis and evaluation.

Use of ICT in teaching and learning can include:

- using the internet to research local air quality data
- animations to illustrate chemical changes during reactions.

Module C1: Air quality – Ideas about Science

Module C1 provides opportunities to develop candidates' understanding of these Ideas about Science

1	**Data: their importance and limitations**	
	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 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.
2.3	• 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.

4	The scientific community	
	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.**

Module C1: Air quality

C1.1 Which chemicals make up air, and which ones are pollutants? How do I make sense of data about air pollution?

1. recall that the atmosphere (air) that surrounds the Earth is made up mainly of nitrogen, oxygen and argon, plus small amounts of water vapour, carbon dioxide and other gases
2. understand that air is a mixture of different gases consisting of small molecules with large spaces between them
3. recall that the relative proportions of the main gases in the atmosphere are approximately 78% nitrogen, 21% oxygen and 1% argon
4. understand that other gases or particulates may be released into the atmosphere by human activity or by natural processes (eg volcanoes), and that these can affect air quality
5. understand how the Earth's early atmosphere was probably formed by volcanic activity and consisted mainly of carbon dioxide and water vapour
6. understand that water vapour condensed to form the oceans when the Earth cooled
7. explain how the evolution of photosynthesising organisms added oxygen to, and removed carbon dioxide from, the atmosphere
8. explain how carbon dioxide was removed from the atmosphere by dissolving in the oceans and then forming sedimentary rocks, and by the formation of fossil fuels
9. understand how human activity has changed the composition of the atmosphere by adding:
    a. small amounts of carbon monoxide, nitrogen oxides and sulfur dioxide to the atmosphere
    b. extra carbon dioxide and small particles of solids (eg carbon) to the atmosphere
10. understand that some of these substances, called pollutants, are directly harmful to humans (eg carbon monoxide reduces the amount of oxygen that blood can carry), and that some are harmful to the environment and so cause harm to humans indirectly (eg sulfur dioxide causes acid rain).

Module C1: Air quality

C1.2 What chemical reactions produce air pollutants? What happens to these pollutants in the atmosphere?

1. recall that coal is mainly carbon
2. recall that petrol, diesel fuel and fuel oil are mainly compounds of hydrogen and carbon (hydrocarbons)
3. understand that, when fuels burn, atoms of carbon and/or hydrogen from the fuel combine with atoms of oxygen from the air to produce carbon dioxide and/or water (hydrogen oxide)
4. understand that a substance chemically combining with oxygen is an example of oxidation, that loss of oxygen is an example of reduction, and that combustion reactions therefore involve oxidation
5. understand that fuels burn more rapidly in pure oxygen than in air
6. recall that oxygen can be obtained from the atmosphere and can be used to support combustion (eg in oxy-fuel welding torches)
7. understand that in a chemical reaction the properties of the reactants and products are different
8. understand that atoms are rearranged during a chemical reaction
9. interpret representations of the rearrangement of atoms during a chemical reaction
10. understand that during the course of a chemical reaction the numbers of atoms of each element must be the same in the products as in the reactants, **thus conserving mass**
11. understand how sulfur dioxide is produced if the fuel that is burned contains any sulfur
12. understand how burning fossil fuels in power stations and for transport pollutes the atmosphere with:
    a. carbon dioxide and sulfur dioxide
    b. carbon monoxide and particulate carbon (from incomplete burning)
    c. nitrogen oxides (from the reaction between atmospheric nitrogen and oxygen at the high temperatures inside engines)
13. relate the formulae for carbon dioxide CO_2, carbon monoxide CO, sulfur dioxide SO_2, nitrogen monoxide NO, nitrogen dioxide NO_2 and water H_2O to visual representations of their molecules
14. **recall that nitrogen monoxide NO is formed during the combustion of fuels in air, and is subsequently oxidised to nitrogen dioxide NO_2 (NO and NO_2 are jointly referred to as 'NOx')**
15. understand that atmospheric pollutants cannot just disappear, they have to go somewhere:
    a. particulate carbon is deposited on surfaces, making them dirty
    b. sulfur dioxide and nitrogen dioxide react with water and oxygen to produce acid rain which is harmful to the environment
    c. carbon dioxide is used by plants in photosynthesis
    d. carbon dioxide dissolves in rain water and in sea water.

Module C1: Air quality

C1.3 What choices can we make personally, locally, nationally or globally to improve air quality?

1. understand how atmospheric pollution caused by power stations that burn fossil fuels can be reduced by:
   a. using less electricity
   b. removing sulfur from natural gas and fuel oil
   c. removing sulfur dioxide and particulates from the flue gases emitted by coal-burning power stations
2. **understand how the acid gas sulfur dioxide is removed from flue gases by wet scrubbing:**
   a. using an alkaline slurry eg a spray of calcium oxide and water
   b. using sea water
   ⓘ *Candidates are not required to write word or symbol equations*
3. understand that the only way of producing less carbon dioxide is to burn less fossil fuels
4. understand how atmospheric pollution caused by exhaust emissions from motor vehicles can be reduced by:
   a. burning less fuel, for example by having more efficient engines
   b. using low sulfur fuels
   c. using catalytic converters (in which nitrogen monoxide is reduced to nitrogen by loss of oxygen, and carbon monoxide is oxidised to carbon dioxide by gain of oxygen)
   d. adjusting the balance between public and private transport
   e. having legal limits to exhaust emissions (which are enforced by the use of MOT tests)
5. **understand the benefits and problems of using alternatives to fossil fuels for motor vehicles, limited to biofuels and electricity.**

3.4.2 Module C2: Material choices

Overview

Our way of life depends on a wide range of materials produced from natural resources. The Earth's crust provides us with crude oil, which is a source of fuel and raw material for producing synthetic polymers. Natural polymers can also be useful and can be obtained from living things. This module considers how measurements of the properties of materials can inform the choice of material for a particular purpose. By taking their own measurements, candidates can explore some of the issues that arise when trying to establish accurate and meaningful data.

Key ideas in this module are illustrated through polymers. Candidates learn how the molecules that make up a polymer fit together and how strongly they are bonded to each other, providing an explanation of the properties of materials. This provides an example of a scientific explanation that makes sense of a wide range of observations.

Candidates also learn how polymers can be modified to give them more desirable properties by the introduction of nanoparticles, which have different properties when compared with larger particles of the same material.

Issues for citizens	Questions that science may help to answer
How can we pick a suitable material for a particular product or task?	How do we measure the properties of materials and why are the results useful? Why is crude oil important as a source of new materials such as plastics and fibres? Why does it help to know about the molecular structure of materials such as plastics and fibres? What is nanotechnology and why is it important?

Opportunities for mathematics

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

- develop a sense of scale in the context of polymers and nanoparticles
- carry out calculations using experimental data, including finding the mean and the range
- use ideas of proportion in the context of surface area
- plot, draw and interpret graphs and charts from candidates' own and secondary data
- extract information from charts showing properties of materials.

Opportunities for practical work

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

- test the properties of materials
- make polymers and modify their properties
- perform or observe the distillation of crude oil.

Opportunities for ICT

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

- logging and storing data, and displaying data in a variety of formats for analysis and evaluation.

Use of ICT in teaching and learning can include:

- using spreadsheets to record and display measurements of the properties of materials
- video clips to illustrate the main stages from extraction of oil to production of synthetic plastic or fibre
- using still images and diagrams to create presentations to show how the properties of a material depend on its molecular structure.

Module C2: Material choices – Ideas about Science

Module C2 provides opportunities to develop candidates' understanding of these Ideas about Science

1	**Data: their importance and limitations** 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**	
	Candidates should understand that:	A candidate who understands this can, for example:
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.

Module C2: Material choices

C2.1 How do we measure the properties of materials and why are the results useful?

1. interpret information about how solid materials can differ with respect to properties such as melting point, strength (in tension or compression), stiffness, hardness and density
2. relate properties to the uses of materials such as plastics, rubbers and fibres
3. relate the effectiveness and durability of a product to the materials used to make it
4. interpret information about the properties of materials such as plastics, rubbers and fibres to assess the suitability of these materials for particular purposes.

Module C2: Material choices

C2.2 Why is crude oil important as a source of new materials such as plastics and fibres?

1. recall that the materials we use are chemicals or mixtures of chemicals, and include metals, ceramics and polymers
2. recall that materials can be obtained or made from living things, and give examples such as cotton, paper, silk and wool
3. recall that there are synthetic materials that are alternatives to materials from living things
4. recall that raw materials from the Earth's crust can be used to make synthetic materials
5. interpret representations of rearrangements of atoms during a chemical reaction
6. understand that in a chemical reaction the numbers of atoms of each element must be the same in the products as in the reactants
7. recall that crude oil consists mainly of hydrocarbons, which are chain molecules of varying lengths made from carbon and hydrogen atoms only
8. recall that only a small percentage of crude oil is used for chemical synthesis and that most is used as fuels
9. understand that the petrochemical industry refines crude oil by fractional distillation; hydrocarbons are separated into fractions of different boiling points, to produce fuels, lubricants and the raw materials for chemical synthesis
10. relate the size of the forces between hydrocarbon molecules to the size of the molecules
11. relate the strength of the forces between hydrocarbon molecules in crude oil to the amount of energy needed for them to break out of a liquid and form a gas, and to the temperature at which the liquid boils
12. understand that some small molecules called monomers can join together to make very long molecules called polymers, and that the process is called polymerisation
13. recall two examples of materials that, because of their superior properties, have replaced materials used in the past.

Module C2: Material choices

C2.3 Why does it help to know about the molecular structure of materials such as plastics and fibres?

1. understand that it is possible to produce a wide range of different polymers with properties that make them each suited to a particular use
2. understand how the properties of polymers depend on how their molecules are arranged and held together
3. relate the strength of the forces between the molecules in a polymer to the amount of energy needed to separate them from each other, and therefore to the strength, stiffness, hardness and melting point of the solid
4. understand how modifications in polymers produce changes to their properties (see C2.1), to include modifications such as:
   a. increased chain length
   b. cross-linking
   c. the use of plasticizers
   d. increased crystallinity.

Module C2: Material choices

C2.4 What is nanotechnology and why is it important?

1. recall that nanotechnology involves structures that are about the same size as some molecules
2. understand that nanotechnology is the use and control of structures that are very small (1 to 100 nanometres in size)
3. understand that nanoparticles can occur naturally (for example in seaspray), by accident (for example as the smallest particulates from combustion of fuels), and by design
4. understand that nanoparticles of a material show different properties compared to larger particles of the same material, and that one of the reasons for this is the much larger surface area of the nanoparticles compared to their volume
5. understand that nanoparticles can be used to modify the properties of materials, and give examples including:
    a. the use of silver nanoparticles to give fibres antibacterial properties
    b. adding nanoparticles to plastics for sports equipment to make them stronger
6. understand that some nanoparticles may have harmful effects on health, and that there is concern that products with nanoparticles are being introduced before these effects have been fully investigated.

3.4.3 Module C3: Chemicals in our lives – risks and benefits

Overview

Thanks to its geological history, Britain is a country that has large deposits of valuable resources including salt and limestone as well as coal, gas and oil. These raw materials have been the basis of a chemical industry for over 200 years. At first many of the industrial processes were highly polluting. This led to new laws and the establishment of regulatory organisations to control the industry. Today the industry is under great pressure to operate processes that are efficient in their use of energy and which do minimal harm to health and the environment.

Salt is particularly important. Salt is necessary in the diet but is hazardous if eaten to excess. Chemists have learnt to convert salt to alkalis and to chlorine, chemicals that are used to make many valuable products.

The use of manufactured chemicals has brought both benefits and risks. Society has become increasingly concerned that there are many chemicals that are used in large amounts, but which have never been thoroughly tested to evaluate their effects on people and the environment.

The data from Life Cycle Assessments shows that in selecting a product for a particular job we should assess not only its 'fitness for purpose' but also the total effects of using the materials that make up the product over its complete life cycle, from its production using raw materials to its disposal.

Issues for citizens	Questions that science may help to answer
Why do we need to use manufactured chemicals? What can society do to ensure that it uses chemicals in ways that are safe and sustainable? When choosing a product made from a particular chemical, what else should we consider besides its cost and how well it does its job?	Why are there valuable sources of raw materials for making chemicals in Britain? Why are salt and limestone so important for the chemical industry? What are the benefits and risks of making chemicals with chlorine?

Opportunities for mathematics

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

- develop a sense of scale in the context of geological time
- carry out calculations using fractions and percentages
- interpret graphs and charts from secondary data
- extract information from charts, graphs and tables about water quality and health
- use ideas about probability in the context of risk.

Opportunities for practical work

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

- purify rock salt
- experiments with acids and alkalis
- make soap
- perform the electrolysis of brine.

Opportunities for ICT

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

- simulating the movement of the continents over geological time periods.

Use of ICT in teaching and learning can include:

- video clips to illustrate the extraction of raw materials and the production of useful chemicals
- animations to illustrate chemical processes
- simulations to explore the impact of choices made during the life cycle of a product
- using the internet to explore case studies of the safe and sustainable use of polymers and materials.

Module C3: Chemicals in our lives – risks and benefits – Ideas about Science

Module C3 provides opportunities to develop candidates' understanding of these Ideas about Science

	3 Developing scientific explanations Candidates should understand that:	A candidate who understands this can, for example:
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.

	5 Risk 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 Risk	
	Candidates should understand that:	A candidate who understands this can, for example:
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	
	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.

Module C3: Chemicals in our lives – risks and benefits

C3.1 What were the origins of minerals in Britain that contribute to our economic wealth?

1. understand that geologists explain most of the past history of the surface of the Earth in terms of processes than can be observed today
2. understand that movements of tectonic plates mean that the parts of ancient continents that now make up Britain have moved over the surface of the Earth
3. understand how geologists use magnetic clues in rocks to track the very slow movement of the continents over the surface of the Earth
4. understand that the movements of continents means that different rocks in Britain formed in different climates
5. understand how processes such as mountain building, erosion, sedimentation, dissolving and evaporation have led to the formation of valuable resources found in England including coal, limestone and salt
6. understand how geologists study sedimentary rocks to find evidence of the conditions under which they were formed, to include:
   a. fossils
   b. shapes of water borne grains compared to air blown grains
   c. presence of shell fragments
   d. ripples from sea or river bottom
7. understand that chemical industries grow up where resources are available locally, eg salt, limestone and coal in north west England.

Module C3: Chemicals in our lives – risks and benefits

C3.2 Where does salt come from and why is it so important?

1. understand the importance of salt (sodium chloride) for the food industry, as a source of chemicals and to treat roads in winter
2. recall that salt can be obtained from the sea or from underground salt deposits
3. understand how underground salt can be obtained by mining, or by solution in water
4. understand why the method used to obtain salt may depend on how the salt is to be used
5. understand how the methods of obtaining salt can have an impact on the environment
6. understand the advantages of adding salt to food as flavouring and as a preservative
7. recall the health implications of eating too much salt
8. be able to evaluate data related to the content of salt in food and health
9. recall that Government departments, such as the Department of Health and the Department for Environment, Food and Rural Affairs, have a role in:
    a. carrying out risk assessments in relation to chemicals in food
    b. advising the public in relation to the effect of food on health.

Module C3: Chemicals in our lives – risks and benefits

C3.3 Why do we need chemicals such as alkalis and chlorine and how do we make them?

1. recall that, even before industrialisation, alkalis were needed to neutralise acid soils, make chemicals that bind natural dyes to cloth, convert fats and oils into soap and to manufacture glass
2. recall that traditional sources of alkali included burnt wood or stale urine
3. understand that alkalis neutralise acids to make salts
4. **recall that soluble hydroxides and carbonates are alkalis**
5. **predict the products of the reactions of soluble hydroxides and carbonates with acids**
6. understand that increased industrialisation led to a shortage of alkali in the nineteenth century
7. understand that the first process for manufacturing alkali from salt and limestone using coal as a fuel caused pollution by releasing large volumes of an acid gas (hydrogen chloride) and creating great heaps of waste that slowly released a toxic and foul smelling gas (hydrogen sulfide)
8. understand that pollution problems can sometimes be solved by turning wastes into useful chemicals
9. understand that oxidation can convert hydrogen chloride to chlorine, and that the properties of a compound are completely different from the elements from which it is made
10. recall that chlorine is used to kill microorganisms in domestic water supplies and as a bleach
11. understand how the introduction of chlorination to treat drinking water made a major contribution to public health
12. interpret data about the effects of polluted water on health and the impact of water treatment with chlorine to control disease
13. understand that there may be disadvantages of chlorinating drinking water, including possible health problems from traces of chemicals formed by reaction of chlorine with organic materials in the water
14. understand that an electric current can be used to bring about chemical change and make new chemicals through a process called electrolysis
15. recall that chlorine is now obtained by the electrolysis of salt solution (brine)

    ⓘ *Technical details and the ionic reactions are not required*
16. recall examples of important uses by industry of the sodium hydroxide, chlorine and hydrogen produced by electrolysis of brine
17. interpret data about the environmental impact of the large scale electrolysis of brine.

Module C3: Chemicals in our lives – risks and benefits

C3.4 What can we do to make our use of chemicals safe and sustainable?

1. understand that there is a large number of industrial chemicals with many widespread uses, including consumer products, for which there is inadequate data to judge whether they are likely to present a risk to the environment and/or human health
2. understand that some toxic chemicals cause problems because they persist in the environment, can be carried over large distances, and may accumulate in food and human tissues
3. recall that PVC is a polymer that contains chlorine as well as carbon and hydrogen
4. understand that the plasticizers used to modify the properties of PVC can leach out from the plastic into the surroundings where they may have harmful effects
5. understand that a Life Cycle Assessment (LCA) involves consideration of the use of resources including water, the energy input or output, and the environmental impact, of each of these stages:
    a. making the material from natural raw materials
    b. making the product from the material
    c. using the product
    d. disposing of the product
6. when given appropriate information from a Life Cycle Assessment (LCA), compare and evaluate the use of different materials for the same purpose.

3.5 Summary of Physics A Unit A181: *Modules P1, P2, P3*

Unit A181 is the unit within assessment route 1 to GCSE Science A where the physics content is assessed. It assesses the content of Modules P1, P2 and P3 together with their associated Ideas about Science. The other route 1 units are Unit A161 (Section 3.3) and Unit A171 (Section 3.4).

The modules in Unit A181 offer students the chance to develop the scientific literacy needed by active and informed citizens in a modern democratic society where science and technology play key roles in shaping our lives. The course content has a clear focus on scientific literacy. Teachers can use a wide range of teaching and learning styles, challenging students to consider critically the issues and choices raised by technology and science. Students will appreciate what science has to say about people, the environment and the Universe.

Ideas about Science in Unit A181

Modules P1, P2 and P3 present learning opportunities for a number of the Ideas about Science. The start of each module details the particular Ideas about Science that can be introduced or developed within the contexts covered in the module. Specific examples of contexts within which Ideas about Science can be taught are given in the OCR scheme of work for GCSE Science A (published separately).

However, it is not intended that understanding and application of Ideas about Science should be limited to the context in which they are taught; they should be applicable to any appropriate scientific context.

Accordingly, questions in Unit A181 can assess any of the Ideas about Science linked to Modules P1, P2 and P3, and these Ideas about Science may be assessed in the context of any of the learning outcomes covered in the three modules.

In summary, the Ideas about Science that can be assessed in Unit A181, within any of the scientific contexts introduced by Modules P1, P2 and P3, are:

Cause-effect explanations
IaS 2.3 – 2.7
Developing scientific explanations
IaS 3.1 – 3.4
The scientific community
IaS 4.1 – 4.4
Risk
IaS 5.1 – 5.7
Making decisions about science and technology
IaS 6.1 – 6.3, 6.5, 6.6

3.5.1 Module P1: The Earth in the Universe

Overview

Scientific discoveries in the solar system and beyond continue to inspire popular culture and affect our understanding of our place in the Universe. In this module, candidates explore the scale of the Universe and its past, present and future, and consider the ideas scientists have and their evidence for them.

Closer to home, candidates consider long-term and short-term changes in the Earth's crust, and how these changes impact on human life. In particular, they find out about earthquakes and volcanoes – explaining them, predicting them and coping with them.

The module focuses on how we know the things we think we know about the Earth and its place in the Universe. Across the whole module, candidates encounter many examples showing relationships between data and explanations. Through these contexts they learn about the way scientists communicate and develop new explanations.

Issues for citizens	Questions that science may help to answer
How do we know about things we can barely see? How do scientists develop explanations of the Earth and space? Why do mountains come in chains, in particular places? Can we predict earthquakes, especially those that are likely to cause most damage?	Where do the elements of life come from? What do we know about the Universe? How have the Earth's continents moved, and with what consequences?

Opportunities for mathematics

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

- develop a sense of scale including: size – from the size of the Earth to that of the solar system and the Universe; speed – from the movement of tectonic plates to the speed of light; and time – from the age of the Earth to the age of the Universe
- carry out calculations using experimental data, including finding the mean and the range
- use ideas of inverse proportion in the context of wavelength and frequency
- use equations, including appropriate units for physical quantities.

Opportunities for practical work

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

- use diffraction gratings to look at a variety of spectra
- measure distances using parallax
- investigate the relationship between brightness of a light source and distance from the source
- model the rock cycle and the movement of tectonic plates
- model the changing magnetic pattern on the sea floor
- explore the build up of forces that precede a 'brickquake'
- explore transverse and longitudinal waves on a slinky spring.

Opportunities for ICT

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

- computer modelling of galaxies in collision
- creating a 3D model of the large-scale structure of the Universe from individual galaxy observations
- processing data on movements of the Earth's lithosphere (as evidence to support the theory of plate tectonics)
- analysing wave reflections in seismic explorations.

Use of ICT in teaching and learning can include:

- animations to illustrate the movement of continents as they are carried by tectonic plates
- using the internet to research particular geohazards
- video clips to show examples of wave motion
- animation to show the behaviour of waves in ripple tanks
- modelling software to investigate the implications of the wave equation.

Module P1: The Earth in the Universe – Ideas about Science

Module P1 provides opportunities to develop candidates' understanding of these Ideas about Science

3	**Developing scientific explanations** 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 other is wrong, and decreases our confidence in the explanation on which the prediction is based.

4	The scientific community	
	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.**

Module P1: The Earth in the Universe

P1.1 What do we know about the place of the Earth in the Universe?

1. recall that the Earth is one of eight planets moving in almost circular paths round the Sun which, together with other smaller objects orbiting the Sun (asteroids, dwarf planets, comets) and moons orbiting several planets, make up the solar system
2. describe the principal differences between planets, moons, the Sun, comets and asteroids including their relative sizes and motions
3. understand that the solar system was formed over very long periods from clouds of gases and dust in space, about five thousand million years ago
4. recall that the Sun is one of thousands of millions of stars in the Milky Way galaxy
5. recall that there are thousands of millions of galaxies, each containing thousands of millions of stars, and that all of these galaxies make up the Universe
6. put in order and recall the relative sizes of: the diameters of the Earth, the Sun, the Earth's orbit, the solar system, the Milky Way, the distance from the Sun to the nearest star, and the distance from the Milky Way to the nearest galaxy
7. understand that all the evidence we have about distant stars and galaxies comes from the radiation astronomers can detect
8. recall that light travels through space (a vacuum) at a very high but finite speed, 300 000 km/s
9. recall that a light-year is the distance travelled by light in a year
10. understand that the finite speed of light means that very distant objects are observed as they were in the past, when the light we now see left them
11. understand how the distance to a star can be measured using parallax (qualitative idea only)
12. understand how the distance to a star can be estimated from its relative brightness
13. understand that light pollution and other atmospheric conditions interfere with observations of the night sky
14. explain why there are uncertainties about the distances of stars and galaxies with reference to the nature and difficulty of the observations on which these are based and the assumptions made in interpreting them
15. understand that the source of the Sun's energy is the fusion of hydrogen nuclei
16. understand that all chemical elements with atoms heavier than helium were made in stars
17. understand that **the redshift in the light coming from them suggests that** distant galaxies are moving away from us
18. **understand that (in general) the further away a galaxy is, the faster it is moving away from us**
19. **understand how the motions of galaxies suggests that space itself is expanding**
20. recall and put in order the relative ages of the Earth, the Sun, and the Universe
21. recall that scientists believe the Universe began with a 'big bang' about 14 thousand million years ago
22. understand that the ultimate fate of the Universe is difficult to predict because of difficulties in measuring the very large distances involved **and the mass of the Universe**, and studying the motion of very distant objects.

Module P1: The Earth in the Universe

P1.2 What do we know about the Earth and how it is changing?

1. understand how rocks provide evidence for changes in the Earth (erosion and sedimentation, fossils, folding)
2. understand that continents would be worn down to sea level by erosion, if mountains were not being continuously formed
3. understand that the rock processes seen today can account for past changes
4. understand that the age of the Earth can be estimated from, and must be greater than, the age of its oldest rocks, which are about four thousand million years old
5. understand Wegener's theory of continental drift and his evidence for it (geometric fit of continents and their matching fossils and rock layers)
6. understand how Wegener's theory accounts for mountain building
7. understand reasons for the rejection of Wegener's theory by geologists of his time (movement of continents not detectable, too big an idea from limited evidence, simpler explanations of the same evidence, Wegener an outsider to the community of geologists)
8. understand that seafloor spreading is a consequence of movement of the mantle (convection due to heating by the core)
9. recall that seafloors spread by a few centimetres a year
10. **understand how seafloor spreading and the periodic reversals of the Earth's magnetic field can explain the pattern in the magnetisation of seafloor rocks on either side of the oceanic ridges**
11. understand that earthquakes, volcanoes and mountain building generally occur at the edges of tectonic plates
12. **understand how the movement of tectonic plates causes earthquakes, volcanoes and mountain building, and contributes to the rock cycle**
13. recall that earthquakes produce wave motions on the surface and inside the Earth which can be detected by instruments located on the Earth's surface
14. recall that earthquakes produce:
    a. P-waves (**longitudinal waves**) which travel through solids and liquids
    b. S-waves (**transverse waves**) which travel through solids but not liquids
15. describe the difference between a transverse and longitudinal wave
16. understand how differences in the **wave speeds and** behaviour of P-waves and S-waves can be used to give evidence for the structure of the Earth
17. in relation to waves, use the equation:

distance	=	wave speed	×	time
(metres, m)		(metres per second, m/s)		(seconds, s)

18. draw and label a diagram of the Earth to show its crust, mantle and core
19. recall that a wave is a disturbance, caused by a vibrating source, that transfers energy in the direction that the wave travels, without transferring matter

P1.2 What do we know about the Earth and how it is changing?

20. recall that the frequency of waves, in hertz (Hz), is the number of waves each second that are made by the source, or that pass through any particular point
21. recall that the wavelength of waves is the distance between the corresponding points on two adjacent cycles
22. recall that the amplitude of a wave is the distance from the maximum displacement to the undisturbed position
23. draw and interpret diagrams showing the amplitude and the wavelength of waves
24. use the equation:

$$\underset{\text{(metres per second, m/s)}}{\text{wave speed}} = \underset{\text{(hertz, Hz)}}{\text{frequency}} \times \underset{\text{(metres, m)}}{\text{wavelength}}$$

25. understand that for a constant wave speed the wavelength of the wave is inversely proportional to the frequency.

3.5.2 Module P2: Radiation and life

Overview

The possible health risks of radiation, both in nature and from technological devices, are becoming of increasing concern. In some cases, misunderstanding the term 'radiation' generates unnecessary alarm. By considering the need to protect the skin from sunlight, candidates are introduced to a general model of radiation travelling from the source to a receiver. They learn about the electromagnetic spectrum and the harmful effects of some radiation.

The greenhouse effect and photosynthesis illustrate how radiation from the Sun is vital to life, whilst the ozone layer is shown to be a natural protection from harmful radiation. Candidates study evidence of global warming and its relationship to the carbon cycle. Possible consequences and preventative actions are explored.

The importance of electromagnetic radiation for communication is explored with a consideration of how mobile phones are used to send digital images and sounds. Finally, through an investigation of evidence concerning the possible harmful effects of low intensity microwave radiation from devices such as mobile phones, candidates learn to evaluate reported health studies and interpret levels of risk.

When considering the whole electromagnetic spectrum, it is sometimes more appropriate to use a photon model; at other times a wave model is considered.

Issues for citizens	Questions that science may help to answer
What is radiation? Is it safe to use mobile phones? Is it safe to sunbathe? Are there any benefits from radiation? What is global warming, and what can be done to prevent or reduce it?	What types of electromagnetic radiation are there? What happens when radiation hits an object? Which types of electromagnetic radiation harm living tissues and why? What ideas about risk do citizens and scientists use? How does electromagnetic radiation make life on Earth possible? What is the evidence for global warming, why might it be occurring, and how serious a threat is it?

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
- use ideas of proportion in the context of energy of a photon and the frequency of the radiation
- plot, draw and interpret graphs and charts from candidates' own and secondary data
- extract information from charts, graphs and tables
- use ideas about correlation in the context of information about the possible effects of electromagnetic radiation on health
- use ideas about probability in the context of risk.

Opportunities for practical work

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

- investigate how well different sun-screens filter ultraviolet radiation
- investigate the properties of microwaves using a mobile phone
- investigate climate change models – both physical models and computer models
- carry out image processing to find out how the information in an image file relates to the quality of the image
- show how noise affects analogue and digital signals.

Opportunities for ICT

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

- computer climate modelling
- displaying data on stratospheric ozone concentrations as a false colour map
- processing digital images and sound files.

Use of ICT in teaching and learning can include:

- slides to illustrate evidence of climate change
- video clips to illustrate infrared imaging
- animations to model Sun's radiation and greenhouse effect
- animations to model effect of carbon dioxide levels on global temperature
- spreadsheets to model features of analogue and digital communications systems
- investigating digital images.

Module P2: Radiation and life – Ideas about Science

Module P2 provides opportunities to develop candidates' understanding of these Ideas about Science

2	**Cause-effect explanations** Candidates should understand that:	A candidate who understands this can, for example:
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.
2.6	• to investigate a claim that a factor increases the chance (or probability) of an outcome, scientists compare samples (eg 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.**

5	Risk	
	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.**

Module P2: Radiation and life

P2.1 What types of electromagnetic radiation are there? What happens when radiation hits an object?

1. interpret situations in which one object affects another some distance away in terms of a general model of electromagnetic radiation:
   a. one object (a source) emits radiation
   b. the radiation travels outwards from the source and can be reflected, transmitted or absorbed (or a combination of these) by materials it encounters
   c. radiation may affect another object (a detector) some distance away, when it is absorbed
2. understand that light is one of a family of radiations called the electromagnetic spectrum
3. understand that a beam of electromagnetic radiation transfers energy in 'packets' called photons
4. understand that the higher the frequency of an electromagnetic radiation, the more energy is transferred by each photon
5. list the electromagnetic radiations in order of the energy transferred by each photon, or in order of frequency:

   radio waves, microwaves, infrared, $^{\text{red}}$ visible light $^{\text{violet}}$, ultraviolet, X-rays, gamma rays
6. recall that all types of electromagnetic radiation travel at exactly the same, very high but finite, speed through space (a vacuum) of 300 000 km/s
7. understand that the energy arriving at **a square metre** of surface each second is a useful measure of the strength (or 'intensity') of a beam of electromagnetic radiation
8. understand that the energy transferred to an absorber by a beam of electromagnetic radiation depends on both the number of photons arriving and the energy of each photon
9. understand that the intensity of a beam of electromagnetic radiation decreases with distance from the source **and explain why, in terms of the ever increasing surface area it reaches and its partial absorption by the medium it travels through**
10. understand that some electromagnetic radiations (ultraviolet radiation, X-rays, gamma rays) have enough energy to change atoms or molecules, **which can initiate chemical reactions**
11. recall that high energy ultraviolet radiation, X-rays and gamma rays can cause ionisation
12. understand that the electromagnetic radiations which are ionising are those with high enough photon energy to remove an electron from an atom or molecule (ionisation).

Module P2: Radiation and life

P2.2 Which types of electromagnetic radiation harm living tissue and why?

1. understand that the heating effect of absorbed radiation can damage living cells
2. relate the heating effect when radiation is absorbed to its intensity and duration
3. understand that some people have concerns about health risks from low intensity microwave radiation, for example from mobile phone handsets and masts, though the evidence for this is disputed
4. understand that some microwaves are strongly absorbed by water molecules and so can be used to heat objects containing water
5. understand that the metal cases and door screens of microwave ovens reflect or absorb microwave radiation and so protect users from the radiation
6. recall that some materials (radioactive materials) emit ionising gamma radiation all the time
7. understand that with increased exposure to ionising radiation, damage to living cells increases eventually leading to cancer or cell death
8. understand that the ozone layer absorbs ultraviolet radiation, emitted by the Sun, **producing chemical changes in that part of the atmosphere**
9. understand that the ozone layer protects living organisms from some of the harmful effects of ultraviolet radiation
10. recall that sun-screens and clothing can be used to absorb some of the ultraviolet radiation from the Sun
11. recall that physical barriers absorb some ionising radiation, for example: X-rays are absorbed by dense materials so can be used to produce shadow pictures of bones in our bodies or of objects in aircraft passengers' luggage, and radiographers are protected from radiation by dense materials such as lead and concrete.

Module P2: Radiation and life

P2.3 What is the evidence for global warming, why might it be occurring, and how serious a threat is it?

1. understand that all objects emit electromagnetic radiation with a principal frequency that increases with temperature
2. recall that the Earth is surrounded by an atmosphere which allows some of the electromagnetic radiation emitted by the Sun to pass through
3. recall that this radiation warms the Earth's surface when it is absorbed
4. understand that the radiation emitted by the Earth, **which has a lower principal frequency than that emitted by the Sun**, is absorbed or reflected back by some gases in the atmosphere; this keeps the Earth warmer than it would otherwise be and is called the greenhouse effect
5. recall that one of the main greenhouse gases in the Earth's atmosphere is carbon dioxide, which is present in very small amounts
6. recall that other greenhouse gases include methane, present in very small amounts, and water vapour
7. interpret simple diagrams representing the carbon cycle
8. use the carbon cycle to explain:
    a. why, for thousands of years, the amount of carbon dioxide in the Earth's atmosphere was approximately constant
    b. that some organisms remove carbon dioxide from the atmosphere by photosynthesis (eg green plants) and many organisms return carbon dioxide to the atmosphere by respiration as part of the recycling of carbon
    c. why, during the past two hundred years, the amount of carbon dioxide in the atmosphere has been steadily rising
9. recall that the rise in atmospheric carbon dioxide is largely the result of:
    a. burning increased amounts of fossil fuels as an energy source
    b. cutting down or burning forests to clear land
10. **understand that computer climate models provide evidence that human activities are causing global warming**
11. understand how global warming could result in:
    a. it being impossible to continue growing some food crops in particular regions because of climate change
    b. more extreme weather events, **due to increased convection and larger amounts of water vapour in the hotter atmosphere**
    c. flooding of low lying land due to rising sea levels, caused by melting continental ice and expansion of water in the oceans.

Module P2: Radiation and life

P2.4 How are electromagnetic waves used in communications?

1. understand that electromagnetic radiation of some frequencies can be used for transmitting information, since:
    a. some radio waves and microwaves are not strongly absorbed by the atmosphere so can be used to carry information for radio and TV programmes
    b. light and infrared radiation can be used to carry information along optical fibres because the radiation travels large distances through glass without being significantly absorbed
2. recall that information can be superimposed on to an electromagnetic carrier wave, to create a signal
3. recall that a signal which can vary continuously is called an analogue signal
4. recall that a signal that can take only a small number of discrete values (usually two) is called a digital signal
5. recall that sound and images can be transmitted digitally (as a digital signal)
6. recall that, in digital transmission, the digital code is made up from just two symbols, ‘0’ and ‘1’
7. understand that this coded information can be carried by switching the electromagnetic carrier wave off and on to create short bursts of waves (pulses) where ‘0’ = no pulse and ‘1’ = pulse
8. recall that when the waves are received, the pulses are decoded to produce a copy of the original sound wave or image
9. understand that an important advantage of digital signals over analogue signals is that if the original signal has been affected by noise it can be recovered more easily **and explain why**
10. recall that the amount of information needed to store an image or sound is measured in bytes (B)
11. understand that, generally, the more information stored the higher the quality of the sound or image
12. understand that an advantage of using digital signals is that the information can be stored and processed by computers.

3.5.3 Module P3: Sustainable energy

Overview

Energy supply is one of the major issues that society must address in the immediate future. Citizens are faced with complex choices and a variety of messages from energy supply companies, environmental groups, the media, scientists and politicians. Some maintain that renewable resources are capable of meeting our future needs, some advocate nuclear power, and some argue that drastic lifestyle changes are required. Decisions about energy use, whether at a personal or a national level, need to be informed by a quantitative understanding of the situation, and this is an underlying theme of the module.

Candidates first survey the ways in which individuals and organisations use energy, and learn how energy demand and use can be measured. They explore the use of energy-efficient devices (eg light bulbs) and consider the quantitative consequences of various lifestyle choices (eg relating to transport and the use of electrical equipment). National data on energy sources introduce a study of electricity generation and distribution; nuclear power generation, the burning of fossil fuels, and renewable resources are compared and contrasted. Finally, candidates review the energy choices available to individuals, organisations and society.

Issues for citizens	Questions that science may help to answer
How can we use less energy? Why do we need to make decisions about nuclear power? Which energy sources should we use?	How is energy used? How can electricity be generated? What are the advantages and disadvantages of different ways of generating electricity?

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 using fractions and percentages, particularly in the context of energy efficiency
- 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 probability in the context of risk.

Opportunities for practical work

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

- compare the power consumption of a variety of devices and relate it to the current passing through the device
- investigate factors affecting the output from solar panels and wind turbines
- make a simple electricity generator and investigate the factors that affect the output.

Opportunities for ICT

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

- the role of computers in managing energy demands over the National Grid
- the role of computers in remote handling of highly radioactive waste.

Use of ICT in teaching and learning can include:

- animations to illustrate key processes in power stations
- internet research for data allowing the comparison of different energy sources
- use of spreadsheets to process and present data comparing use of different energy sources.

Module P3: Sustainable energy – Ideas about Science

Module P3 provides opportunities to develop candidates' understanding of these Ideas about Science

5	**Risk** 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.
5.6	• **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 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.
6.5	• 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.

Module P3: Sustainable energy

P3.1 How much energy do we use?

1. understand that the demand for energy is continually increasing and that this raises issues about the availability of energy sources and the environmental effects of using these sources
2. recall the main primary energy sources that humans use: fossil fuels (oil, gas, coal), nuclear fuels, biofuels, wind, waves, and radiation from the Sun
3. understand why electricity is called a secondary energy source
4. understand that power stations which burn fossil fuels produce carbon dioxide which contributes to global warming and climate change
5. understand that when electric current passes through a component (or device), energy is transferred from the power supply to the component and/or to the environment
6. recall that the power (in watts, W) of an appliance or device is a measure of the amount of energy it transfers each second, **ie the rate at which it transfers energy**
7. use the following equation to calculate the amount of energy transferred in a process, in joules and in kilowatt hours:

energy transferred	=	power	×	time
(joules, J)		(watts, W)		(seconds, s)
(kilowatt hours, kWh)		(kilowatts, kW)		(hours, h)

8. use the following equation to calculate the rate at which an electrical device transfers energy:

power	=	voltage	×	current
(watts, W)		(volts, V)		(amperes, A)

9. understand that a joule is a very small amount of energy, so a domestic electricity meter measures the energy transfer in kilowatt hours
10. calculate the cost of energy supplied by electricity given the power, the time and the cost per kilowatt hour
11. interpret and process data on energy use, presented in a variety of ways
12. interpret and construct Sankey diagrams to show understanding that energy is conserved
13. use the following equation in the context of electrical appliances and power stations:

   $$\text{efficiency} = \frac{\text{energy usually transferred}}{\text{total energy supplied}} \times 100\%$$

   ⓘ *Candidates will be expected to consider / calculate efficiency as a decimal ratio and as a percentage*

14. suggest examples of ways to reduce energy usage in personal and national contexts.

Module P3: Sustainable energy

P3.2 How can electricity be generated?

1. understand that electricity is convenient because it is easily transmitted over distances and can be used in many ways
2. recall that mains electricity is produced by generators
3. understand that generators produce a voltage across a coil of wire by spinning a magnet near it
4. understand that the bigger the current supplied by a generator, the more primary fuel it uses every second
5. understand that in many power stations a primary energy source is used to heat water; the steam produced drives a turbine which is coupled to an electrical generator
6. label a block diagram showing the basic components and structures of hydroelectric, nuclear and other thermal power stations
7. understand that nuclear power stations produce radioactive waste
8. understand that radioactive waste emits ionising radiation
9. understand that with increased exposure to ionising radiation, damage to living cells increases eventually leading to cancer or cell death
10. understand the distinction between contamination and irradiation by a radioactive material, and explain why contamination by a radioactive material is more dangerous than a short period of irradiation from the radioactive material
11. understand that many renewable sources of energy drive the turbine directly eg hydroelectric, wave and wind
12. interpret a Sankey diagram for electricity generation and distribution that includes information on the efficiency of energy transfers
13. recall that the mains supply voltage to our homes is 230 volts
14. understand that electricity is distributed through the National Grid at high voltages to reduce energy losses.

Module P3: Sustainable energy

P3.3 Which energy sources should we choose?

1. discuss both qualitatively and quantitatively (based on given data where appropriate), the effectiveness of different choices in reducing energy demands in:
   a. domestic contexts
   b. work place contexts
   c. national contexts
2. understand that the choice of energy source for a given situation depends upon a number of factors including:
   a. environmental impact
   b. economics
   c. waste produced
   d. carbon dioxide emissions
3. describe advantages and disadvantages of different energy sources, including

   non-renewable energy sources such as:
   a. fossil fuels
   b. nuclear

   and renewable energy sources such as:
   c. biofuel
   d. solar
   e. wind
   f. water (waves, tides, hydroelectricity)
   g. geothermal
4. interpret and evaluate information about different energy sources for generating electricity, considering:
   a. efficiency
   b. economic costs
   c. environmental impact
   d. power output and lifetime.
5. **understand that to ensure a security of electricity supply nationally, we need a mix of energy sources.**

3.6 Summary of Science A Unit A141: *Modules B1, C1, P1*

Unit A141 is the first unit for GCSE Science A and forms part of assessment route 2 to this qualification. It assesses the content of Modules B1, C1 and P1 together with their associated Ideas about Science. The other route 2 units are Unit A142 (Section 3.7) and Unit A143 (Section 3.8).

Ideas about Science in Unit A141

Modules B1, C1 and P1 present learning opportunities for a number of the Ideas about Science. The start of each module details the particular Ideas about Science that can be introduced or developed within the contexts covered in the module. Specific examples of contexts within which Ideas about Science can be taught are given in the OCR scheme of work for GCSE Science A (published separately).

However, it is not intended that understanding and application of Ideas about Science should be limited to the context in which they are taught; they should be applicable to any appropriate scientific context.

Accordingly, questions in Unit A141 can assess any of the Ideas about Science linked to Modules B1, C1 and P1, and these Ideas about Science may be assessed in the context of any of the learning outcomes covered in the three modules.

In summary, the Ideas about Science that can be assessed in Unit A141, within any of the scientific contexts introduced by Modules B1, C1 and P1, are:

Data: their importance and limitations
IaS 1.1 – 1.6
Cause-effect explanations
IaS 2.1, 2.3 – 2.5
Developing scientific explanations
IaS 3.1 – 3.4
The scientific community
IaS 4.1 – 4.4
Making decisions about science and technology
IaS 6.3 – 6.6

Modules assessed in Unit A141

The detailed content of the appropriate modules is found in Section 3.3 (Module B1), Section 3.4 (Module C1) and Section 3.5 (Module P1). An overview only is provided in the table below.

Module B1: You and your genes

- What are genes and how do they affect the way that organisms develop?
- Why can people look like their parents, brothers and sisters, but not be identical to them?
- How can and should genetic information be used? How can we use our knowledge of genes to prevent disease?
- How is a clone made?

Module C1: Air quality

- Which chemicals make up air, and which ones are pollutants? How do I make sense of data about air pollution?
- What chemical reactions produce air pollutants? What happens to these pollutants in the atmosphere?
- What choices can we make personally, locally, nationally or globally to improve air quality?

Module P1: The Earth in the Universe

- What do we know about the place of the Earth in the Universe?
- What do we know about the Earth and how it is changing?

3.7 Summary of Science A Unit A142: *Modules B2, C2, P2*

Unit A142 is the second unit for GCSE Science A and forms part of assessment route 2 to this qualification. It assesses the content of Modules B2, C2 and P2 together with their associated Ideas about Science. The other route 2 units are Unit A141 (Section 3.6) and Unit A143 (Section 3.8).

Ideas about Science in Unit A142

Modules B2, C2 and P2 present learning opportunities for a number of the Ideas about Science. The start of each module details the particular Ideas about Science that can be introduced or developed within the contexts covered in the module. Specific examples of contexts within which Ideas about Science can be taught are given in the OCR scheme of work for GCSE Science A (published separately).

However, it is not intended that understanding and application of Ideas about Science should be limited to the context in which they are taught; they should be applicable to any appropriate scientific context.

Accordingly, questions in Unit A142 can assess any of the Ideas about Science linked to Modules B2, C2 and P2, and these Ideas about Science may be assessed in the context of any of the learning outcomes covered in the three modules.

In summary, the Ideas about Science that can be assessed in Unit A142, within any of the scientific contexts introduced by Modules B2, C2 and P2, are:

Data: their importance and limitations
IaS 1.1 – 1.6
Cause-effect explanations
IaS 2.2 – 2.7
The scientific community
IaS 4.1, 4.2
Risk
IaS 5.1 – 5.7
Making decisions about science and technology
IaS 6.4 – 6.6

Modules assessed in Unit A142

The detailed content of the appropriate modules is found in Section 3.3 (Module B2), Section 3.4 (Module C2) and Section 3.5 (Module P2). An overview only is provided in the table below.

Module B2: Keeping healthy

- How do our bodies resist infection?
- What are vaccines and antibiotics and how do they work?
- What factors increase the risk of heart disease?
- How do our bodies keep a healthy water balance?

Module C2: Material choices

- How do we measure the properties of materials and why are the results useful?
- Why is crude oil important as a source of new materials such as plastics and fibres?
- Why does it help to know about the molecular structure of materials such as plastics and fibres?
- What is nanotechnology and why is it important?

Module P2: Radiation and life

- What types of electromagnetic radiation are there? What happens when radiation hits an object?
- Which types of electromagnetic radiation harm living tissue and why?
- What is the evidence for global warming, why might it be occurring, and how serious a threat is it?
- How are electromagnetic waves used in communications?

3.8 Summary of Science A Unit A143: *Modules B3, C3, P3*

Unit A143 is the third unit for GCSE Science A and forms part of assessment route 2 to this qualification. It assesses the content of Modules B3, C3 and P3 together with their associated Ideas about Science. The other route 2 units are Unit A141 (Section 3.6) and Unit A142 (Section 3.7).

Ideas about Science in Unit A143

Modules B3, C3 and P3 present learning opportunities for a number of the Ideas about Science. The start of each module details the particular Ideas about Science that can be introduced or developed within the contexts covered in the module. Specific examples of contexts within which Ideas about Science can be taught are given in the OCR scheme of work for GCSE Science A (published separately).

However, it is not intended that understanding and application of Ideas about Science should be limited to the context in which they are taught; they should be applicable to any appropriate scientific context.

Accordingly, questions in Unit A143 can assess any of the Ideas about Science linked to Modules B3, C3 and P3, and these Ideas about Science may be assessed in the context of any of the learning outcomes covered in the three modules.

In summary, the Ideas about Science that can be assessed in Unit A143, within any of the scientific contexts introduced by Modules B3, C3 and P3, are:

Developing scientific explanations
IaS 3.1 – 3.4
The scientific community
IaS 4.3, 4.4
Risk
IaS 5.1 – 5.7
Making decisions about science and technology
IaS 6.1 – 6.6

Modules assessed in Unit A143

The detailed content of the appropriate modules is found in Section 3.3 (Module B3), Section 3.4 (Module C3) and Section 3.5 (Module P3). An overview only is provided in the table below.

Module B3: Life on Earth

- Systems in balance – how do different species depend on each other?
- How has life on Earth evolved?
- What is the importance of biodiversity?

Module C3: Chemicals in our lives – risks and benefits

- What were the origins of minerals in Britain that contribute to our economic wealth?
- Where does salt come from and why is it so important?
- Why do we need chemicals such as alkalis and chlorine and how do we make them?
- What can we do to make our use of chemicals safe and sustainable?

Module P3: Sustainable energy

- How much energy do we use?
- How can electricity be generated?
- Which energy sources should we choose?

4 Assessment of GCSE Science A

4.1 Overview of the assessment in GCSE Science A

There are **two** alternative routes to achieve GCSE Science A:

- route 1 using Unit A161 from Biology A, Unit A171 from Chemistry A and Unit 181 from Physics A (separate science papers)
- route 2 using Units A141, A142 and A143 from Science A (mixed science papers).

Route 1

GCSE Science A J241	
Unit A161: *Modules B1, B2, B3*	
25% of the total GCSE 1 hour written paper 60 marks	This question paper: • is offered in Foundation and Higher Tiers • assesses Modules B1, B2 and B3 • uses both objective style and free response questions (there is no choice of questions) • assesses the quality of written communication.
Unit A171: *Modules C1, C2, C3*	
25% of the total GCSE 1 hour written paper 60 marks	This question paper: • is offered in Foundation and Higher Tiers • assesses Modules C1, C2 and C3 • uses both objective style and free response questions (there is no choice of questions) • assesses the quality of written communication.
Unit A181: *Modules P1, P2, P3*	
25% of the total GCSE 1 hour written paper 60 marks	This question paper: • is offered in Foundation and Higher Tiers • assesses Modules P1, P2 and P3 • uses both objective style and free response questions (there is no choice of questions) • assesses the quality of written communication.
Unit A144: *Controlled assessment*	
25% of the total GCSE Controlled assessment 6–7 hours 64 marks	This unit: • comprises a case study task and a practical data analysis task • is assessed by teachers, internally standardised and then externally moderated by OCR • assesses the quality of written communication.

Route 2

GCSE Science A J241	
Unit A141: *Modules B1, C1, P1*	
25% of the total GCSE 1 hour written paper 60 marks	This question paper: • is offered in Foundation and Higher Tiers • assesses Modules B1, C1 and P1 • uses both objective style and free response questions (there is no choice of questions) • assesses the quality of written communication.
Unit A142: *Modules B2, C2, P2*	
25% of the total GCSE 1 hour written paper 60 marks	This question paper: • is offered in Foundation and Higher Tiers • assesses Modules C1, C2 and C3 • uses both objective style and free response questions (there is no choice of questions) • assesses the quality of written communication.
Unit A143: *Modules B3, C3, P3*	
25% of the total GCSE 1 hour written paper 60 marks	This question paper: • is offered in Foundation and Higher Tiers • assesses Modules P1, P2 and P3 • uses both objective style and free response questions (there is no choice of questions) • assesses the quality of written communication.
Unit A144: *Controlled assessment*	
25% of the total GCSE Controlled assessment 6–7 hours 64 marks	This unit: • comprises a case study task and a practical data analysis task • 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 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 A161, A171 and A181 (route 1), and in Units A141, A142 and A143 (route 2), candidates are entered for an option in either the Foundation Tier or the Higher Tier. Unit A144 (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, A141/F and A142/H.

4.3 Assessment objectives

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 Science A

There are **two** alternative routes to achieve GCSE Science A: route 1 and route 2.

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

Route 1

Unit	% of GCSE			Total
	AO1	AO2	AO3	
Units A161, A171 and A181	30	34	11	75
Unit A144: Controlled assessment	2	5	18	25
Total	**32**	**39**	**29**	**100**

Route 2

Unit	% of GCSE			Total
	AO1	AO2	AO3	
Units A141–A143	30	34	11	75
Unit A144: 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.

GCSEs are unitised schemes. Candidates can take units across several different series provided the terminal rules are satisfied. They can also re-sit.

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 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 marks 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, eg 60/100.

The uniform mark grade boundaries 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%	100	90	80	70	60	50	40	30	20	0

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

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 given a uniform mark in the range f–u but will be graded as 'u'.

Candidate's uniform marks for each unit will be combined to give a total uniform mark for the specification. The candidate's overall grade will be determined by the total uniform mark.

The following table shows the minimum total mark for each overall grade:

Qualification	Max Uniform Mark	Qualification Grade								
		A*	A	B	C	D	E	F	G	U
J241	400	360	320	280	240	200	160	120	80	0

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 have a limited understanding that scientific advances may have ethical implications, benefits and risks. They recognise simple inter-relationships between science and society. 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 and technological skills, knowledge and understanding in practical and some other contexts. They show limited understanding of the nature of science and its applications. They can explain straightforward models of phenomena, events and processes. Using a limited range of skills and techniques, they answer scientific questions, solve straightforward problems and test ideas.

Candidates interpret and evaluate some qualitative and quantitative data and information from a limited 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, its laws, its applications and the influences of society on science and science on society. They understand how 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 and technological skills, knowledge and understanding in a range of practical and other contexts. They recognise, understand and use straightforward links between hypotheses, evidence, theories, and explanations. They use models to explain phenomena, events and processes. Using appropriate methods, sources of information and data, they apply their skills to answer 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 develop arguments with supporting explanations. They draw conclusions consistent with 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 laws, its applications, and the influences of society on science and science on 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 and technological 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 to explain 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 (QWC) is assessed in all units and is integrated into 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 a suitable structure and style of writing.

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

5 Controlled assessment in GCSE 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 specific guidance and support is provided in the *Guide to controlled assessment for GCSE Twenty First Century Science*, which will be available on the OCR website from Spring 2011.

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. The controlled assessment for GCSE Science A is divided into two elements; a case study and a practical data analysis. Each year a choice of three tasks for each element will be offered; one (per element) for each subject area of biology, chemistry and physics. Within each subject area the tasks will be based on the Science Modules B1–B3, C1–C3 and P1–P3.

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 each task. Tasks will not be valid for submission in any examination series other than that indicated.

Every year, three new tasks for both elements of the controlled assessment 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 three provided for each element of the controlled assessment. 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 decide on an individual basis.

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

5.2 Nature of controlled assessment tasks

5.2.1 Introduction to skills assessment

The controlled assessment for GCSE Science A comprises two elements:

- a case study of a topical issue in science that focuses on evaluating evidence provided or reported by others
- a practical data analysis task that focuses on analysis, interpretation and evaluation of students' own first-hand data and is designed as a stepping stone towards the wider range of skills required to carry out an independent, complete investigation.

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.

5.2.2 Introduction to the case study

In everyday life, science-related issues are most often presented through reports in the media such as newspapers and magazines, websites and television. The case study is designed to enable candidates to demonstrate their skills in evaluating this information together with the underlying scientific principles, and to develop appropriate ways of making decisions about such issues.

Controlled assessment tasks for GCSE Science A case studies require candidates to:

- plan ways to answer scientific questions
- devise appropriate methods for the collection of numerical and other data
- collect, process, analyse and interpret secondary data including the use of appropriate technology
- draw evidence-based conclusions
- evaluate methods of data collection and the quality of the resulting data.

The case study is designed to encourage research skills in locating and evaluating scientific evidence, claims and opinions in the media and other sources. It is expected that candidates will develop skills in these areas during the course that will prepare them for this assessment. Furthermore, the case study provides a motivating context within which candidates can write at length about a topic they have researched for themselves, allowing them to demonstrate understanding of all aspects of Ideas about Science, including:

- IaS1: Data: their importance and limitations
- IaS2: Cause-effect explanations
- IaS3: Developing scientific explanations
- IaS4: The scientific community
- IaS5: Risk
- IaS6: Making decisions about science and technology.

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 case study. Ideas about Science are detailed in Appendix B.

OCR will set case study tasks and provide stimulus material for each case study. The topics chosen will involve some degree of controversy, or disagreement, either about the interpretation of the scientific evidence, or about how individuals or society should respond. The case study should not be simply a report of some new discovery, but rather an exercise in comparing opposing views/opinions and using understanding of science to decide on appropriate courses of action.

The task topics provided by OCR will be chosen to extend or reinforce learning and each will be closely related to a topic studied as part of the course. In this way, the task which is to be used for assessment can be linked to the scheme of work.

The title for a case study will need to be framed by candidates within the context of the task and the stimulus material provided. It is best phrased as a question to be answered by careful balancing of evidence and opinions from a variety of sources. Case studies will often fall into one of three main types:

- Evaluating claims where there is uncertainty in scientific knowledge (eg ‘Does using mobile phones increase the risk of brain damage?’). Controversies of this type focus attention on the relationship between data and explanations in science, and on the quality of research which underlies competing claims.
- Decision making on a science-related issue (eg ‘Should a shopping street be pedestrianised to reduce air pollution?’ or ‘Should the Government restrict research into human cloning?’). Studies in this category are more likely to involve elements of personal choice, values and beliefs, and may involve the balancing of risks and benefits of any proposed action.
- Personal or social choices (eg ‘Should my child receive the triple MMR vaccine?’). Ethical and personal issues are likely to figure in such studies, but it is important to evaluate these in relation to what is known about the science which underlies the issue.

Candidates will be provided with the initial stimulus for the case study, but should be encouraged to plan searches for a range of opinions and their supporting evidence in order to reach a balanced conclusion.

In addition to using the stimulus material provided, candidates will research text books, the internet and other sources to find secondary data which will help them to evaluate claims and opinions related to the topic. They will consider the information in relation to their own scientific knowledge and understanding, taking into account the quality of supporting evidence as well as the apparent validity of each source. Finally, they will decide between the claims made and give recommendations for appropriate actions. The case study will normally be presented as a written report.

Candidates will find it helpful to have a clear sense of audience in their writing to encourage them to explain the basic science behind the topic, for example they could imagine an audience of students in Year 9.

Although the case study will often take the form of a formal written report, candidates should not be discouraged from using other forms, for example:

- a newspaper or magazine article
- a presentation
- a poster or booklet
- a web page.

In all cases, sufficient detail must be included to allow evaluation in all of the performance areas and therefore some types of presentation will require supporting notes.

A case study represents a major piece of work and it is not expected that candidates will attempt more than one during the course. If a candidate does attempt more than one case study, then the total for the assessment should be the highest total for any one case study. It is not permitted to aggregate marks from two or more different pieces of work, nor to add marks obtained from separate, limited range tasks, exercises or part-studies.

The information provided by OCR with each case study task will include:

- *News sheet for candidates*: a collection of several articles about different aspects of a topical issue in science, to be issued to candidates at the start of the task. The articles will represent a variety of views, so that there is scope for students to formulate their own questions to be addressed, allowing some autonomy and choice in the exact aspects to be considered. Where necessary, the material may include some background scientific information and suggestions for questions which candidates could use as a basis for searches for further information. Candidates will be able to use the material as they wish, including the use of direct quotations and illustrations suitably referenced.
- *Information for teachers*: this will include an indication of links between the case study and topics studied in course modules, showing where underlying theory relevant to the case study is likely to be taught in the course. This will help centres to decide the most appropriate timing for this component of the assessment. Notes on assessment issues will also be provided.

5.2.3 Introduction to the practical data analysis

The practical data analysis controlled assessment task requires candidates to design and carry out practical activity based on testing a hypothesis, in which they have been personally involved in collecting first-hand data. They will then analyse, interpret and evaluate the outcomes. The task therefore provides a strong foundation for progression to full-scale individual investigations in Additional Science A, Biology A, Chemistry A or Physics A.

Controlled assessment tasks for GCSE Science A practical data analyses require candidates to:

- plan practical ways to answer scientific questions and test hypotheses
- devise appropriate methods for the collection of numerical and other data
- assess and manage risks when carrying out practical work
- collect, process, analyse and interpret primary data including the use of appropriate technology
- draw evidence-based conclusions
- evaluate methods of data collection and the quality of the resulting data.

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 investigative experiments. Before starting the controlled assessment, all candidates should have a full understanding of the procedures they will need to use and be able to access an adequate range and quantity of data for analysis, interpretation and evaluation.

In addition, each practical data analysis task requires both science knowledge and understanding of the topic and an ability to apply Ideas about Science, in particular:

- 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 a practical data analysis. Ideas about Science are detailed in Appendix B.

Each year, OCR will provide a choice of hypotheses to be tested by candidates. Candidates will need to understand the hypothesis before developing a strategy to test the hypothesis, including selection of methods for collecting primary data. Although candidates will be able to collaborate and share results, marks for the assessment will be based on the work done individually by each candidate.

The tasks provided will be open-ended and investigative in nature. The structure of the assessment means that these can include investigations where it would be unreasonable to expect an individual candidate to collect sufficient data to complete the task, eg electrolysis experiments where each data point takes a substantial time to measure, or field studies where large amounts of data may be required.

The information provided by OCR for each practical data analysis task will include:

- *Information for candidates*: a description of the hypothesis to test placing the work into an appropriate wider context, to be issued to candidates at the start of the task
- *Information for teachers*: an overview of the task including notes on possible approaches and assessment issues, and guidance for technicians including lists of apparatus and materials requirements

5.2.4 Summary of tasks in Unit A144

Assessment Task	Task Marks	Weighting
Task 1: Case study	32	12.5%
Task 2: Practical data analysis	32	12.5%
Total	**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 6–7 hours in producing the work for this unit. Candidates should be allowed sufficient time to complete the tasks.

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 and work independently to produce the report on the final stage (analysis, evaluation and review) for the case study and practical data analysis.

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 secondary data for the case study

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

  In the research and planning stage, including the collection of secondary data, 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. 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 candidates to key things that must be included in their final piece of work. However, each candidate must develop their own, individual response.

5.3.2 Analysis, evaluation and review for the case study

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

  The final 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. Resources, notes and other materials collected during the research and planning stage may be referred to and used, but prepared text which addresses assessment strands B and C must not be directly incorporated into the report. 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, all work must be collected in between each session, including any electronic data storage such as USB memory sticks and rewritable CDs. Although the case studies will be assessed on the basis of the final report only, all materials used during the writing up phase must be kept securely in folders as evidence and provided to moderators if requested.

5.3.3 Research and planning, and collecting data for the practical data analysis

- Strategy: research and planning **1 hour**

  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. 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 hour**

  In the data collection stage, a limited level of control is required. Candidates will carry out practical work under direct teacher supervision. They may work in collaboration during this stage but all candidates must be actively involved. Candidates will also need to develop their own individual response in determining how best to collect and record data. It is not permitted to base the assessment solely on secondary data or (computer) simulations, or on data recorded by candidates whilst watching demonstrations.

5.3.4 Analysis, evaluation and review for the practical data analysis

- Analysis, evaluation and review **1 hour**

  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.

5.3.5 Presentation of the final pieces of work for the case study and practical data analysis tasks

Candidates must observe certain procedures in the production of controlled assessment tasks.

- Tables, graphs and spreadsheets may be produced using appropriate ICT. These should be inserted into the 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 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 units 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: case study and section 5.4.7 Marking criteria for controlled assessment tasks: practical data analysis). These identify levels of performance for the skills, knowledge and understanding that the candidate is required to demonstrate. Guidance for each specific task will be provided 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 for Twenty First Century Science GCSE 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 case study and practical data analysis. 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, more specific guidance will also be given in the *Information for teachers* on applying the marking criteria in the context of the task.

Candidates' progress through the tasks is assessed in three strands for the case study and four strands for the practical data analysis, each of which corresponds to a different type of performance by the candidate. Two of the three strands for the Case Study include two different aspects of the work. Thus, marking is based on a total of 9 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 four different mark levels. This provides a level of response mark scheme where achievement is divided into four non-overlapping bands.

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.

In strand A of the case study, each aspect is marked on a scale of 0 – 4 marks.

For all other strands of the case study and practical data analysis, each aspect is marked on a scale of 0 – 8 marks, with each of the four bands covering a range of two marks: 1–2, 3–4, 5–6 and 7–8. 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 E of the practical data analysis, 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.

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 provides a means of dialogue and feedback between teacher and candidate and a means of communication between teachers during internal standardisation.

5.4.4 Overview of marking criteria for controlled assessment tasks: case study

The three strands in the marking criteria for the case study are designed to match different types of performance; two of them are divided into two different aspects. These do not correspond with any particular sequence that candidates are likely to consistently follow in their reports. Positive achievement should therefore be credited in the appropriate strand wherever it is found in the report.

Strand A: finding sources of information	This strand depends on understanding of: IaS4: The scientific community
Aspect A(a): planning and research to collect information/data	Credit will be given for selection of appropriate sources and materials from those available, rather than indiscriminate copying. Credit will also be given for judgement shown in planning the use of sources which allow comparison of a variety of different opinions or views of the topic.
Aspect A(b): acknowledgement and evaluation of sources	All sources should be referenced and it should be clear where each piece of information has come from. Direct quotations should be acknowledged. Candidates should show that they have considered the validity of sources when making choices of material to include.
Strand B: science explanations	This strand depends on understanding of: IaS1: Data: their importance and limitations IaS2: Cause–effect explanations
providing scientific explanations	Candidates should use explanatory scientific theory to help them analyse and interpret the information/data they have collected. Candidates should look beyond the claims or opinions they find in their sources to analyse the evidence which supports them, and the level of agreement between different sources. Quality of written communication is also assessed in strand B.
Strand C: conclusions and recommendations	This strand depends on understanding of: IaS4: The scientific community IaS5: Risk IaS6: Making decisions about science and technology
Aspect C(a): comparing opposing views and evidence	Candidates should compare the evidence they have collected for each different view of the topic. They should evaluate the claims and opinions they have studied, and compare their relative value as guides to future action. Candidates should be encouraged to structure the report clearly. Thinking about a good structure for the contents can help candidates to organise their ideas. Use of tables of contents and sub-headings between sections of text are valuable in this context.
Aspect C(b): conclusions and recommendations	Candidates should give a conclusion about the issues involved, showing how this is based on their science understanding and their evaluation of the evidence they have collected. They discuss the best course(s) of action based on their conclusion. Credit will be given for discussion of the perceived benefits and associated risks of any proposed actions and an appreciation that different groups may be affected in different ways.

5.4.5 Marking criteria for controlled assessment tasks: case study

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

Strand/ Aspect	0	1 mark	2 marks	3 marks	4 marks	AO
A(a)	*	The content of the report does not go beyond what was given in the initial stimulus material.	The report includes information/ data from at least one additional relevant source found by the candidate.	Information/data has been selected from sources which represent conflicting views or opinions.	The information/data selected is relevant and provides balanced coverage of the range of views or opinions.	AO2: 4 marks
A(b)	*	Links to at least some sources are indicated, though these may not be fully detailed (eg reference to web-site home page or book by title only).	Most sources found by the candidate are identified, but many lack full details (eg reference to web-site home page or book by title only).	Comments are made about the validity of sources. References to nearly all sources used are sufficiently detailed to identify the pages that information has been taken from. Quotations are clearly identified.	Ownership and status of sources are evaluated to justify selection or rejection of information from them. References are fully detailed and link opinions or data to their authors.	AO2: 2 marks AO3: 2 marks
	0	1 – 2 marks	3 – 4 marks	5 – 6 marks	7 – 8 marks	AO
B	*	Only superficial mentions of any science explanations are given. The response may be simplistic, with frequent errors of spelling, punctuation or grammar and have little or no use of scientific vocabulary.	There is a basic outline of the main scientific ideas which are relevant to the claims and opinions. Some relevant scientific terms are correctly used, but spelling, punctuation and grammar are of variable quality.	There is a review of the evidence and of the scientific knowledge needed to understand the issues studied. Information is effectively organised with generally sound spelling, punctuation and grammar. Specialist terms are used appropriately.	Detailed scientific knowledge is used to analyse and interpret the evidence collected. 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

Strand/ Aspect	0	1 – 2 marks	3 – 4 marks	5 – 6 marks	7 – 8 marks	AO
C(a)	*	Evidence is unselectively reported without organising it in relation to different views of the issue being studied. The report has very little structure or coherence.	Items of evidence are clearly identified as 'for' or 'against' a particular view. The report has an appropriate sequence with some structure (eg use of sub-headings).	The evidence is compared to establish how it supports or refutes different views. Information is organised for effective communication of ideas.	Details of the evidence related to opposing views is evaluated and critically compared to show how the evidence supports or refutes each of the views. Issues are reported clearly with a consistent style.	AO3: 8 marks
C(b)	*	A simple conclusion is stated without linking it to supporting claims or evidence.	A conclusion is given based on the extent to which views or opinions discussed in the report are supported by scientific evidence.	Suggestions for appropriate recommendations are based on a conclusion which is clearly linked to evidence in the report.	Limitations of the conclusion, and alternative recommendations are considered, showing awareness of different interpretations of the evidence.	AO1: 2 marks AO3: 6 marks

* No response, or response not sufficient for award of 1 mark

5.4.6 Overview of marking criteria for controlled assessment tasks: practical data analysis

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

Candidates will draw on their knowledge and understanding of science at all stages of a practical data analysis task. The table shows how they can also draw on their knowledge of 'How Science Works' through appropriate references to the 'Ideas about Science' in Appendix B.

Aspect	Notes
Strand D: choice of methods, techniques and equipment	Candidates make choices about the methods, techniques and equipment used to collect high quality data. They show awareness of safe working practices and the hazards associated with materials. At the highest level, a full risk assessment is included. Candidates will find it helpful to refer to: IaS1: Data: their importance and limitations, IaS2: Cause-effect explanations, IaS3: Developing scientific explanations, and IaS5: Risk.
Strand E: revealing patterns in data	The primary data collected by candidates is analysed to reveal any patterns or relationships. Candidates will find it helpful to refer to IaS2: Cause-effect explanations. To allow access to a wider range of activities, this aspect has two alternative sets of descriptors. One is for the quality of graphical display. The alternative row can be used to award credit for statistical or numerical analysis of data.
Strand F: evaluation of data	Candidates should show awareness of any limitations imposed by the apparatus or techniques used and suggest improvements to the method. Recognition and management of risk should also be taken into account when assessing this strand. Candidates will find it helpful to refer to: IaS1: Data: their importance and limitations, and IaS5: Risk.
Strand G: reviewing confidence in the hypothesis	Candidates assess how well the available data supports the hypothesis and explain its scientific basis. Quality of written communication should also be taken into account when assessing this aspect of the work. Candidates will find it helpful to refer to: IaS1: Data: their importance and limitations, IaS2: Cause-effect explanations, and IaS3: Developing scientific explanations.

5.4.7 Marking criteria for controlled assessment tasks: practical data analysis

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

Strand	0	1 – 2 marks	3 – 4 marks	5 – 6 marks	7 – 8 marks	AO
D	*	Describe the method and apparatus selected to collect data. Make an appropriate comment about safe working.	Comment on the techniques and equipment selected to collect data, showing some understanding of the need for repeatability. Correctly identify hazards associated with the procedures used.	Describe the techniques and equipment selected to collect an appropriate range of data of generally good quality, including regular repeats or checks for repeatability. Identify any significant risks and suggest some precautions.	Justify the method, range of values, equipment and techniques selected to collect data of high quality. Complete a full and appropriate risk assessment identifying ways of minimising risks associated with the work.	AO2: 6 marks AO3: 2 marks
E	*	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 eg species distribution maps.	Indicate the spread of data (eg 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 eg 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 eg statistical methods, use of inverse relationships, or calculation of gradient of graphs.	

Strand	0	1 – 2 marks	3 – 4 marks	5 – 6 marks	7 – 8 marks	AO
F	*	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
G	*	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

* No response, or response not sufficient for award of 1 mark

5.4.8 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	Case study	Practical data analysis	TOTAL
AO1: Recall, select and communicate their knowledge and understanding of science	4	2	6
AO2: Apply skills, knowledge and understanding of science in practical and other contexts	6	6	12
AO3: Analyse and evaluate evidence, make reasoned judgements and draw conclusions based on evidence	22	24	46
TOTAL	32	32	64

5.4.9 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.

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 sections 5.4.5 and 5.4.7. 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 each of these units, 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. You can choose different options for different units. Please see the section 8.2.1 for entry codes.

5.7.2 Submitting moderation samples via post

The sample of candidate's 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's work.

We would advise you to keep evidence of work submitted to the moderator, eg 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, which is accessed via Interchange, is a system which has been created to enable centres to submit candidate work electronically for moderation. It allows centres to upload work for several candidates at once but does not function as an e-portfolio for candidates.

The OCR GCSE Science A Unit A144 can be submitted via the OCR Repository.

Once you receive your sample request, you should upload the work to the OCR Repository within three days of receiving the request. Instructions for how to upload files to OCR using the OCR Repository can be found on the OCR website and in the *Guide to controlled assessment for GCSE Twenty First Century Science*, which will be available on the OCR website from Spring 2011.

It is the centre's responsibility to ensure that any work submitted to OCR electronically is virus-free.

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.

6 Support for GCSE Science A

6.1 Free support and training from OCR

OCR recognises that the introduction of the new specifications and controlled assessment will bring challenges for implementation and teaching.

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:

- New OCR GCSE Sciences website www.gcse-science.com to access information and support materials quickly and easily
- Specimen assessment materials and mark schemes
- Guide to controlled assessment
- Sample controlled assessment materials
- Exemplar candidate work
- Teacher's handbook
- Sample schemes of work and lesson plans
- Guide to curriculum planning
- Frequently asked questions.

Essential FREE support services including:

- Free INSET training – for information visit www.gcse-science.com
- Interchange – a completely secure, free website to help centres reduce administrative tasks at exam time
- E-alerts – register now for regular updates at www.ocr.org.uk/2011signup
- 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 partners

We have been working closely with Oxford University Press, our publisher partner for OCR GCSE Twenty First Century Science 2011, to help ensure their new resources are available when you need them and match the new specifications.

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 edition of these resources is packed with up to date science, as well as the familiar topics you enjoy teaching including step by step guidance for answering all types of exam questions, 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 publications

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 2011 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

6.3.1 Get ready... introducing the new specification

If you would like an overview of the new OCR Science specifications, we have half-day ‘Get ready’ courses running in three locations. For more information and to book online visit www.ocreventbooker.org.uk using **course code OSCP3**.

6.3.2 Get started...towards successful delivery of the new specification

Our ‘Get started’ courses will look at the new specification in more depth, with emphasis on first delivery. The courses planned for summer 2011 will focus on controlled assessment. For more information about our full range of OCR GCSE Science courses visit www.ocr.org.uk/science2011/training

6.4 OCR support services

6.4.1 Active Results

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

activeresults

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

Devised specifically for the UK market, 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 in a number of ways:

- 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 at https://interchange.ocr.org.uk.

Access to GCSE Science A

7.1 Disability Discrimination Act (DDA) information relating to GCSE Science A

GCSEs often require assessment of a broad range of competencies. 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 qualifications and subject criteria were reviewed by the regulators to identify whether any of the competencies 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 competencies 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 *Regulations and Guidance Relating to Candidates who are Eligible for Adjustments in Examinations* produced 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 QCDA's GCSE subject criteria equalities review and are as follows:

	Yes/No	Type of assessment
Readers	Yes	All assessments
Scribers	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
BSL interpreters	Yes	All assessments
Oral language modifiers	Yes	All assessments
MQ papers	Yes	All assessments
Extra time	Yes	All assessments

7.2 Arrangements for candidates with particular requirements

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. Centres should consult the JCQ document *Access Arrangements, Reasonable Adjustments and Special Consideration*.

8 Administration of GCSE Science A

8.1 Availability of assessment

There are two examination series each year, in January and June. GCSE Science A units will be assessed from January 2012. There are **two** alternative routes to achieve GCSE Science A: route 1 and route 2.

Assessment availability and unit weighting can be summarised as follows:

Route 1

	Unit A161 (25%)	Unit A171 (25%)	Unit A181 (25%)	Unit A144 (25%)	Certification availability
January 2012	✓	✓	✓		–
June 2012	✓	✓	✓	✓	✓*
January 2013	✓	✓	✓		✓*
June 2013	✓	✓	✓	✓	✓*
January 2014	✓	✓	✓		✓*
June 2014	✓	✓	✓	✓	✓*

Route 2

	Unit A141 (25%)	Unit A142 (25%)	Unit A143 (25%)	Unit A144 (25%)	Certification availability
January 2012	✓	✓			–
June 2012	✓	✓	✓	✓	✓*
January 2013	✓	✓	✓		✓*
June 2013	✓	✓	✓	✓	✓*
January 2014	✓	✓	✓		✓*
June 2014	✓	✓	✓	✓	✓*

GCSE Science A certification is available for the first time in June 2012, and each January and June thereafter.

*Centres are reminded that at least 40% of the assessment must be taken in the examination series in which the qualification is certificated. This can be any combination of assessment units, including written papers and controlled assessment units.

8.2 Making entries

Centres must be registered with OCR in order to make any entries, including estimated entries. It is recommended that centres apply to OCR to become a registered centre well in advance of making their first entries.

Submitting entries accurately and on time is critical to the successful delivery of OCR's services to centres. Entries received after the advertised deadlines can ultimately jeopardise the final production and delivery of results. Therefore, please make sure that you are aware of the entry deadlines, which are available on the OCR website.

8.2.1 Making unit entries

Centres must have made an entry for a unit in order for OCR to supply the appropriate forms and/or moderator details for controlled assessment.

It is essential that unit entry codes are quoted in all correspondence with OCR.

There are **two** alternative routes to achieve GCSE Science A: route 1 and route 2.

Externally assessed units (route 1)

Within Units A161, A171 and A181 candidates must be entered for either the Foundation Tier or the Higher Tier option. It is not necessary for candidates to enter at the same tier in every unit. Candidates may, if they wish, attempt papers for a particular unit at both tiers, but not in the same examination series.

Unit entry code	Component code	Assessment method	Unit title
A161 F	01	Written paper	Biology A Unit A161: *Modules B1, B2, B3* (Foundation Tier)
A161 H	02	Written paper	Biology A Unit A161: *Modules B1, B2, B3* (Higher Tier)
A171 F	01	Written paper	Chemistry A Unit A171: *Modules C1, C2, C3* (Foundation Tier)
A171 H	02	Written paper	Chemistry A Unit A171 *Modules C1, C2, C3* (Higher Tier)
A181 F	01	Written paper	Physics A Unit A181 *Modules P1, P2, P3* (Foundation Tier)
A181 H	02	Written paper	Physics A Unit A181 *Modules P1, P2, P3* (Higher Tier)

Externally assessed units (route 2)

Within Units A141, A142 and A143 candidates must be entered for either the Foundation Tier or the Higher Tier option. It is not necessary for candidates to enter at the same tier in every unit. Candidates may, if they wish, attempt papers for a particular unit at both tiers, but not in the same examination series.

Unit entry code	Component code	Assessment method	Unit title
A141 F	01	Written paper	Science A Unit A141: *Modules B1, C1, P1* (Foundation Tier)
A141 H	02	Written paper	Science A Unit A141: *Modules B1, C1, P1* (Higher Tier)
A142 F	01	Written paper	Science A Unit A142: *Modules B2, C2, P2* (Foundation Tier)
A142 H	02	Written paper	Science A Unit A142: *Modules B2, C2, P2* (Higher Tier)
A143 F	01	Written paper	Science A Unit A143: *Modules B3, C3, P3* (Foundation Tier)
A143 H	02	Written paper	Science A Unit A143: *Modules B3, C3, P3* (Higher Tier)

Controlled assessment unit (both routes)

For the Controlled assessment Unit A144, candidates must be entered for either the OCR Repository option or the postal moderation option. Centres must enter all of their candidates for ONE of the options. It is not possible for centres to offer both components within the same series.

Unit entry code	Component code	Assessment method	Unit title
A144 A	01	Moderated via OCR Repository	Controlled assessment
A144 B	02	Moderated via postal moderation	Controlled assessment

8.2.2 Qualification entries

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

Candidates may enter for:

- GCSE certification code J241.

A candidate who has completed all the units required for the qualification must enter for certification in the same examination series in which the terminal rules are satisfied.

GCSE Science A certification is available for the first time in June 2012, and each January and June thereafter. (First certification in GCSE Additional Science A, GCSE Biology A, GCSE Chemistry A and GCSE Physics A is available in June 2013.)

8.3 Terminal rule

Candidates must take at least 40% of the overall assessment in the same series they enter for the qualification certification.

Guidance on the terminal rule can be found on the OCR website.

8.4 Unit and qualification re-sits

Candidates may re-sit each unit once before entering for certification for a GCSE. The better result for each unit will count towards the final qualification, **provided that the terminal rule is satisfied**.

However, candidates may enter for the qualification an unlimited number of times.

Please refer to the Admin Guide on the OCR website for more information.

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 (by the Enquiries about Results deadline).

Please refer to the JCQ *Post-Results Services* booklet and the OCR Admin Guide for further guidance about action on the release of results. Copies of the latest versions of these documents can be obtained from the OCR website.

8.6 Shelf-life of units

Individual unit results, prior to certification of the qualification, have a shelf-life limited only by that of the qualification.

8.7 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 1310.

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, schools and 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, for example from their centre or the institution to which they wish to progress.

9 Other information about GCSE Science A

9.1 Overlap with other qualifications

This specification has been developed alongside GCSE Additional Science A, GCSE Biology A, GCSE Chemistry A and GCSE Physics A and GCSE Additional Applied Science. This specification includes the content of Modules 1–3 of 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.

9.4 Code of Practice/Common criteria requirements/Subject criteria

This specification complies in all respects with the current GCSE, GCE, Principal Learning and Project Code of Practice as available on the Ofqual website, *The Statutory Regulation of External Qualifications 2004*, and the subject criteria for GCSE Science A.

9.5 Language

This specification and associated assessment materials are in English only.

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.	P1: Study of scientists and their reactions to competing explanations to account for the distribution of the continents on Earth. P2: Exploring the variety of opinions of scientists about the likely extent of global warming. B3: Study of scientists' reactions to competing explanations to account for evidence relating to evolution of life on Earth.
Social issues Risk and the factors which decide the level of risk people are willing to accept in different circumstances.	B2: Assessing the risks associated with vaccination and the reaction of different people to these risks. P2: People's response to the risks associated with electromagnetic radiation. P3: Risks associated with contamination or irradiation by radioactive materials.
Economic issues The range of factors which have to be considered when weighing the costs and benefits of scientific activity.	Case Study of a topical science-related issue. C2: The technical, economic and social issues that have to be taken into account when designing a material object. P3: Long and short term economic and environmental costs and benefits related to the use of various energy sources.
Ethical issues The ethical implications of selected scientific issues.	B1: Ethical issues arising from implications of modern genetic technologies. B2: Ethical issues arising from vaccination policy. C2: Comparison of technical feasibility and values in the context of life cycle analysis for a particular product.
Spiritual issues Scientific explanations which give insight into human nature.	B1: Genes and inheritance. B3: The human nervous system.
Cultural issues Scientific explanations which give insight into the local and global environment.	C1: The origins of pollutants and what happens to them in the atmosphere. B2: Vaccination policy, for different diseases, and in different countries. P2: The cycling of carbon and climate change.

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 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		IT		WwO		IoLP		PS	
	1	2	1	2	1	2	1	2	1	2	1	2
A141	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓
A142	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓
A143	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓
A144	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Unit	C		AoN		IT		WwO		IoLP		PS	
	1	2	1	2	1	2	1	2	1	2	1	2
A161	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓
A171	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓
A181	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓
A144	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Detailed opportunities for generating Key Skills evidence through this specification are posted on the OCR website (www.ocr.org.uk). A summary document for Key Skills Coordinators showing ways in which opportunities for Key Skills arise within GCSE courses has been published.

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 science.

Opportunities for ICT include:

- using video clips to provide the context for topics studied and to illustrate the practical importance of the scientific ideas
- gathering information from the internet and software libraries
- 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 Science 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

9.11 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 A144, 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.

9.12 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

A

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: Ideas about Science

The 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 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 natural 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 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 Appendix 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 Appendix, 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 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 ways in which evidence of understanding can be demonstrated.

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 (eg 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 • can 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.

Appendix C: Mathematics skills for GCSE science qualifications

C

Candidates are permitted to use calculators in all assessments.

Candidates should be able to:

- understand number, size and scale and the quantitative relationship between units
- understand when and how to use estimation
- carry out calculations involving +, – , ×, ÷, either singly or in combination, decimals, fractions, percentages and positive whole number powers,
- provide answers to calculations to an appropriate number of significant figures
- understand and use the symbols =, <, >, ~
- understand and use direct proportion and simple ratios
- calculate arithmetic means
- understand and use common measures and simple compound measures such as speed
- plot and draw graphs (line graphs, bar charts, pie charts, scatter graphs, histograms) selecting appropriate scales for the axes
- substitute numerical values into simple formulae and equations using appropriate units
- translate information between graphical and numeric form
- extract and interpret information from charts, graphs and tables
- understand the idea of probability
- calculate area, perimeters and volumes of simple shapes

In addition, higher tier candidates should be able to

- **interpret, order and calculate with numbers written in standard form**
- **carry out calculations involving negative powers (only –1 for rate)**
- **change the subject of an equation**
- **understand and use inverse proportion**
- **understand and use percentiles and deciles.**

Appendix D: 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	$\times 10^{12}$

E Appendix E: 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, ie 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 micro-organisms 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.

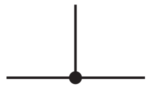
Such adaptations might include a reduced scale of working, deciding that the fume cupboard provision was inadequate or the skills of the candidates were insufficient to attempt particular activities safely. The significant findings of such risk assessment should then be recorded, for example on schemes 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.

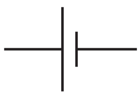
Appendix F: Electrical symbols

junction of conductors

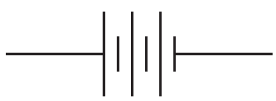


switch

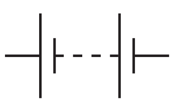
primary or secondary cell



battery of cells

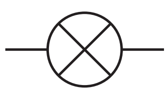


or

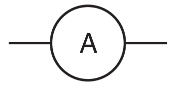


power supply

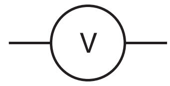
lamp



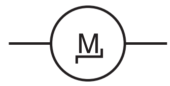
ammeter



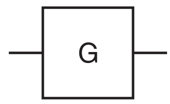
voltmeter



motor

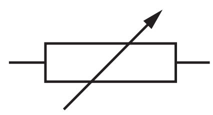


generator

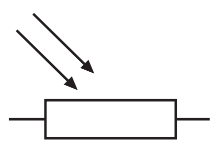


fixed resistor

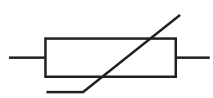
variable resistor



light dependent resistor (LDR)



thermistor



Appendix G: 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.*

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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

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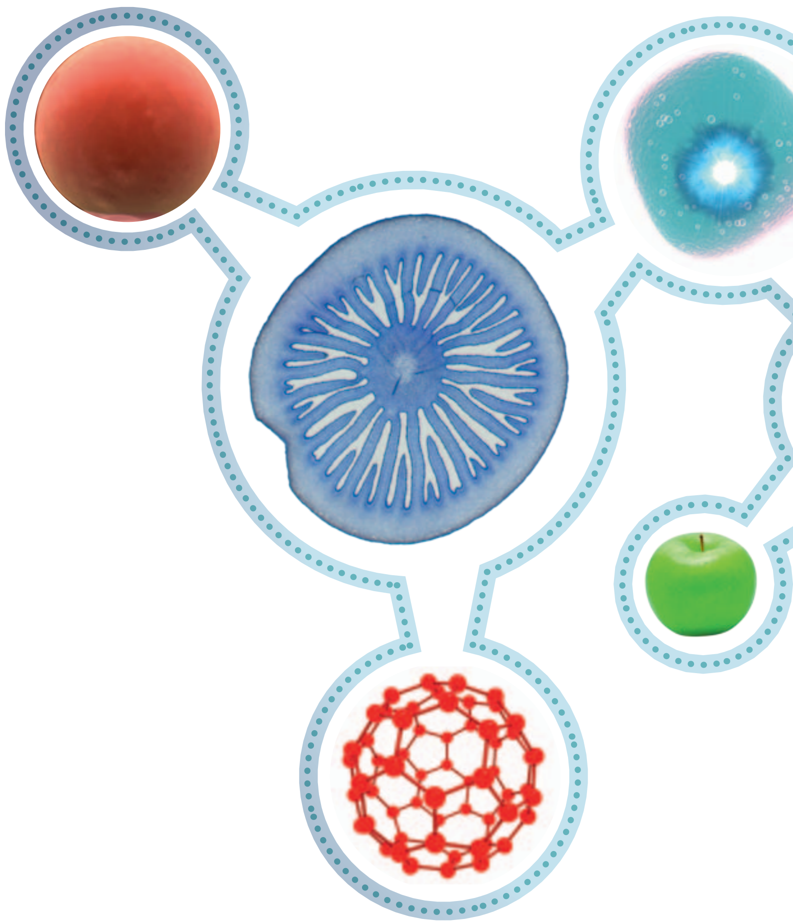
2) Become an approved OCR centre – if your centre is completely new to OCR and has not previously used us for any examinations, visit **www.ocr.org.uk/centreapproval** to become an approved OCR centre.



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