

# **GCSE** Specification

# **Additional Science**

For exams June 2014 onwards For certification June 2014 onwards





# Additional Science 4408

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# Introduction

### **1.1** Why choose AQA?

We, AQA, are the United Kingdom's favourite awarding body and more candidates get their academic qualifications from us than from any other body. But why are we so popular?

We understand the different requirements of each subject by working with teachers. Our GCSEs:

- help candidates to achieve their full potential
- are relevant for today's challenges
- are manageable for schools and colleges
- are easy for candidates of all levels of ability to understand
- lead to accurate results, delivered on time
- are affordable and value for money.

We provide a wide range of support services for teachers, including:

- access to subject departments
- training for teachers, including practical teaching strategies and methods that work, presented by senior examiners
- individual support for Controlled Assessment
- 24-hour support through our website and online with Ask AQA
- past question papers and mark schemes
- a wide range of printed and electronic resources for teachers and candidates
- free online results analysis, with Enhanced Results Analysis.

# We are an educational charity focused on the needs of the learner. All our income is spent on improving the quality of our specifications, examinations and support services. We don't aim to profit from education, we want you to.

If you are already a customer we thank you for your support. If you are thinking of joining us we look forward to welcoming you.

### **1.2** Why choose GCSE Additional Science?

GCSE Additional Science enables you to provide a Key Stage 4 science course for learners of any ability, whether they intend to study science further or not. The specification presents biology, chemistry and physics in separate teaching and learning units, with a choice of two routes for assessment. The model of Controlled Assessment, Investigative Skills Assignments (ISAs), is straightforward and the previous version proved popular with teachers. This course, when combined with GCSE Science A or GCSE Science B, provides a firm foundation for progression to AS and A-level Science.

Two routes through GCSE Additional Science are available:

- Route 1 offers separate assessments of biology, chemistry and physics, together with the Controlled Assessment
- Route 2 offers assessments combining biology, chemistry and physics, together with the Controlled Assessment. The subjects are not integrated and can still be separately taught.

The different routes are offered to suit different methods of curriculum planning. For example, Route 1 could suit centres teaching KS4 over three years to prepare learners for separate GCSEs in biology, chemistry and physics, while Route 2 could enable centres to teach biology, chemistry and physics concurrently throughout KS4 to learners preparing for two science GCSEs.

During the development of our specifications, we have been careful to ensure natural progression from KS3 and we have paid attention to the Assessment of Pupil Progress approach developed by National Strategies. In Unit 4, we have signposted the assessment focus threads to match those used in KS3.

When our science AS and A-levels were developed for first teaching from September 2008, we were very careful to ensure that there was no 'gap' so that learners could easily progress from KS4. We used the same model of internal assessment (ISAs). Research into the outcomes of learners at GCSE and A-level has shown that we were successful in ensuring a smooth transition. A-levels are due to be redeveloped to follow from this GCSE development, and we will continue to ensure our portfolio of specifications offers good progression routes.

When developing this specification, we've retained what you've told us you like, and changed what you've told us we could improve. We've kept:

- a lot of the biology, chemistry and physics content in our current specifications, so you can still use the books and most of the resources you've got now
- guidance in each sub-section showing how the biology, chemistry and physics can be used to teach the wider implications of how science works
- separate assessments for biology, chemistry and physics so you can teach the sciences separately if you want
- ISAs our ISA tests are one of the most popular features of our current specifications, and the new Controlled Assessment ISA has been updated to meet the requirements of the current regulations.

#### We've added:

- an alternative assessment route, with combined assessments that could facilitate some approaches to curriculum planning
- examples of practical work that could support teaching in each sub-section. Full details are included in our resources.

We've changed:

- some of the content following the feedback we've received; this has enabled us to update and refresh the material
- the style of the exams. There are no objective tests with separate answer sheets that candidates have to complete. The three exams all have open questions as well as closed questions.

GCSE Additional Science is one of many qualifications that AQA offers for Key Stage 4. AQA's range, including GCSEs, Diplomas and Entry Level qualifications, enables teachers to select and design appropriate courses for all learners.

GCSE Additional Science is one of five related GCSE specifications that allow biology, chemistry and physics to be taught separately with a pure science approach. We also offer two GCSE specifications that are integrated and put the scientific content into everyday contexts. Our GCSE suite is:

- Science A
- Science B
- Biology
- Chemistry
- Physics
- Additional Science
- Additional Applied Science.

Each qualification is a single GCSE award, and progression routes are flexible. Science A could be followed by Additional Science, or equally by Additional Applied Science. Similarly, Science B could lead to either Additional Science or Additional Applied Science. Our separate science GCSEs have common units with Science A and Additional Science, enabling co-teaching following single, double or triple science routes. This also facilitates a compressed KS3, followed by the teaching of separate science GCSEs over three years.

Both GCSE Science A and GCSE Science B cover the Programme of Study for KS4, enabling centres to meet the entitlement requirements of the National Curriculum at KS4. In GCSE Science A, biology, chemistry and physics can be taught separately by subject specialists, since the content is not integrated but is presented in discrete units. GCSE Science B is an integrated science specification with a context-led approach. With the exception of GCSE Science B, which is a new development, AQA's science GCSEs have evolved from our current specifications. Some changes have been required by regulations. In our work, we've taken advice from a wide range of teachers and organisations with an interest in science education.

In addition to this specification and the associated specimen papers, we offer a wide range of related support and resources for teachers, much of it free. This includes:

- Preparing to Teach meetings
- online schemes of work
- ideas for practical work including worksheets and technician guidance
- practice tests for homework
- our Enhanced Results Analysis service.

This support is accessible through a web-based portal called *The Science Lab*.

### **1.3** How do I start using this specification?

To ensure you receive all the teaching and examination material, it is important that the person responsible for making the decision to teach AQA informs both AQA and their Examinations Officer.

#### Step One

To confirm you will be teaching this specification please sign up to teach and complete the online form. You will then receive your free GCSE Sciences welcome pack(s) that contains teaching and support material.

#### Step Two

Inform your Examinations Officer of your choice to ensure you receive all your examination material. Your Examinations Officer will make sure that your centre is registered with AQA and will complete the *Intention to Enter* and *Estimated Entries* when required to do so.

If your centre has not used AQA for any examinations in the past, please contact our centre approval team at **centreapproval@aqa.org.uk** 

### **1.4** How can I find out more?

You can choose to find out more about this specification or the services that AQA offers in a number of ways.

#### Ask AQA

We provide 24-hour access to useful information and answers to the most commonly asked questions at **aqa.org.uk/askaqa** 

If the answer to your question is not available, you can submit a query through **Ask AQA** and we will respond within two working days.

#### Speak to your subject team

You can talk directly to the GCSE Sciences subject team about this specification on **08442 090 415** or e-mail **science-gcse@aqa.org.uk** 

#### Teacher Support

Details of the full range of current Teacher Support and CPD courses are available on our web site at http://web.aqa.org.uk/qual/cpd/index.php

There is also a link to our fast and convenient online booking system for all of our courses at http://coursesandevents.aqa.org.uk/training

#### Latest information online

You can find out more including the latest news, how to register to use Enhanced Results Analysis, support and downloadable resources on our website at **aqa.org.uk** 

# **Specification at a Glance**

Two routes are available, to suit different methods of curriculum planning in centres:

- **Route 1** Units 1, 2, 3 and 4
- **Route 2** Units 5, 6 and 4

For Route 1, candidates take separate exams in biology, chemistry and physics, together with the Controlled Assessment. For Route 2, candidates take combined exams in biology, chemistry and physics, together with the Controlled Assessment.



### GCSE ADDITIONAL SCIENCE

### OR 4409

Unit 5: Additional Science 1

Written paper - 1 hour 30 minutes

90 marks – **35 %** 

#### Structured and closed questions

At least one question assessing Quality of Written Communication in a science context

Assesses:

Biology 2 (B2.1 to B2.4) Chemistry 2 (C2.1 to C2.3) Physics 2 (P2.1 to P2.3)

#### Unit 2: Chemistry 2

Written paper - 1 hour

60 marks – **25 %** 

Unit 1: Biology 2 Written paper – 1 hour

60 marks - 25%

#### Structured and closed questions

Structured and closed questions

Communication in a science context

At least one question assessing Quality of Written Communication in a science context

EITHER

4408

At least one question assessing Quality of Written

#### Unit 3: Physics 2

Written paper - 1 hour

60 marks – **25 %** 

#### Structured and closed questions

At least one question assessing Quality of Written Communication in a science context

#### **Unit 6: Additional Science 2**

#### Written paper - 1 hour 30 minutes

90 marks - 40%

#### Structured and closed questions

At least one question assessing Quality of Written Communication in a science context Assesses:

Biology 2 (B2.5 to B2.8) Chemistry 2 (C2.4 to C2.7) Physics 2 (P2.4 to P2.6)

#### Unit 4: Controlled assessment

Investigative Skills Assignment – two written assessments plus one or two lessons for practical work and data processing

#### 50 marks – **25 %**

#### Controlled Assessment:

- we set the ISAs and send you all the information before the course starts
- you choose which of several ISAs to do and when
- your candidates do the ISA test in class time
- you mark their tests using marking guidance from us
- we moderate your marks.

# **Subject Content**

### 3.1 Introduction to Subject Content

The subject content of this specification is presented in five sections:

- How Science Works
- the three sections of substantive content, Biology 2, Chemistry 2, Physics 2
- the Controlled Assessment (Unit 4).

It is intended that the How Science Works content is integrated and delivered not only through the Controlled Assessment but also through the context of the content of **Biology 2**, **Chemistry 2** and **Physics 2**.

The organisation of each sub-section of the substantive content is designed to facilitate this approach. Each of the sub-sections of Biology 2, Chemistry 2 and Physics 2 starts with the statement:

### 'Candidates should use their skills, knowledge and understanding to:'.

This introduces a number of activities, for example:

 make informed judgements about the social and ethical issues concerning the use of stem cells from embryos in medical research and treatments.

These activities are intended to enable candidates to develop the skills, knowledge and understanding of How Science Works.

Other aspects of the skills, knowledge and understanding of How Science Works will be better developed through investigative work and it is expected that teachers will adopt a practical enquiry approach to the teaching of many topics.

The subject content is presented in two columns. The left-hand column lists the content that needs to be

delivered. The right-hand column contains guidance and expansion of the content to aid teachers in delivering it and gives further details on what will be examined.

At the end of each section there is a list of ideas for investigative practical work that could be used to help candidates develop their practical enquiry skills to understand and engage with the content.

Opportunities to carry out practical work should be provided in the context of each section. These opportunities should allow candidates to:

- use their knowledge and understanding to pose scientific questions and define scientific problems
- plan and carry out investigative activities, including appropriate risk management, in a range of contexts
- collect, select, process, analyse and interpret both primary and secondary data to provide evidence
- evaluate their methodology, evidence and data.

In the written papers, questions will be set that examine How Science Works in biology, chemistry and physics contexts.

Examination questions will use examples that are both familiar and unfamiliar to candidates. All applications will use the knowledge and understanding developed through the substantive content.

#### Tiering of subject content

In this specification there is additional content for Higher Tier candidates. This is denoted in the subject content in **bold type** and annotated as **HT only** in Sections 3.3 to 3.5.

### **3.2** How Science Works

This section is the content underpinning the science that candidates need to know and understand. Candidates will be tested on How Science Works in **both** the written papers and the Controlled Assessment.

The scientific terms used in this section are clearly defined by the ASE in *The Language of Measurement: Terminology used in school science investigations* (Association for Science Education, 2010). Teachers should ensure that they, and their candidates, are familiar with these terms. Definitions of the terms will **not** be required in assessments, but candidates will be expected to use them correctly.

#### The thinking behind the doing

Science attempts to explain the world in which we live. It provides technologies that have had a great impact on our society and the environment. Scientists try to explain phenomena and solve problems using evidence. The data to be used as evidence must be repeatable, reproducible and valid, as only then can appropriate conclusions be made.

A scientifically literate person should, amongst other things, be equipped to question, and engage in debate on, the evidence used in decision-making.

The repeatability and the reproducibility of evidence refer to how much we trust the data. The validity of evidence depends on these, as well as on whether the research answers the question. If the data is not repeatable or reproducible the research cannot be valid.

To ensure repeatability, reproducibility and validity of evidence, scientists consider a range of ideas that relate to:

- how we observe the world
- designing investigations so that patterns and relationships between variables may be identified
- making measurements by selecting and using instruments effectively
- presenting and representing data
- identifying patterns and relationships and making suitable conclusions.

These ideas inform decisions and are central to science education. They constitute the 'thinking behind the doing' that is a necessary complement to the subject content of biology, chemistry and physics.

#### Fundamental ideas

Evidence must be approached with a critical eye. It is necessary to look closely at how measurements have been made and what links have been established. Scientific evidence provides a powerful means of forming opinions. These ideas pervade all of How Science Works.

- It is necessary to distinguish between opinion based on valid, repeatable and reproducible evidence and opinion based on non-scientific ideas (prejudices, whim or hearsay).
- Scientific investigations often seek to identify links between two or more variables. These links may be:
  - causal, in that a change in one variable causes a change in another
  - due to association, in that changes in one variable and a second variable are linked by a third variable
  - due to chance occurrence.
- Evidence must be looked at carefully to make sure that it is:
  - repeatable
  - reproducible
  - valid.

#### Observation as a stimulus to investigation

Observation is the link between the real world and scientific ideas. When we observe objects, organisms or events we do so using existing knowledge. Observations may suggest hypotheses that can be tested.

- A hypothesis is a proposal intended to explain certain facts or observations.
- A prediction is a statement about the way something will happen in the future.
- Observations can lead to the start of an investigation, experiment or survey. Existing models can be used creatively to suggest explanations for observations (hypotheses).
   Careful observation is necessary before deciding which variables are the most important.
   Hypotheses can then be used to make predictions that can be tested.
- Data from testing a prediction can support or refute the hypothesis or lead to a new hypothesis.
- If the hypotheses and models we have available to us do not completely match our data or observations, we need to check the validity of our observations or data, or amend the models.



#### Designing an investigation

An investigation is an attempt to determine whether or not there is a relationship between variables. Therefore it is necessary to identify and understand the variables in an investigation. The design of an investigation should be scrutinised when evaluating the validity of the evidence it has produced.

- An independent variable is one that is changed or selected by the investigator. The dependent variable is measured for each change in the independent variable.
- For a measurement to be valid it must measure only the appropriate variable.
- A fair test is one in which only the independent variable affects the dependent variable, and other variables are kept the same. These are called control variables.
- When using large-scale survey results, it is necessary to select data from conditions that are similar.
- Control groups are often used in biological and medical research to ensure that observed effects are due to changes in the independent variable alone.
- Care is needed in selecting values of variables to be recorded in an investigation. A trial run will help identify appropriate values to be recorded, such as the number of repeated readings needed and their range and interval.

- An accurate measurement is one that is close to the true value.
- The design of an investigation must provide data with sufficient precision to form a valid conclusion.

#### Making measurements

When making measurements we must consider such issues as inherent variation due to variables that have not been controlled, human error and the characteristics of the instruments used. Evidence should be evaluated with the repeatability and validity of the measurements that have been made in mind.

- There will always be some variation in the actual value of a variable, no matter how hard we try to repeat an event.
- The resolution of an instrument refers to the smallest change in a value that can be detected.
- Even when an instrument is used correctly, human error may occur; this could produce random differences in repeated readings or a systematic shift from the true value.
- Random error can result from inconsistent application of a technique. Systematic error can result from consistent misapplication of a technique.
- Any anomalous values should be examined to try to identify the cause and, if a product of a poor measurement, ignored.

#### **Presenting data**

To explain the relationship between two or more variables, data may be presented in such a way as to make the patterns more evident. There is a link between the type of graph used and the type of variable represented. The choice of graphical representation depends upon the type of variable represented.

- The range of the data refers to the maximum and minimum values.
- The mean (or average) of the data refers to the sum of all the measurements divided by the number of measurements taken.
- Tables are an effective means of displaying data but are limited in how they portray the design of an investigation.
- Bar charts can be used to display data in which one of the variables is categoric.
- Line graphs can be used to display data in which both the independent and dependent variables are continuous.
- Scattergrams can be used to show an association between two variables.

#### Using data to draw conclusions

The patterns and relationships observed in data represent the behaviour of the variables in an investigation. However, it is necessary to look at patterns and relationships between variables with the limitations of the data in mind in order to draw conclusions.

- Patterns in tables and graphs can be used to identify anomalous data that require further consideration.
- A line of best fit can be used to illustrate the underlying relationship between variables.
- Conclusions must be limited by, and not go beyond, the data available.

#### **Evaluation**

In evaluating a whole investigation the repeatability, reproducibility and validity of the data obtained must be considered.

#### Societal aspects of scientific evidence

A judgement or decision relating to social-scientific issues may not be based on evidence alone, as other societal factors may be relevant.

- Evidence must be scrutinised for any potential bias of the experimenter, such as funding sources or allegiances.
- Evidence can be accorded undue weight, or dismissed too lightly, simply because of its political significance. If the consequences of the evidence could provoke public or political disquiet, the evidence may be downplayed.
- The status of the experimenter may influence the weight placed on evidence; for instance, academic or professional status, experience and authority.
- Scientific knowledge gained through investigations can be the basis for technological developments.
- Developments in science and technology have ethical, social, economic or environmental consequences, which should always be taken into account when evaluating the impacts of any new developments.

- Advancements in science can have ethical implications. The effects of these must be taken into account in a balanced way to facilitate decision making.
- Decisions are made by individuals and by society on issues relating to science and technology.

#### Limitations of scientific evidence

Science can help us in many ways but it cannot supply all the answers.

- We are still finding out about things and developing our scientific knowledge.
- There are some questions that we cannot answer, maybe because we do not have enough repeatable, reproducible and valid evidence.
- There are some questions that science cannot answer directly. These tend to be questions where beliefs, opinions and ethics are important.



### 3.3 Unit 1: Biology 2

#### B2.1 Cells and simple cell transport

All living things are made up of cells. The structures of different types of cells are related to their functions. To get into or out of cells, dissolved substances have to cross the cell membranes.

## Candidates should use their skills, knowledge and understanding to:

 relate the structure of different types of cells to their function.

#### B2.1.1 Cells and cell structure

a) Most human and animal cells have the following parts:

- a nucleus, which controls the activities of the cell
- cytoplasm, in which most of the chemical reactions take place
- a cell membrane, which controls the passage of substances into and out of the cell
- mitochondria, which are where most energy is released in respiration
- ribosomes, which are where protein synthesis occurs.
- b) Plant and algal cells also have a cell wall made of cellulose, which strengthens the cell. Plant cells often have:
  - chloroplasts, which absorb light energy to make food
  - a permanent vacuole filled with cell sap.
- c) A bacterial cell consists of cytoplasm and a membrane surrounded by a cell wall; the genes are not in a distinct nucleus.
- d) Yeast is a single-celled organism. Yeast cells have a nucleus, cytoplasm and a membrane surrounded by a cell wall.
- e) Cells may be specialised to carry out a particular function.

#### B2.1.2 Dissolved substances

- a) Dissolved substances can move into and out of cells by diffusion.
- b) Diffusion is the spreading of the particles of a gas, or of any substance in solution, resulting in a net movement from a region where they are of a higher concentration to a region with a lower concentration. The greater the difference in concentration, the faster the rate of diffusion.
- c) Oxygen required for respiration passes through cell membranes by diffusion.

Suggested ideas for practical work to develop skills and understanding include the following:

- observation of cells under a microscope, eg sprouting mung beans to show root hair cells
- computer simulations to model the relative size of different cells, organelles and molecules
- computer simulations to model the process of diffusion
- making model cells
- diffusion of ammonium hydroxide in a glass tube using litmus as the indicator
- investigate how temperature affects the rate of diffusion of glucose through Visking tubing.

#### **B2.2** Tissues, organs and organ systems

The cells of multicellular organisms may differentiate and become adapted for specific functions. Tissues are aggregations of similar cells; organs are aggregations of tissues performing specific physiological functions. Organs are organised into organ systems, which work together to form organisms.

#### B2.2.1 Animal organs

a) Large multicellular organisms develop systems for exchanging materials. During the development of a multicellular organism, cells differentiate so that they can perform different functions.

#### Additional guidance:

Candidates should develop an understanding of size and scale in relation to cells, tissues, organs and organ systems.

- **b)** A tissue is a group of cells with similar structure and function. Examples of tissues include:
  - muscular tissue, which can contract to bring about movement
  - glandular tissue, which can produce substances such as enzymes and hormones
  - epithelial tissue, which covers some parts of the body.
- c) Organs are made of tissues. One organ may contain several tissues. The stomach is an organ that contains:
  - muscular tissue, to churn the contents
  - glandular tissue, to produce digestive juices
  - epithelial tissue, to cover the outside and the inside of the stomach.
- d) Organ systems are groups of organs that perform a particular function. The digestive system is one example of a system in which humans and other mammals exchange substances with the environment.

The digestive system includes:

- glands, such as the pancreas and salivary glands, which produce digestive juices
- the stomach and small intestine, where digestion occurs
- the liver, which produces bile
- the small intestine, where the absorption of soluble food occurs
- the large intestine, where water is absorbed from the undigested food, producing faeces.

#### Additional guidance:

Candidates should be able to recognise the organs of the digestive system on a diagram.

#### B2.2.2 Plant organs

a) Plant organs include stems, roots and leaves.

#### Additional guidance:

Details of the internal structure of these organs are limited to the leaf.

- b) Examples of plant tissues include:
  - epidermal tissues, which cover the plant
  - mesophyll, which carries out photosynthesis
  - xylem and phloem, which transport substances around the plant.

#### B2.3 Photosynthesis

Green plants and algae use light energy to make their own food. They obtain the raw materials they need to make this food from the air and the soil. The conditions plants are grown in can be changed to promote growth.

## Candidates should use their skills, knowledge and understanding to:

- interpret data showing how factors affect the rate of photosynthesis
- evaluate the benefits of artificially manipulating the environment in which plants are grown.

#### B2.3.1 Photosynthesis

a) Photosynthesis is summarised by the equation:

light energy

carbon dioxide + water \_\_\_\_ ■ glucose + oxygen

b) During photosynthesis:

- light energy is absorbed by a green substance called chlorophyll, which is found in chloroplasts in some plant cells and algae
- this energy is used by converting carbon dioxide (from the air) and water (from the soil) into sugar (glucose)
- oxygen is released as a by-product.

c) The rate of photosynthesis may be limited by:

- shortage of light
- Iow temperature
- shortage of carbon dioxide.

 d) Light, temperature and the availability of carbon dioxide interact and in practice any one of them may be the factor that limits photosynthesis.

#### Additional guidance:

Candidates should be able to relate the principle of limiting factors to the economics of enhancing the following conditions in greenhouses:

- light intensity
- temperature
- carbon dioxide concentration.
- e) The glucose produced in photosynthesis may be converted into insoluble starch for storage. Plant cells use some of the glucose produced during photosynthesis for respiration.
- f) Some glucose in plants and algae is used:
  - to produce fat or oil for storage
  - to produce cellulose, which strengthens the cell wall
  - to produce proteins.
- **g)** To produce proteins, plants also use nitrate ions that are absorbed from the soil.

#### Suggested ideas for practical work to develop skills and understanding include the following:

- investigating the need for chlorophyll for photosynthesis with variegated leaves
- taking thin slices of potato and apple and adding iodine to observe under the microscope
- investigate the effects of light, temperature and carbon dioxide levels (using Cabomba, algal balls or leaf discs from brassicas) on the rate of photosynthesis
- computer simulations to model the rate of photosynthesis in different conditions
- the use of sensors to investigate the effect of carbon dioxide and light levels on the rate of photosynthesis and the release of oxygen.

#### B2.4 Organisms and their environment

Living organisms form communities, and we need to understand the relationships within and between these communities. These relationships are affected by external influences.

# Candidates should use their skills, knowledge and understanding to:

- suggest reasons for the distribution of living organisms in a particular habitat
- evaluate methods used to collect environmental data, and consider the validity of the method and the reproducibility of the data as evidence for environmental change.

#### Additional guidance:

Candidates should understand:

- the terms mean, median and mode
- that sample size is related to both validity and reproducibility.

#### B2.4.1 Distribution of organisms

- a) Physical factors that may affect organisms are:
  - temperature
  - availability of nutrients
  - amount of light
  - availability of water
  - availability of oxygen and carbon dioxide.

b) Quantitative data on the distribution of organisms can be obtained by:

- random sampling with quadrats
- sampling along a transect.

#### Suggested ideas for practical work to develop skills and understanding include the following:

- investigative fieldwork involving sampling techniques and the use of quadrats and transects; which might include, on a local scale, the:
  - patterns of grass growth under trees
  - distribution of daisy and dandelion plants in a field
  - distribution of lichens or moss on trees, walls and other surfaces
  - distribution of the alga Pleurococcus on trees, walls and other surfaces
  - leaf size in plants growing on or climbing against walls, including height and effect of aspect
- analysing the measurement of specific abiotic factors in relation to the distribution of organisms
- the study of hay infusions
- the use of sensors to measure environmental conditions in a fieldwork context.

#### B2.5 Proteins – their functions and uses

Proteins have many functions, both inside and outside the cells of living organisms. Proteins, as enzymes, are now used widely in the home and in industry.

# Candidates should use their skills, knowledge and understanding to:

 evaluate the advantages and disadvantages of using enzymes in the home and in industry.

#### B2.5.1 Proteins

- a) Protein molecules are made up of long chains of amino acids. These long chains are folded to produce a specific shape that enables other molecules to fit into the protein. Proteins act as:
  - structural components of tissues such as muscles
  - hormones
  - antibodies
  - catalysts.
- b) Catalysts increase the rate of chemical reactions. Biological catalysts are called enzymes. Enzymes are proteins.

#### B2.5.2 Enzymes

- a) The shape of an enzyme is vital for the enzyme's function. High temperatures change the shape.
- **b)** Different enzymes work best at different pH values.
- c) Some enzymes work outside the body cells. The digestive enzymes are produced by specialised cells in glands and in the lining of the gut. The enzymes then pass out of the cells into the gut where they come into contact with food molecules. They catalyse the breakdown of large molecules into smaller molecules.
- d) The enzyme amylase is produced in the salivary glands, the pancreas and the small intestine. This enzyme catalyses the breakdown of starch into sugars in the mouth and small intestine.
- e) Protease enzymes are produced by the stomach, the pancreas and the small intestine. These enzymes catalyse the breakdown of proteins into amino acids in the stomach and the small intestine.

- f) Lipase enzymes are produced by the pancreas and small intestine. These enzymes catalyse the breakdown of lipids (fats and oils) into fatty acids and glycerol in the small intestine.
- **g)** The stomach also produces hydrochloric acid. The enzymes in the stomach work most effectively in these acid conditions.
- h) The liver produces bile, which is stored in the gall bladder before being released into the small intestine. Bile neutralises the acid that is added to food in the stomach. This provides alkaline conditions in which enzymes in the small intestine work most effectively.
- i) Some microorganisms produce enzymes that pass out of the cells. These enzymes have many uses in the home and in industry.

In the home:

- biological detergents may contain protein-digesting and fat-digesting enzymes (proteases and lipases)
- biological detergents are more effective at low temperatures than other types of detergents.

In industry:

- proteases are used to 'pre-digest' the protein in some baby foods
- carbohydrases are used to convert starch into sugar syrup
- isomerase is used to convert glucose syrup into fructose syrup, which is much sweeter and therefore can be used in smaller quantities in slimming foods.
- j) In industry, enzymes are used to bring about reactions at normal temperatures and pressures that would otherwise require expensive, energy-demanding equipment. However, most enzymes are denatured at high temperatures and many are costly to produce.

#### Suggested ideas for practical work to develop skills and understanding include the following:

- design an investigation to find the optimum temperature for biological and non-biological washing powders to remove stains from cotton and other materials
- investigate the action of enzymes using catalase at different concentrations and measuring the rate at which oxygen is given off from different foods, eg liver, potato, celery and apple
- plan and carry out an investigation into enzyme action using the reaction between starch and amylase at different temperatures, pH and concentrations
- using small pieces of cooked sausage, use 2% pepsin and 0.01M HCl in water baths at different temperatures to estimate the rate of digestion. This can also be carried out with 2% trypsin and 0.1M NaOH. The concentration of both enzymes can be varied
- using computer simulations of enzymes to model their action in varying conditions of pH, temperature and concentration.

#### **B2.6** Aerobic and anaerobic respiration

Respiration in cells can take place aerobically or anaerobically. The energy released is used in a variety of ways. The human body needs to react to the increased demand for energy during exercise.

# Candidates should use their skills, knowledge and understanding to:

interpret the data relating to the effects of exercise on the human body.

#### **B2.6.1** Aerobic respiration

- a) The chemical reactions inside cells are controlled by enzymes.
- b) During aerobic respiration (respiration that uses oxygen) chemical reactions occur that:
  - use glucose (a sugar) and oxygen
  - release energy.
- c) Aerobic respiration takes place continuously in both plants and animals.
- d) Most of the reactions in aerobic respiration take place inside mitochondria.
- e) Aerobic respiration is summarised by the equation:

glucose + oxygen  $\rightarrow$  carbon dioxide + water (+ energy)

- f) Energy that is released during respiration is used by the organism. The energy may be used:
  - to build larger molecules from smaller ones
  - in animals, to enable muscles to contract
  - in mammals and birds, to maintain a steady body temperature in colder surroundings
  - in plants, to build up sugars, nitrates and other nutrients into amino acids which are then built up into proteins.
- g) During exercise a number of changes take place:
  - the heart rate increases
  - the rate and depth of breathing increases.
- h) These changes increase the blood flow to the muscles and so increase the supply of sugar and oxygen and increase the rate of removal of carbon dioxide.
- i) Muscles store glucose as glycogen, which can then be converted back to glucose for use during exercise.

#### B2.6.2 Anaerobic respiration

- a) During exercise, if insufficient oxygen is reaching the muscles they use anaerobic respiration to obtain energy.
- **b)** Anaerobic respiration is the incomplete breakdown of glucose and produces lactic acid.
- c) As the breakdown of glucose is incomplete, much less energy is released than during aerobic respiration. Anaerobic respiration results in an oxygen debt that has to be repaid in order to oxidise lactic acid to carbon dioxide and water.
- d) If muscles are subjected to long periods of vigorous activity they become fatigued, ie they stop contracting efficiently. One cause of muscle fatigue is the build-up of lactic acid in the muscles. Blood flowing through the muscles removes the lactic acid.

#### Additional guidance:

HT only

#### Suggested ideas for practical work to develop skills and understanding include the following:

- investigating the rate of respiration in yeast using carbon dioxide sensors and data loggers
- investigating the effect of exercise on pulse rate, either physically or using pulse sensors and data loggers
- investigating the link between exercise and breathing rate with a breathing sensor
- investigating holding masses at arm's length and timing how long it takes the muscles to fatigue
- designing an investigation using force meters and data loggers to find the relationship between the amount of force exerted by a muscle and muscle fatigue.

#### B2.7 Cell division and inheritance

Characteristics are passed on from one generation to the next in both plants and animals. Simple genetic diagrams can be used to show this. There are ethical considerations in treating genetic disorders.

## Candidates should use their skills, knowledge and understanding to:

 explain why Mendel proposed the idea of separately inherited factors and why the importance of this discovery was not recognised until after his death

#### Additional guidance:

Candidates should be familiar with the principles Mendel used in investigating monohybrid inheritance in peas. They should understand that Mendel's work preceded the work by other scientists which linked Mendel's 'inherited factors' with chromosomes.

- interpret genetic diagrams, including family trees
- construct genetic diagrams of monohybrid crosses and predict the outcomes of monohybrid crosses and be able to use the terms homozygous, heterozygous, phenotype and genotype

#### Additional guidance:

#### **HT** only

Foundation Tier candidates should be able to interpret genetic diagrams of monohybrid inheritance and sex inheritance but will **not** be expected to construct genetic diagrams or use the terms homozygous, heterozygous, phenotype or genotype.

- predict and /or explain the outcome of crosses between individuals for each possible combination of dominant and recessive alleles of the same gene
- make informed judgements about the social and ethical issues concerning the use of stem cells from embryos in medical research and treatments
- make informed judgements about the economic, social and ethical issues concerning embryo screening.

#### Additional guidance:

Data may be given for unfamiliar contexts.

#### B2.7.1 Cell division

- a) In body cells the chromosomes are normally found in pairs. Body cells divide by mitosis.
- b) The chromosomes contain the genetic information.
- c) When a body cell divides by mitosis:
  - copies of the genetic material are made
  - then the cell divides once to form two genetically identical body cells.
- d) Mitosis occurs during growth or to produce replacement cells.
- e) Body cells have two sets of chromosomes; sex cells (gametes) have only one set.
- f) Cells in reproductive organs testes and ovaries in humans – divide to form gametes.

#### Additional guidance:

Knowledge and understanding of the stages in mitosis and meiosis is **not** required.

#### Additional guidance:

Throughout section 2.7 candidates should develop an understanding of the relationship from the molecular level upwards between genes, chromosomes, nuclei and cells and relate these to tissues, organs and systems (2.2 and 2.3).

#### Additional guidance:

For Foundation Tier, knowledge of meiosis is restricted to where the process occurs and that gametes are produced by meiosis.

**g)** The type of cell division in which a cell divides to form gametes is called meiosis.

#### h) When a cell divides to form gametes:

- copies of the genetic information are made
- then the cell divides twice to form four gametes, each with a single set of chromosomes.
- When gametes join at fertilisation, a single body cell with new pairs of chromosomes is formed. A new individual then develops by this cell repeatedly dividing by mitosis.
- j) Most types of animal cells differentiate at an early stage whereas many plant cells retain the ability to differentiate throughout life. In mature animals, cell division is mainly restricted to repair and replacement.

#### Additional guidance:

HT only

#### Additional guidance:

Candidates should understand that genetic diagrams are biological models which can be used to predict the outcomes of crosses.

- k) Cells from human embryos and adult bone marrow, called stem cells, can be made to differentiate into many different types of cells, eg nerve cells.
- I) Human stem cells have the ability to develop into any kind of human cell.
- **m)** Treatment with stem cells may be able to help conditions such as paralysis.
- n) The cells of the offspring produced by asexual reproduction are produced by mitosis from the parental cells. They contain the same alleles as the parents.

#### B2.7.2 Genetic variation

- a) Sexual reproduction gives rise to variation because, when gametes fuse, one of each pair of alleles comes from each parent.
- b) In human body cells, one of the 23 pairs of chromosomes carries the genes that determine sex. In females the sex chromosomes are the same (XX); in males the sex chromosomes are different (XY).
- c) Some characteristics are controlled by a single gene. Each gene may have different forms called alleles.
- d) An allele that controls the development of a characteristic when it is present on only one of the chromosomes is a dominant allele.
- e) An allele that controls the development of characteristics only if the dominant allele is not present is a recessive allele.
- f) Chromosomes are made up of large molecules of DNA (deoxyribo nucleic acid) which has a double helix structure.

h) Each gene codes for a particular combination

of amino acids which makes a specific protein.

#### g) A gene is a small section of DNA.

Additional guidance:

HT only

#### Additional guidance:

Knowledge and understanding of stem cell techniques is **not** required.

#### Additional guidance:

Candidates are **not** expected to know the names of the four bases or how complementary pairs of bases enable DNA replication to take place.

 Each person (apart from identical twins) has unique DNA. This can be used to identify individuals in a process known as DNA fingerprinting.

#### B2.7.3 Genetic disorders

#### a) Some disorders are inherited.

- b) Polydactyly having extra fingers or toes is caused by a dominant allele of a gene and can therefore be passed on by only one parent who has the disorder.
- c) Cystic fibrosis (a disorder of cell membranes) must be inherited from both parents. The parents may be carriers of the disorder without actually having the disorder themselves. It is caused by a recessive allele of a gene and can therefore be passed on by parents, neither of whom has the disorder.
- **d)** Embryos can be screened for the alleles that cause these and other genetic disorders.

#### Additional guidance:

Knowledge and understanding of genetic fingerprinting techniques is **not** required.

#### Additional guidance:

Attention is drawn to the potential sensitivity needed in teaching about inherited disorders.

#### Additional guidance:

Knowledge and understanding of embryo screening techniques is **not** required.

Suggested ideas for practical work to develop skills and understanding include the following:

- observation or preparation and observation of root tip squashes to illustrate chromosomes and mitosis
- using genetic beads to model mitosis and meiosis and genetic crosses
- making models of DNA
- extracting DNA from kiwi fruit.

#### B2.8 Speciation

Changes in the environment of plants and animals may cause them to die out. The fossil record shows that new organisms arise, flourish, and after a time become extinct. The record also shows changes that lead to the formation of new species.

## Candidates should use their skills, knowledge and understanding to:

 suggest reasons why scientists cannot be certain about how life began on Earth.

#### Additional guidance:

The uncertainty arises from the lack of enough valid and reliable evidence.

#### B2.8.1 Old and new species

- a) Evidence for early forms of life comes from fossils.
- b) Fossils are the 'remains' of organisms from many years ago, and are found in rocks. Fossils may be formed in various ways:
  - from the hard parts of animals that do not decay easily
  - from parts of organisms that have not decayed because one or more of the conditions needed for decay are absent
  - when parts of the organism are replaced by other materials as they decay
  - as preserved traces of organisms, eg footprints, burrows and rootlet traces.
- c) Many early forms of life were soft-bodied, which means that they have left few traces behind. What traces there were have been mainly destroyed by geological activity.
- d) We can learn from fossils how much or how little organisms have changed as life developed on Earth.
- e) Extinction may be caused by:
  - changes to the environment over geological time
  - new predators
  - new diseases
  - new, more successful, competitors
  - a single catastrophic event, eg massive volcanic eruptions or collisions with asteroids
  - through the cyclical nature of speciation.

- f) New species arise as a result of:
  - isolation two populations of a species become separated, eg geographically
  - genetic variation each population has a wide range of alleles that control their characteristics
  - natural selection in each population, the alleles that control the characteristics which help the organism to survive are selected
  - speciation the populations become so different that successful interbreeding is no longer possible.

#### Additional guidance:

#### HT only

For Foundation Tier, ideas are restricted to knowledge and understanding of isolation.



### 3.4 Unit 2: Chemistry 2

Throughout this unit candidates will be expected to write word equations for reactions specified. **Higher Tier** candidates will also be expected to write and balance symbol equations for reactions specified throughout the unit.

#### C2.1 Structure and bonding

Simple particle theory is developed in this unit to include atomic structure and bonding. The arrangement of electrons in atoms can be used to explain what happens when elements react and how atoms join together to form different types of substances.

#### Candidates should use their skills, knowledge and understanding to:

- write formulae for ionic compounds from given symbols and ionic charges
- represent the electronic structure of the ions in sodium chloride, magnesium oxide and calcium chloride in the following form:



for sodium ion (Na+)

represent the covalent bonds in molecules such as water, ammonia, hydrogen, hydrogen chloride, methane and oxygen, and in giant structures such as diamond and silicon dioxide, in the following forms:



represent the bonding in metals in the following form:





**Delocalised electrons** 

### Additional guidance:

HT only

#### C2.1.1 Structure and bonding

a)	Compounds are substances in which atoms of two o	
	more elements are chemically combined.	

b) Chemical bonding involves either transferring or sharing electrons in the highest occupied energy levels (shells) of atoms in order to achieve the electronic structure of a noble gas.

		Additional guidance:
c)	When atoms form chemical bonds by transferring electrons, they form ions. Atoms that lose electrons become positively charged ions. Atoms that gain electrons become negatively charged ions. Ions have the electronic structure of a noble gas (Group 0).	Candidates should be able to relate the charge on simple ions to the group number of the element in the periodic table.
d)	The elements in Group 1 of the periodic table, the alkali metals, all react with non-metal elements to form ionic compounds in which the metal ion has a single positive charge.	Knowledge of the chemical properties of alkali metals is limited to their reactions with non-metal elements.
e)	The elements in Group 7 of the periodic table, the halogens, all react with the alkali metals to form ionic compounds in which the halide ions have a single negative charge.	Knowledge of the chemical properties of the halogens is limited to reactions with alkali metals.
f)	An ionic compound is a giant structure of ions. Ionic compounds are held together by strong electrostatic forces of attraction between oppositely charged ions. These forces act in all directions in the lattice and this is called ionic bonding.	Candidates should be familiar with the structure of sodium chloride but do <b>not</b> need to know the structures of other ionic compounds.
g)	When atoms share pairs of electrons, they form covalent bonds. These bonds between atoms are strong. Some covalently bonded substances consist of simple molecules such as $H_2$ , $Cl_2$ , $O_2$ , $HCl$ , $H_2O$ , $NH_3$ and $CH_4$ . Others have giant covalent structures (macromolecules), such as diamond and silicon dioxide.	Candidates should know the bonding in the examples in the specification for this unit, and should be able to recognise simple molecules and giant structures from diagrams that show their bonding.
h)	Metals consist of giant structures of atoms arranged	

in a regular pattern.

 i) The electrons in the highest occupied energy levels (outer shell) of metal atoms are delocalised and so free to move through the whole structure. This corresponds to a structure of positive ions with electrons between the ions holding them together by strong electrostatic attractions.

#### Additional guidance:

HT only

#### Suggested ideas for practical work to develop skills and understanding include the following:

- molecular modelling
- modelling electron transfer and electron sharing using computer simulations
- Group 1 and Group 7 reactions, eg sodium with chlorine
- the reactions of bromine, chlorine and iodine with iron wool
- growing metal crystals by displacement reactions using metals and salts
- modelling metal structures using polyspheres and bubble rafts.

#### **C2.2** How structure influences the properties and uses of substances

Substances that have simple molecular, giant ionic and giant covalent structures have very different properties. Ionic, covalent and metallic bonds are strong. However, the forces between molecules are weaker, eg in carbon dioxide and iodine. Metals have many uses. When different metals are combined, alloys are formed. Shape memory alloys have a range of uses. There are different types of polymers with different uses. Nanomaterials have new properties because of their very small size.

Candidates should use their skills, knowledge and understanding to:	Additional guidance:
<ul> <li>relate the properties of substances to their uses</li> </ul>	Candidates may be provided with information about the properties of substances that are not specified in this unit to enable them to relate these to their uses.
<ul> <li>suggest the type of structure of a substance given its properties</li> </ul>	
	Additional guidance:
<ul> <li>evaluate developments and applications of new materials, eg nanomaterials, fullerenes and shape memory materials.</li> </ul>	Candidates should be familiar with some examples of new materials but do <b>not</b> need to know the properties or names of specific new materials.

#### C2.2.1 Molecules

- a) Substances that consist of simple molecules are gases, liquids or solids that have relatively low melting points and boiling points.
- b) Substances that consist of simple molecules have only weak forces between the molecules (intermolecular forces). It is these intermolecular forces that are overcome, not the covalent bonds, when the substance melts or boils.

#### Additional guidance:

**HT** only

Candidates need to be able to explain that intermolecular forces are weak in comparison with covalent bonds.

c) Substances that consist of simple molecules do not conduct electricity because the molecules do not have an overall electric charge.

#### C2.2.2 Ionic compounds

- a) Ionic compounds have regular structures (giant ionic lattices) in which there are strong electrostatic forces in all directions between oppositely charged ions. These compounds have high melting points and high boiling points because of the large amounts of energy needed to break the many strong bonds.
- **b)** When melted or dissolved in water, ionic compounds conduct electricity because the ions are free to move and carry the current.

#### C2.2.3 Covalent structures

- a) Atoms that share electrons can also form giant structures or macromolecules. Diamond and graphite (forms of carbon) and silicon dioxide (silica) are examples of giant covalent structures (lattices) of atoms. All the atoms in these structures are linked to other atoms by strong covalent bonds and so they have very high melting points.
- **b)** In diamond, each carbon atom forms four covalent bonds with other carbon atoms in a giant covalent structure, so diamond is very hard.
- c) In graphite, each carbon atom bonds to three others, forming layers. The layers are free to slide over each other because there are no covalent bonds between the layers and so graphite is soft and slippery.
- d) In graphite, one electron from each carbon atom is delocalised. These delocalised electrons allow graphite to conduct heat and electricity.
- e) Carbon can also form fullerenes with different numbers of carbon atoms. Fullerenes can be used for drug delivery into the body, in lubricants, as catalysts, and in nanotubes for reinforcing materials, eg in tennis rackets.

#### Additional guidance:

Knowledge of the structures of specific ionic compounds other than sodium chloride is **not** required.

#### Additional guidance:

Candidates should be able to recognise other giant structures or macromolecules from diagrams showing their bonding.

#### Additional guidance:

Higher Tier candidates should be able to explain the properties of graphite in terms of weak intermolecular forces between the layers.

#### HT only

Candidates should realise that graphite is similar to metals in that it has delocalised electrons.

#### HT only

Candidates' knowledge is limited to the fact that the structure of fullerenes is based on hexagonal rings of carbon atoms.

#### C2.2.4 Metals

a) Metals conduct heat and electricity because of the delocalised electrons in their structures.

#### Additional guidance:

#### HT only

Candidates should know that conduction depends on the ability of electrons to move throughout the metal.

- each other and so metals can be bent and shaped. c) Alloys are usually made from two or more different

b) The layers of atoms in metals are able to slide over

- metals. The different sized atoms of the metals distort the layers in the structure, making it more difficult for them to slide over each other, and so make alloys harder than pure metals.
- d) Shape memory alloys can return to their original shape after being deformed, eg Nitinol used in dental braces.

#### C2.2.5 Polymers

- a) The properties of polymers depend on what they are made from and the conditions under which they are made. For example, low density (LD) and high density (HD) poly(ethene) are produced using different catalysts and reaction conditions.
- b) Thermosoftening polymers consist of individual, tangled polymer chains. Thermosetting polymers consist of polymer chains with cross-links between them so that they do not melt when they are heated.

#### Additional guidance: Higher Tier candidates should be able to explain

the properties of thermosoftening polymers in terms of intermolecular forces.

- C2.2.6 Nanoscience
- a) Nanoscience refers to structures that are 1–100 nm in size, of the order of a few hundred atoms. Nanoparticles show different properties to the same materials in bulk and have a high surface area to volume ratio, which may lead to the development of new computers, new catalysts, new coatings, highly selective sensors, stronger and lighter construction materials, and new cosmetics such as sun tan creams and deodorants.

#### Additional guidance:

Candidates should know what is meant by nanoscience and nanoparticles and should consider some of the applications of these materials, but do not need to know specific examples or properties.

Questions may be set on information that is provided about these materials and their uses.

#### Suggested ideas for practical work to develop skills and understanding include the following:

- demonstration of heating sulfur and pouring it into cold water to produce plastic sulfur
- investigating the properties of ionic compounds, eg NaCI:
  - melting point, conductivity, solubility, use of hand lens to study crystal structure
- investigating the properties of covalent compounds:
  - simple molecules, eg wax, methane, hexane
  - macromolecules, eg SiO<sub>2</sub> (sand)
- investigating the properties of graphite
- demonstrations involving shape memory alloys
- investigating the properties of metals and alloys:
  - melting point and conductivity, hardness, tensile strength, flexibility
  - using models, for example using expanded polystyrene spheres or computer animations to show how layers of atoms slide
  - making metal crystals by displacement reactions, eg copper wire in silver nitrate solution
- distinguishing between LD and HD poly(ethene) using 50:50 ethanol:water
- making slime using different concentrations of poly(ethenol) and borax solutions
- investigating the effect of heat on polymers to find which are thermosoftening and which are thermosetting.

#### C2.3 Atomic structure, analysis and quantitative chemistry

The relative masses of atoms can be used to calculate how much to react and how much we can produce, because no atoms are gained or lost in chemical reactions. There are various methods used to analyse these substances.

### Candidates should use their skills, knowledge and understanding to:

 evaluate sustainable development issues relating the starting materials of an industrial process to the product yield and the energy requirements of the reactions involved.

#### Additional guidance:

Candidates may be given appropriate information from which to draw conclusions.
## C2.3.1 Atomic structure

a) Atoms can be represented as shown in this example:

Mass number 23 Na Atomic number 11

b) The relative masses of protons, neutrons and electrons are:

Name of particle	Mass	
Proton	1	
Neutron	1	
Electron	Very small	

- c) The total number of protons and neutrons in an atom is called its mass number.
- d) Atoms of the same element can have different numbers of neutrons; these atoms are called isotopes of that element.

) The relative atomic mass of an element (A <sub>r</sub> ) compares the mass of atoms of the element with the <sup>12</sup> C isotope. It is an average value for the isotopes of the element.	HT only
The relative formula mass $(M_r)$ of a compound is the sum of the relative atomic masses of the atoms in the numbers shown in the formula.	Candidates are expected to use relative atomic masses in the calculations specified in the subject content. Candidates should be able to calculate the relative formula mass ( $M_r$ ) of a compound from its formula.

**g)** The relative formula mass of a substance, in grams, is known as one mole of that substance.

## C2.3.2 Analysing substances

- a) Elements and compounds can be detected and identified using instrumental methods. Instrumental methods are accurate, sensitive and rapid and are particularly useful when the amount of a sample is very small.
- b) Chemical analysis can be used to identify additives in foods. Artificial colours can be detected and identified by paper chromatography.

## Additional guidance:

Knowledge of methods other than paper chromatography is **not** required, but questions may include information based on the results of chemical analysis.

- c) Gas chromatography linked to mass spectroscopy (GC-MS) is an example of an instrumental method:
  - gas chromatography allows the separation of a mixture of compounds
  - the time taken for a substance to travel through the column can be used to help identify the substance
  - the output from the gas chromatography column can be linked to a mass spectrometer, which can be used to identify the substances leaving the end of the column
  - the mass spectrometer can also give the relative molecular mass of each of the substances separated in the column.

## Additional guidance:

Candidates need only a basic understanding of how GC-MS works, limited to:

- different substances, carried by a gas, travel through a column packed with a solid material at different speeds, so that they become separated
- the number of peaks on the output of a gas chromatograph shows the number of compounds present
- the position of the peaks on the output indicates the retention time
- a mass spectrometer can identify substances very quickly and accurately and can detect very small quantities.

### **HT** only

The molecular mass is given by the molecular ion peak.

Knowledge of fragmentation patterns is not required.

## C2.3.3 Quantitative chemistry

- a) The percentage of an element in a compound can be calculated from the relative mass of the element in the formula and the relative formula mass of the compound.
- b) The empirical formula of a compound can be calculated from the masses or percentages of the elements in a compound.
- c) The masses of reactants and products can be calculated from balanced symbol equations.

### Additional guidance:

Candidates should be able to calculate the percentage of an element in a compound, given its formula.

#### HT only

Candidates should be able to calculate empirical formulae.

#### HT only

Candidates should be able to calculate the masses of individual products from a given mass of a reactant and the balanced symbol equation.

- d) Even though no atoms are gained or lost in a chemical reaction, it is not always possible to obtain the calculated amount of a product because:
  - the reaction may not go to completion because it is reversible
  - some of the product may be lost when it is separated from the reaction mixture
  - some of the reactants may react in ways different from the expected reaction.

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- e) The amount of a product obtained is known as the yield. When compared with the maximum theoretical amount as a percentage, it is called the percentage yield.
- f) In some chemical reactions, the products of the reaction can react to produce the original reactants. Such reactions are called reversible reactions and are represented:

 $A + B \rightleftharpoons C + D$ 

For example:

ammonium chloride === ammonia + hydrogen chloride

## Suggested ideas for practical work to develop skills and understanding include the following:

- investigating food colours using paper chromatography
- working out the empirical formulae of copper oxide and magnesium oxide
- calculating yields, for example magnesium burning to produce magnesium oxide or wire wool burning to produce iron oxide
- there are opportunities in this section to build in the idea of instrumentation precision, eg for the collection of gases, the use of boiling tubes, gas jars or gas syringes
- copper sulfate hydration / dehydration
- heating ammonium chloride in a test tube
- adding alkali and acid alternately to bromine water or to potassium chromate solution
- 'blue bottle' reaction (RSC Classic Chemistry Experiments no. 83)
- oscillating reaction (RSC Classic Chemistry Experiments no. 140).

#### Additional guidance:

Higher Tier candidates will be expected to calculate percentage yields of reactions.

## C2.4 Rates of reaction

Being able to speed up or slow down chemical reactions is important in everyday life and in industry. Changes in temperature, concentration of solution, gas pressure, surface area of solids and the presence of catalysts all affect the rates of reactions. Catalysts can help to reduce the cost of some industrial processes.

Candidates should use their skills, knowledge and understanding to:	Additional guidance:	
<ul> <li>interpret graphs showing the amount of product formed (or reactant used up) with time, in terms of the rate of the reaction</li> </ul>	Knowledge of specific reactions other than those in the subject content for this unit is <b>not</b> expected, but candidates will be expected to have studied examples of chemical reactions and processes in developing their skills during their study of this section.	
<ul> <li>explain and evaluate the development, advantages and disadvantages of using catalysts in industrial processes.</li> </ul>	Information may be given in examination questions so that candidates can make evaluations.	

## C2.4.1 Rates of reaction

a)	The rate of a chemical reaction can be found by
	measuring the amount of a reactant used or the
	amount of product formed over time:

Rate of reaction = amount of reactant used time

Rate of reaction =  $\frac{\text{amount of product formed}}{\text{time}}$ 

b) Chemical reactions can only occur when reacting particles collide with each other and with sufficient energy. The minimum amount of energy particles must have to react is called the activation energy.

- c) Increasing the temperature increases the speed of the reacting particles so that they collide more frequently and more energetically. This increases the rate of reaction.
- d) Increasing the pressure of reacting gases increases the frequency of collisions and so increases the rate of reaction.
- e) Increasing the concentration of reactants in solutions increases the frequency of collisions and so increases the rate of reaction.
- f) Increasing the surface area of solid reactants increases the frequency of collisions and so increases the rate of reaction.

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**g)** Catalysts change the rate of chemical reactions but are not used up during the reaction. Different reactions need different catalysts.

### Additional guidance:

Knowledge of named catalysts other than those specified in the subject content for this unit is **not** required, but candidates should be aware of some examples of chemical reactions and processes that use catalysts.

 h) Catalysts are important in increasing the rates of chemical reactions used in industrial processes to reduce costs.

### Suggested ideas for practical work to develop skills and understanding include the following:

- designing and carrying out investigations into factors such as:
  - temperature, eg magnesium with acids at different temperatures
  - surface area, eg different sizes of marble chips
  - catalysts, eg the decomposition of hydrogen peroxide using manganese(IV) oxide, potato and/or liver; the ignition of hydrogen using platinum; oxidation of ammonia using platinum; cracking liquid paraffin using broken pot
  - concentration, eg sodium thiosulfate solution and dilute hydrochloric acid.

There are opportunities here for measurements using sensors (eg carbon dioxide, oxygen, light, pH, gas pressure and temperature) to investigate reaction rates.

## C2.5 Exothermic and endothermic reactions

Chemical reactions involve energy transfers. Many chemical reactions involve the release of energy. For other chemical reactions to occur, energy must be supplied.

## Candidates should use their skills, knowledge and understanding to:

 evaluate everyday uses of exothermic and endothermic reactions.

#### Additional guidance:

Candidates may be given data from which to draw conclusions.

## C2.5.1 Energy transfer in chemical reactions

a) When chemical reactions occur, energy is transferred to or from the surroundings.

### Additional guidance:

Knowledge of delta H ( $\Delta$ H) conventions and enthalpy changes, including the use of positive values for endothermic reactions and negative values for exothermic reactions, is **not** required.

b) An exothermic reaction is one that transfers energy to the surroundings. Examples of exothermic reactions include combustion, many oxidation reactions and neutralisation. Everyday uses of exothermic reactions include self-heating cans (eg for coffee) and hand warmers.

- c) An endothermic reaction is one that takes in energy from the surroundings. Endothermic reactions include thermal decompositions. Some sports injury packs are based upon endothermic reactions.
- d) If a reversible reaction is exothermic in one direction, it is endothermic in the opposite direction. The same amount of energy is transferred in each case. For example:

hydrated	endothermic	anhydrous		
copper		copper	+	water
sulfate	evothermic	sulfate		
(blue)	CAOUTICITITIC	(white)		

### Suggested ideas for practical work to develop skills and understanding include the following:

- investigating temperature changes of neutralisations and displacement reactions, eg zinc and copper sulfate
- investigating temperature changes when dissolving ammonium nitrate, or reacting citric acid and sodium hydrogencarbonate
- adding ammonium nitrate to barium hydroxide
- demonstration of the addition of concentrated sulfuric acid to sugar
- demonstration of the reaction between iodine and aluminium after activation by a drop of water
- demonstration of the screaming jelly baby
- demonstration of the thermite reaction, ie aluminium mixed with iron(III) oxide
- investigation of hand warmers, self-warming cans, sports injury packs.

There are opportunities here for measurements using temperature sensors to investigate energy transfer.



## C2.6 Acids, bases and salts

Soluble salts can be made from acids, and insoluble salts can be made from solutions of ions. When acids and alkalis react the result is a neutralisation reaction.

# Candidates should use their skills, knowledge and understanding to:

 select an appropriate method for making a salt, given appropriate information.

## C2.6.1 Making salts

- a) The state symbols in equations are (s), (l), (g) and (aq).
- b) Soluble salts can be made by reacting acids with:
  - metals not all metals are suitable; some are too reactive and others are not reactive enough
  - insoluble bases the base is added to the acid until no more will react and the excess solid is filtered off
  - alkalis an indicator can be used to show when the acid and alkali have completely reacted to produce a salt solution.
- c) Salt solutions can be crystallised to produce solid salts.
- d) Insoluble salts can be made by mixing appropriate solutions of ions so that a precipitate is formed.
   Precipitation can be used to remove unwanted ions from solutions, for example in treating water for drinking or in treating effluent.

## C2.6.2 Acids and bases

- a) Metal oxides and hydroxides are bases. Soluble hydroxides are called alkalis.
- b) The particular salt produced in any reaction between an acid and a base or alkali depends on:
  - the acid used (hydrochloric acid produces chlorides, nitric acid produces nitrates, sulfuric acid produces sulfates)
  - the metal in the base or alkali.

#### Additional guidance:

Candidates should be able to suggest methods to make a named soluble salt.

#### Additional guidance:

Candidates should be able to name the substances needed to make a named insoluble salt.

- c) Ammonia dissolves in water to produce an alkaline solution. It is used to produce ammonium salts. Ammonium salts are important as fertilisers.
- d) Hydrogen ions, H+(aq), make solutions acidic and hydroxide ions, OH<sup>-</sup>(aq), make solutions alkaline. The pH scale is a measure of the acidity or alkalinity of a solution.
- c) In neutralisation reactions, hydrogen ions react with hydroxide ions to produce water. This reaction can be represented by the equation:

## Additional guidance:

Candidates should be familiar with the pH scale from 0 to 14, and know that pH 7 indicates a neutral solution.

 $\mathsf{H^+(aq)} + \mathsf{OH^-(aq)} \rightarrow \mathsf{H_2O(l)}$ 

### Suggested ideas for practical work to develop skills and understanding include the following:

- the preparation of soluble salts:
  - copper sulfate by adding copper oxide to sulfuric acid
  - magnesium sulfate by adding magnesium oxide to sulfuric acid
  - copper chloride by adding copper oxide to hydrochloric acid
  - zinc nitrate by adding zinc oxide to nitric acid
  - sodium chloride by adding sodium hydroxide to hydrochloric acid
  - copper sulfate by adding copper carbonate to sulfuric acid
  - investigation of the effect of conditions on the yield of the salt
- the preparation of insoluble salts:
  - lead iodide by mixing solutions of lead nitrate and potassium iodide
  - barium sulfate by mixing solutions of barium chloride and sodium sulfate
  - investigation of the effect of conditions on the formation of precipitates.

There are opportunities here for using pH sensors to investigate neutralisation.

## C2.7 Electrolysis

lonic compounds have many uses and can provide other substances. Electrolysis is used to produce alkalis and elements such as aluminium, chlorine and hydrogen. Oxidation–reduction reactions do not just involve oxygen.

# Candidates should use their skills, knowledge and understanding to:

predict the products of electrolysing solutions of ions

### Additional guidance:

Knowledge and understanding is limited to the methods indicated in the subject content.

 explain and evaluate processes that use the principles described in this unit, including the use of electroplating.

## C2.7.1 Electrolysis

- a) When an ionic substance is melted or dissolved in water, the ions are free to move about within the liquid or solution.
- b) Passing an electric current through ionic substances that are molten, for example lead bromide, or in solution breaks them down into elements. This process is called electrolysis and the substance that is broken down is called the electrolyte.
- c) During electrolysis, positively charged ions move to the negative electrode, and negatively charged ions move to the positive electrode.
- **d)** Electrolysis is used to electroplate objects. This may be for a variety of reasons and includes copper plating and silver plating.
- e) At the negative electrode, positively charged ions gain electrons (reduction) and at the positive electrode, negatively charged ions lose electrons (oxidation).
- f) If there is a mixture of ions, the products formed depend on the reactivity of the elements involved.
- g) Reactions at electrodes can be represented by half equations, for example:

$$\begin{array}{c} 2\mathsf{CI}^- \to \mathsf{CI}_2 + 2\mathsf{e}^- \\ & \mathsf{or} \\ 2\mathsf{CI}^- - 2\mathsf{e}^- \to \mathsf{CI}_2 \end{array}$$

#### Additional guidance:

#### **HT** only

Candidates should be able to complete and balance half equations for the reactions occurring at the electrodes during electrolysis.

- h) Aluminium is manufactured by the electrolysis of a molten mixture of aluminium oxide and cryolite. Aluminium forms at the negative electrode and oxygen at the positive electrode. The positive electrode is made of carbon, which reacts with the oxygen to produce carbon dioxide.
- i) The electrolysis of sodium chloride solution produces hydrogen and chlorine. Sodium hydroxide solution is also produced. These are important reagents for the chemical industry, eg sodium hydroxide for the production of soap and chlorine for the production of bleach and plastics.

### Additional guidance:

Candidates should understand why cryolite is used in this process.

## Suggested ideas for practical work to develop skills and understanding include the following:

- the electrolysis of molten lead bromide or zinc chloride
- investigation of the electrolysis of any solutions of a soluble ionic compound, eg copper chloride, sodium chloride, zinc bromide, zinc iodide
- a demonstration of the Hoffman voltameter
- the electroplating of copper foil with nickel in a nickel sulfate solution
- the movement of ions, eg by electrolysis of a crystal of KMnO<sub>4</sub> on filter paper dampened with sodium chloride solution, or electrolysis of CuCrO<sub>4</sub> in a saturated urea solution using a U-tube
- using conductivity sensors to monitor conductivity and changes in conductivity.

## **3.5** Unit 3: Physics 2

## P2.1 Forces and their effects

Forces can cause changes to the shape or motion of an object. Objects can move in a straight line at a constant speed. They can also change their speed and / or direction (accelerate or decelerate). Graphs can help us to describe the movement of an object. These may be distance-time graphs or velocity-time graphs.

## Candidates should use their skills, knowledge and understanding to:

- interpret data from tables and graphs relating to speed, velocity and acceleration
- evaluate the effects of alcohol and drugs on stopping distances
- evaluate how the shape and power of a vehicle can be altered to increase the vehicle's top speed
- draw and interpret velocity-time graphs for objects that reach terminal velocity, including a consideration of the forces acting on the object.

## P2.1.1 Resultant forces

- Whenever two objects interact, the forces they exert on each other are equal and opposite.
- b) A number of forces acting at a point may be replaced by a single force that has the same effect on the motion as the original forces all acting together. This single force is called the resultant force.
- c) A resultant force acting on an object may cause a change in its state of rest or motion.

#### Additional guidance:

Candidates should be able to determine the resultant of opposite or parallel forces acting in a straight line.

d) If the resultant force acting on a stationary object is:

- zero, the object will remain stationary
- not zero, the object will accelerate in the direction of the resultant force.

e) If the resultant force acting on a moving object is:

- zero, the object will continue to move at the same speed and in the same direction
- not zero, the object will accelerate in the direction of the resultant force.

	P2.1.2	Forces and motion
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	Additional guidance:
a) The acceleration of an object is determined by the resultant force acting on the object and the mass of the object.	F is the resultant force in newtons, N
$a = \frac{F}{m}$ or $F = m \times a$	<i>m</i> is the mass in kilograms, kg
	<i>a</i> is the acceleration in metres per second squared, m/s <sup>2</sup>
<b>b)</b> The gradient of a distance-time graph represents speed.	Candidates should be able to construct distance-time graphs for an object moving in a straight line when the body is stationary or moving with a constant speed.
c) Calculation of the speed of an object from the gradient of a distance-time graph.	HT only
d) The velocity of an object is its speed in a given direction.	
	Additional guidance:
e) The acceleration of an object is given by the equation:	a is the acceleration in metres per second squared, m/s <sup>2</sup>
V = II	v is the final velocity in metres per second, m/s
$a = \frac{v - a}{t}$	<i>u</i> is the initial velocity in metres per second, m/s
	<i>t</i> is the time taken in seconds, s
f) The gradient of a velocity-time graph represents acceleration.	
	Additional guidance:
g) Calculation of the acceleration of an object from the gradient of a velocity-time graph.	HT only
<ul> <li>h) Calculation of the distance travelled by an object from a velocity-time graph.</li> </ul>	HT only
P2.1.3 Forces and braking	

		Additional guidance:
a)	When a vehicle travels at a steady speed the resistive forces balance the driving force.	Candidates should realise that most of the resistive forces are caused by air resistance.
b)	The greater the speed of a vehicle the greater the braking force needed to stop it in a certain distance.	Candidates should understand that for a given braking force the greater the speed, the greater the stopping distance.

- c) The stopping distance of a vehicle is the sum of the distance the vehicle travels during the driver's reaction time (thinking distance) and the distance it travels under the braking force (braking distance).
- d) A driver's reaction time can be affected by tiredness, drugs and alcohol.
- e) When the brakes of a vehicle are applied, work done by the friction force between the brakes and the wheel reduces the kinetic energy of the vehicle and the temperature of the brakes increases.
- f) A vehicle's braking distance can be affected by adverse road and weather conditions and poor condition of the vehicle.

## **P2.1.4** Forces and terminal velocity

- a) The faster an object moves through a fluid the greater the frictional force that acts on it.
- b) An object falling through a fluid will initially accelerate due to the force of gravity. Eventually the resultant force will be zero and the object will move at its terminal velocity (steady speed).
- c) Draw and interpret velocity-time graphs for objects that reach terminal velocity, including a consideration of the forces acting on the object.
- d) Calculate the weight of an object using the force exerted on it by a gravitational force:

 $W = m \times g$ 

## Additional guidance:

Additional guidance:

Additional guidance:

Additional guidance:

affect a driver's ability to react.

Candidates should appreciate that distractions may

Candidates should understand that 'adverse road

of the car is limited to the car's brakes or tyres.

Candidates should understand why the use of a

parachute reduces the parachutist's terminal velocity.

conditions' includes wet or icy conditions. Poor condition

W is the weight in newtons, N

m is the mass in kilograms, kg

g is the gravitational field strength in newtons per kilogram, N/kg

## **P2.1.5** Forces and elasticity

- a) A force acting on an object may cause a change in shape of the object.
- b) A force applied to an elastic object such as a spring will result in the object stretching and storing elastic potential energy.

### Additional guidance:

Calculation of the energy stored when stretching an elastic material is **not** required.

- c) For an object that is able to recover its original shape, elastic potential energy is stored in the object when work is done on the object to change its shape.
- **d)** The extension of an elastic object is directly proportional to the force applied, provided that the limit of proportionality is not exceeded:

### Additional guidance:

F is the force in newtons, N

k is the spring constant in newtons per metre, N/m

 $F = k \times e$ 

e is the extension in metres, m

Suggested ideas for practical work to develop skills and understanding include the following:

- dropping a penny and a feather in a vacuum and through the air to show the effect of air resistance
- plan and carry out an investigation into Hooke's law
- catapult practicals to compare stored energy
- measurement of acceleration of trolleys using known forces and masses
- timing objects falling through a liquid, eg wallpaper paste or glycerine, using light gates or stop clocks
- plan and carry out an investigation to measure the effects of air resistance on parachutes, paper spinners, cones or bun cases
- measuring reaction time with and without distractions, eg iPod off and then on.

## P2.2 The kinetic energy of objects speeding up or slowing down

When an object speeds up or slows down, its kinetic energy increases or decreases. The forces which cause the change in speed do so by doing work. The momentum of an object is the product of the object's mass and velocity.

# Candidates should use their skills, knowledge and understanding to:

- evaluate the benefits of different types of braking system, such as regenerative braking.
- evaluate the benefits of air bags, crumple zones, seat belts and side impact bars in cars.

### Additional guidance:

This should include ideas of both energy changes and momentum changes.

## P2.2.1 Forces and energy

- a) When a force causes an object to move through a distance work is done.
- **b)** Work done, force and distance, are related by the equation:

#### Additional guidance:

W is the work done in joules, J

F is the force applied in newtons, N

*d* is the distance moved in the direction of the force in metres, m

 $W = F \times d$ 

c) Energy is transferred when work is done.

## Additional guidance:

Candidates should be able to discuss the transfer of kinetic energy in particular situations. Examples might include shuttle re-entry or meteorites burning up in the atmosphere.

d) Work done against frictional forces.

	Additional guidance:
e) Power is the work done or energy transferred in a given time.	P is the power in watts, W
- F	<i>E</i> is the energy transferred in joules, J
$P = \frac{E}{t}$	<i>t</i> is the time taken in seconds, s
f) Gravitational potential energy is the energy that an object has by virtue of its position in a gravitational field.	Candidates should understand that when an object is raised vertically work is done against gravitational force and the object gains gravitational potential energy.
$E_{\rm p} = m \times g \times h$	E <sub>p</sub> is the change in gravitational potential energy in joules, J
	<i>m</i> is the mass in kilograms, kg
	g is the gravitational field strength in newtons per kilogram, N/kg
	h is the change in height in metres, m
g) The kinetic energy of an object depends on its mass and its speed	
	$E_{\rm k}$ is the kinetic energy in joules, J
$E_{\rm k} = \frac{1}{2} \times m \times v^2$	<i>m</i> is the mass in kilograms, kg
	v is the speed in metres per second, m/s

## P2.2.2 Momentum

	Additional guidance:
a) Momentum is a property of moving objects.	
$p = m \times v$	p is momentum in kilograms metres per second, kg m/s
$\rho = m \times v$	<i>m</i> is the mass in kilograms, kg
	<i>v</i> is the velocity in metres per second, m/s
<ul><li>b) In a closed system the total momentum before an event is equal to the total momentum after the event. This is called conservation of momentum.</li></ul>	Candidates may be required to complete calculations involving two objects.
	Examples of events are collisions and explosions.

## Suggested ideas for practical work to develop skills and understanding include the following:

- investigating the transfer of E<sub>o</sub> to E<sub>k</sub> by dropping a card through a light gate
- plan and carry out an investigation to measure velocity using trolleys and ramps
- running upstairs and calculating work done and power, lifting weights to measure power
- a motor lifting a load to show how power changes with load
- stretching different materials before using as catapults to show the different amounts of energy transferred, indicated by speed reached by the object or distance travelled.

## P2.3 Currents in electrical circuits

The current in an electric circuit depends on the resistance of the components and the supply.

# Candidates should use their skills, knowledge and understanding to:

- apply the principles of basic electrical circuits to practical situations
- evaluate the use of different forms of lighting, in terms of cost and energy efficiency.

### Additional guidance:

Examples might include filament bulbs, fluorescent bulbs and light-emitting diodes (LEDs).

## P2.3.1 Static electricity

- a) When certain insulating materials are rubbed against each other they become electrically charged. Negatively charged electrons are rubbed off one material and onto the other.
- b) The material that gains electrons becomes negatively charged. The material that loses electrons is left with an equal positive charge.
- c) When two electrically charged objects are brought together they exert a force on each other.
- **d)** Two objects that carry the same type of charge repel. Two objects that carry different types of charge attract.
- e) Electrical charges can move easily through some substances, eg metals.

## P2.3.2 Electrical circuits

		Additional guidance:
a)	Electric current is a flow of electric charge. The size of the electric current is the rate of flow of electric charge. The size of the current is given by the equation:	
	$I = \frac{Q}{t}$	I is the current in amperes (amps), A
	t	Q is the charge in coulombs, C
		<i>t</i> is the time in seconds, s
b)	The potential difference (voltage) between two points in an electric circuit is the work done (energy transferred) per coulomb of charge that passes between the points.	Teachers can use either of the terms potential difference or voltage. Questions will be set using the term potential difference. Candidates will gain credit for the correct use of either term.
	$V = \frac{W}{W}$	V is the potential difference in volts, V
	Q	W is the work done in joules, J
		Q is the charge in coulombs, C
c)	Circuit diagrams using standard symbols. The following standard symbols should be known:	Candidates will be required to interpret and draw circuit diagrams.
		Knowledge and understanding of the use of thermistors in circuits eg thermostats is required.
		Knowledge and understanding of the applications of light-dependent resistors (LDRs) is required, eg switching lights on when it gets dark
	-V- voltmeter	
	∎ ∎ battery A) ammeter	
	- diode	
	- resistor	
	- Variable resistor - LDR	
	LED	

d) Current–potential difference graphs are used to show how the current through a component varies with the potential difference across it.

e) The current–potential difference graphs for a resistor at constant temperature.



- f) The resistance of a component can be found by measuring the current through, and potential difference across, the component.
- **g)** The current through a resistor (at a constant temperature) is directly proportional to the potential difference across the resistor.
- h) Calculate current, potential difference or resistance using the equation:

$$V = I \times R$$

## Additional guidance:

V is the potential difference in volts, V

I is the current in amperes (amps), A

R is the resistance in ohms,  $\Omega$ 

- The current through a component depends on its resistance. The greater the resistance the smaller the current for a given potential difference across the component.
- j) The potential difference provided by cells connected in series is the sum of the potential difference of each cell (depending on the direction in which they are connected).

k) For components connected in series:

- the total resistance is the sum of the resistance of each component
- there is the same current through each component
- the total potential difference of the supply is shared between the components.
- I) For components connected in parallel:
  - the potential difference across each component is the same
  - the total current through the whole circuit is the sum of the currents through the separate components.

m) The resistance of a filament bulb increases as the temperature of the filament increases.



 n) The current through a diode flows in one direction only. The diode has a very high resistance in the reverse direction



Additional guidance:

#### HT only

Candidates should be able to explain resistance change in terms of ions and electrons.

#### Additional guidance:

Candidates should be aware that there is an increasing use of LEDs for lighting, as they use a much smaller current than other forms of lighting.

p) The resistance of a light-dependent resistor (LDR) decreases as light intensity increases.

o) An LED emits light when a current flows through

it in the forward direction.

**q)** The resistance of a thermistor decreases as the temperature increases.

Additional guidance:

thermistor only is required.

Knowledge of a negative temperature coefficient

Suggested ideas for practical work to develop skills and understanding include the following:

- using filament bulbs and resistors to investigate potential difference/current characteristics
- investigating potential difference/current characteristics for LDRs and thermistors
- setting up series and parallel circuits to investigate current and potential difference
- plan and carry out an investigation to find the relationship between the resistance of thermistors and their temperature
- investigating the change of resistance of LDRs with light intensity.

## P2.4 Using mains electricity safely and the power of electrical appliances

Mains electricity is useful but can be very dangerous. It is important to know how to use it safely.

Electrical appliances transfer energy. The power of an electrical appliance is the rate at which it transforms energy. Most appliances have their power and the potential difference of the supply they need printed on them. From this we can calculate their current and the fuse they need.

# Candidates should use their skills, knowledge and understanding to:

- understand the principles of safe practice and recognise dangerous practice in the use of mains electricity
- compare the uses of fuses and circuit breakers
- evaluate and explain the need to use different cables for different appliances
- consider the factors involved when making a choice of electrical appliances.

## Additional guidance:

Candidates should consider the efficiency and power of the appliance.

## P2.4.1 Household electricity

- a) Cells and batteries supply current that always passes in the same direction. This is called direct current (d.c.).
- **b)** An alternating current (a.c.) is one that is constantly changing direction.

### Additional guidance:

Candidates should be able to compare and calculate potential differences of d.c. supplies and the peak potential differences of a.c. supplies from diagrams of oscilloscope traces.

Higher Tier candidates should be able to determine the period and hence the frequency of a supply from diagrams of oscilloscope traces.

- c) Mains electricity is an a.c. supply. In the UK it has a frequency of 50 cycles per second (50 hertz) and is about 230 V.
- **d)** Most electrical appliances are connected to the mains using cable and a three-pin plug.

		Additional guidance:
e)	The structure of electrical cable.	Candidates should be familiar with both two-core and three-core cable.
f)	The structure and wiring of a three-pin plug.	Knowledge and understanding of the materials used in three-pin plugs is required, as is the colour coding of the covering of the three wires.

g)	If an electrical fault causes too great a current, the circuit is disconnected by a fuse or a circuit breaker in the live wire.	
h)	When the current in a fuse wire exceeds the rating of the fuse it will melt, breaking the circuit.	
		Additional guidance:
i)	Some circuits are protected by Residual Current Circuit Breakers (RCCBs).	Candidates should realise that RCCBs operate by detecting a difference in the current between the live and neutral wires. Knowledge of how the devices do this is <b>not</b> required. Candidates should be aware of the fact that this device operates much faster than a fuse.
j)	Appliances with metal cases are usually earthed.	Candidates should be aware that some appliances are double insulated, and therefore have no earth wire connection.
k)	The earth wire and fuse together protect the wiring of the circuit.	Candidates should have an understanding of the link between cable thickness and fuse value.

## P2.4.2 Current, charge and power

		Additional guidance:
a)	When an electrical charge flows through a resistor, the resistor gets hot.	Candidates should understand that a lot of energy is wasted in filament bulbs as heat. Less energy is wasted in power-saving lamps such as Compact Fluorescent Lamps (CFLs). Candidates should understand that there is a choice when buying new appliances in how efficiently they transfer energy.
b)	The rate at which energy is transferred by an appliance is called the power. $P = \frac{E}{t}$	<i>P</i> is power in watts, W <i>E</i> is energy in joules, J <i>t</i> is time in seconds, s
c)	Power, potential difference and current are related by the equation: $P = I \times V$	Candidates should be able to calculate the current through an appliance from its power and the potential difference of the supply, and from this determine the size of fuse needed. <i>P</i> is power in watts, W <i>I</i> is current in amperes (amps), A
		V is potential difference in volts, V

d) Energy transferred, potential difference and charge are related by the equation:

 $E = V \times Q$ 

Additional guidance:

HT only

E is energy in joules, J

V is potential difference in volts, V

Q is charge in coulombs, C

Suggested ideas for practical work to develop skills and understanding include the following:

- measuring oscilloscope traces
- demonstrating the action of fuse wires
- using fluctuations in light intensity measurements from filament bulbs to determine the frequency of a.c.
- measuring the power of 12 V appliances by measuring energy transferred (using a joulemeter or ammeter and voltmeter) in a set time.

# **P2.5** What happens when radioactive substances decay, and the uses and dangers of their emissions

Radioactive substances emit radiation from the nuclei of their atoms all the time. These nuclear radiations can be very useful but may also be very dangerous. It is important to understand the properties of different types of nuclear radiation. To understand what happens to radioactive substances when they decay, we need to understand the structure of the atoms from which they are made. The use of radioactive sources depends on their penetrating power and half-life.

# Candidates should use their skills, knowledge and understanding to:

- evaluate the effect of occupation and/or location on the level of background radiation and radiation dose
- evaluate the possible hazards associated with the use of different types of nuclear radiation
- evaluate measures that can be taken to reduce exposure to nuclear radiations
- evaluate the appropriateness of radioactive sources for particular uses, including as tracers, in terms of the type(s) of radiation emitted and their half-lives
- explain how results from the Rutherford and Marsden scattering experiments led to the 'plum pudding' model being replaced by the nuclear model.

### Additional guidance:

Candidates should realise that new evidence can cause a theory to be re-evaluated.

Candidates should realise that, according to the nuclear model, most of the atom is empty space.

## P2.5.1 Atomic structure

- a) The basic structure of an atom is a small central nucleus composed of protons and neutrons surrounded by electrons.
- **b)** The relative masses and relative electric charges of protons, neutrons and electrons.
- c) In an atom the number of electrons is equal to the number of protons in the nucleus. The atom has no overall electrical charge.
- d) Atoms may lose or gain electrons to form charged particles called ions.
- e) The atoms of an element always have the same number of protons, but have a different number of neutrons for each isotope. The total number of protons in an atom is called its atomic number. The total number of protons and neutrons in an atom is called its mass number.

## P2.5.2 Atoms and radiation

	Additional guidance:
a) Some substances give out radiation from the nuclei of their atoms all the time, whatever happens to them. These substances are said to be radioactive.	Candidates should be aware of the random nature of radioactive decay.
<b>b)</b> The origins of background radiation.	Knowledge and understanding should include both natural sources, such as rocks and cosmic rays from space, and man-made sources such as the fallout from nuclear weapons tests and nuclear accidents.

c) Identification of an alpha particle as two neutrons and two protons, the same as a helium nucleus, a beta particle as an electron from the nucleus and gamma radiation as electromagnetic radiation.

# d) Nuclear equations to show single alpha and beta decay.

### Additional guidance:

#### HT only

Candidates will be required to balance such equations, limited to the completion of atomic number and mass number. The identification of daughter elements from such decays is not required.

e) Properties of the alpha, beta and gamma radiations limited to their relative ionising power, their penetration through materials and their range in air.

## Additional guidance:

Candidates should appreciate the relative size of the nucleus compared to the size of the atom.

f) Alpha and beta radiations are deflected by both electric and magnetic fields but gamma radiation is not.

#### Additional guidance:

All candidates should know that alpha particles are deflected less than beta particles and in an opposite direction.

Higher Tier candidates should be able to explain this in terms of the relative mass and charge of each particle.

- **g)** The uses of and the dangers associated with each type of nuclear radiation.
- h) The half-life of a radioactive isotope is the average time it takes for the number of nuclei of the isotope in a sample to halve, or the time it takes for the count rate from a sample containing the isotope to fall to half its initial level.

#### Suggested ideas for practical work to develop skills and understanding include the following:

- using hot-cross buns to show the 'plum pudding' model
- using dice to demonstrate probabilities involved in half-life
- using Geiger counters to measure the penetration and range in air of the radiation from different sources.

## P2.6 Nuclear fission and nuclear fusion

During the process of nuclear fission, atomic nuclei split. This process releases energy, which can be used to heat water and turn it into steam. The steam drives a turbine, which is connected to a generator and generates electricity.

Nuclear fusion is the joining together of atomic nuclei and is the process by which energy is released in stars.

# Candidates should use their skills, knowledge and understanding to:

 compare the uses of nuclear fusion and nuclear fission.

## P2.6.1 Nuclear fission

- a) There are two fissionable substances in common use in nuclear reactors: uranium-235 and plutonium-239.
- b) Nuclear fission is the splitting of an atomic nucleus.
- c) For fission to occur, the uranium-235 or plutonium-239 nucleus must first absorb a neutron.

### Additional guidance:

Limited to the generation of electricity.

### Additional guidance:

The majority of nuclear reactors use uranium-235.

- d) The nucleus undergoing fission splits into two smaller nuclei and two or three neutrons and energy is released.
- e) The neutrons may go on to start a chain reaction.

## Additional guidance:

Candidates should be able to sketch or complete a labelled diagram to illustrate how a chain reaction may occur.

## P2.6.2 Nuclear fusion

- A) Nuclear fusion is the joining of two atomic nuclei to form a larger one.
- **b)** Nuclear fusion is the process by which energy is released in stars.
- c) Stars form when enough dust and gas from space is pulled together by gravitational attraction. Smaller masses may also form and be attracted by a larger mass to become planets.
- d) During the 'main sequence' period of its life cycle a star is stable because the forces within it are balanced.
- e) A star goes through a life cycle. This life cycle is determined by the size of the star.

#### Additional guidance:

Candidates should be able to explain why the early Universe contained only hydrogen but now contains a large variety of different elements.

The term 'radiation pressure' will **not** be required.

Candidates should be familiar with the chart on the next page that shows the life cycles of stars.



f) Fusion processes in stars produce all of the naturally Car

## Additional guidance:

Candidates should be able to explain how stars are able to maintain their energy output for millions of years.

Candidates should know that elements up to iron are formed during the stable period of a star. Elements heavier than iron are formed in a supernova.

Suggested ideas for practical work to develop skills and understanding include the following:

• using domino tracks for fission / chain reactions.

occurring elements. These elements may be

distributed throughout the Universe by the explosion

of a massive star (supernova) at the end of its life.

## 3.6 Unit 4: Controlled Assessment

## 3.6.1 Introduction

This unit is assessed by Controlled Assessment. It is worth 25% of the total marks and consists of a minimum of **one** practical investigation based on topics in the specification.

Access arrangements (see sections 4.5 and 5.4) can enable candidates with special needs to undertake this assessment.

Teachers are encouraged to undertake a wide range of practical and investigative work, including fieldwork, with their candidates. We take the view that it is not good practice to do practical work only for the Controlled Assessment. As teachers know well, candidates enjoy and are motivated by practical work. Throughout this specification we have given many examples of practical work supporting the science content. Full details of this practical work are included in our resources package. In this unit, candidates use a range of practical skills and knowledge in **one** investigation chosen from those supplied by AQA. The investigations are based on topics in the specification. Guidance for teachers will be given with each investigation. Every year, three Controlled Assessments will be available; one for each unit. Each task assesses How Science Works skills, not candidates' knowledge and understanding of the science context.

The right-hand column of the tables below shows the Assessment Focus thread from National Strategies APP (Assessing Pupils' Progress). This will enable teachers to ensure progression from KS3 to KS4.

## AS4.1 Plan practical ways to develop and test candidates' own scientific ideas

## Candidates should be able to:

AS4.1.1 develop hypotheses and plan practical ways to test them, by:	Additional guidance: A	F/thread
a) being able to develop a hypothesis	Candidates should be able to suggest the outcome of an investigation.	1/4
b) being able to test hypotheses	Candidates should be able to plan a fair test to investigate their hypotheses.	) <b>1/4</b>
c) using appropriate technology.	Candidates should appreciate that technology such as data logging may provide a better mea of obtaining data. They should be able to sugg appropriate technology for collecting data and explain why a particular technological method i the most appropriate. Candidates should use I whenever appropriate.	<b>4/1</b> ans jest is ICT

## AS4.2 Assess and manage risks when carrying out practical work

## Candidates should be able to:

AS4.2.1 assess and manage risks when carrying out practical work, by:	Additional guidance: AF	F/thread
<ul> <li>a) identifying some possible hazards in practical situations</li> </ul>	Candidates will be expected to independently recognise a range of familiar hazards and consult appropriate resources and expert advice	<b>4/4</b> ce.
b) suggesting ways of managing risks.	Candidates should assess risks to themselves and others and take action to reduce these risk by adapting their approaches to practical work in order to control risk.	<b>4/4</b>

## AS4.3 Collect primary and secondary data

## Candidates should be able to:

## AS4.3.1 make observations, by:

a) carrying out practical work and research, and using the data collected to develop hypotheses.

AF/thread 4/3

AS4.3.2 demonstrate an understanding of the need to acquire high-quality data, by:	Additional guidance: AF/thread
<ul> <li>appreciating that, unless certain variables are controlled, the results may not be valid</li> </ul>	Candidates should be able to explain whether 4/3 results can be considered valid and recognise when an instrument or technique might not be measuring the variable intended.
<ul> <li>b) identifying when repeats are needed in order to improve reproducibility</li> </ul>	Candidates should recognise that a second set of <b>4/3</b> readings with another instrument or by a different observer could be used to cross check results.
c) recognising the value of further readings to establish repeatability and accuracy	Candidates should understand that accuracy is a <b>4/3</b> measure of how close the measured value is to the true value.
d) considering the resolution of the measuring device	Candidates should be able to explain that resolution <b>4/3</b> is the smallest change in the quantity being measured (input) of a measuring instrument that gives a perceptible change in the indication (output).
e) considering the precision of the measured data where precision is indicated by the degree of scatter from the mean	Candidates should be able to distinguish between <b>4/3</b> accuracy and precision when applied to an instrument's readings.
f) identifying the range of the measured data.	Candidates should be able to identify the upper 4/3 and lower limits of the range and be able to identify which extra results within or outside the range would be appropriate.

## AS4.4 Select and process primary and secondary data

## Candidates should be able to:

AS4.4.1 show an understanding of the value of means, by:	Additional guidance: AF/th	read
a) appreciating when it is appropriate to calculate a mean		5/1
<ul> <li>b) calculating the mean of a set of at least three results.</li> </ul>	Candidates should be able to recognise the need to exclude anomalies before calculating means to an appropriate number of decimal places.	5/1
AS4.4.2 demonstrate an understanding of how data may be displayed, by:	Additional guidance: AF/th	read
a) drawing tables	Candidates should be able to draw up a table of two or more columns, with correct headings and units, adequately representing the data obtained.	3/2
b) drawing charts and graphs	Candidates should be able to construct an appropriate graphical representation of the data such as a bar chart or line graph and draw a line of best fit when appropriate. Candidates may use ICT to produce their graphs or charts.	3/2
c) choosing the most appropriate form of presentation.	Candidates should be able to identify the most appropriate method of display for any given set of data.	3/1

## AS4.5 Analyse and interpret primary and secondary data

AS4.5.1 distinguish between a fact and an opinion, by:	Additional guidance: AF	/thread
<ul> <li>a) recognising that an opinion might be influenced by factors other than scientific fact</li> </ul>	Candidates should recognise that the opinion may be influenced by economic, ethical, moral, social or cultural considerations.	2/1
<b>b)</b> identifying scientific evidence that supports an opinion.		1/2
AS4.5.2 review methodology to assess fitness for purpose, by:	Additional guidance: AF	/thread
a) identifying causes of variation in data	Candidates should be able to identify from data whether there is any variation other than obvious anomalies, and identify a potential cause for variation or uncertainty.	<b>5/2</b>
b) recognising and identifying the cause of random errors. If a data set contains random errors, repeating the readings and calculating a new mean can reduce their effect.	Candidates should appreciate that human error might be the cause of inaccurate measurements and explain how human error might have influen the accuracy of a measurement or might have introduced bias into a set of readings.	<b>5/2</b> s
c) recognising and identifying the cause of anomalous results	Candidates should be able to identify anomalous results and suggest what should be done about them.	s <b>5/2</b>
d) recognising and identifying the cause of systematic errors.	Candidates should be able to identify when a data set contains a systematic error and appreciate that repeat readings cannot reduce the effect of systematic errors.	5/2
	Candidates should realise that a zero error is a type of systematic error. They should be able to identify if a scale has been incorrectly used and suggest how to compensate for a zero error.	5/2
AS4.5.3 identify patterns in data, by:		

a) describing the relationship between two variables and deciding whether the relationship is causal or by association.

Additional guidance:AF/threadCandidates should be able to use terms such<br/>as linear or directly proportional, or describe a<br/>complex relationship.5/3

AS4.5.4 draw conclusions using scientific ideas and evidence, by:	Additional guidance: AF/thr	read
a) writing a conclusion, based on evidence that relates correctly to known facts	Candidates should be able to state simply what the evidence shows to justify a conclusion, and recognise the limitations of the evidence.	5/3
b) using secondary sources	Candidates should appreciate that secondary sources or alternative methods can increase reproducibility.	5/3
<ul> <li>c) identifying extra evidence that is required for a conclusion to be made</li> </ul>	Candidates should be able to suggest that extra evidence might be required for a conclusion to be made, and be able to describe the extra evidence required.	5/4
d) evaluating methods of data collection.	Candidates should appreciate that the evidence obtained may not allow the conclusion to be made with confidence. Candidates should be able to explain why the evidence obtained does not allow the conclusion to be made with confidence.	5/4

# **AS4.6** Use of scientific models and evidence to develop hypotheses, arguments and explanations

## Candidates should be able to:

AS4.6.1 review hypotheses in the light of outcomes, by:		Additional guidance: AF/t	hread
a)	a) considering whether or not any hypothesis made is supported by the evidence	Candidates should be able to assess the extent to which the hypothesis is supported by the outcome.	1/2
b)	developing scientific ideas as a result of observations and measurements.	Candidates should be able to suggest ways in which the hypothesis may need to be amended of whether it needs to be discarded in the light of the achieved outcome of an investigation.	<b>1/2</b> r e

## Guidance on Managing Controlled Assessment

## What is Controlled Assessment?

For each subject, Controlled Assessment regulations from Ofqual stipulate the level of control required for task setting, task taking and task marking. The 'task' is what the candidate has to do; the 'level of control' indicates the degree of freedom given to teachers and candidates for different aspects of the 'task'.

For GCSE Additional Science the regulations state:	For this specification, this means:
Task setting – high control	<ul> <li>We prepare equivalent Investigative Skills Assignments (ISAs) each year.</li> </ul>
Task taking (research/data collection) – limited control	We require the practical work and data collection to be carried out under teacher supervision, during normal class contact time.
	If more than one lesson is used, candidates' data and research work must be collected at the end of each lesson.
	<ul> <li>Candidates can work together during the investigation, but each candidate must contribute to the collection of the data and process the data individually.</li> </ul>
Task taking (analysis and evaluation of findings) – high control	<ul> <li>ISA tests should be taken under formal supervision, in silence without co-operation between candidates.</li> </ul>
	<ul> <li>Candidates should be given their processed data for reference during the ISA test, and will also be provided with a data sheet of secondary data.</li> </ul>
	<ul> <li>Teachers should not help candidates answer the questions.</li> </ul>
	<ul> <li>Each ISA test has a fixed time limit unless the candidate is entitled to access arrangements.</li> </ul>
	<ul> <li>Candidates' processed data and their ISA tests are collected by the teacher at the end of each test.</li> </ul>
Task marking – medium control	We provide 'marking guidelines' for each ISA test.
	We moderate your marking.

#### What is the Controlled Assessment like?

The Controlled Assessment comprises an ISA test which is assessed in two sections.

Prior to taking Section 1 of the ISA test, candidates independently develop their own hypothesis and research possible methods for carrying out an experiment to test **their** hypothesis. During this research, candidates need to do a risk assessment and prepare a table for their results.

**Section 1** of the ISA test (45 minutes, 20 marks) consists of questions relating to the candidate's own research.

Following Section 1 candidates carry out their investigation, and record and analyse their results.

If the candidate's plan is unworkable, unsafe or unmanageable in the laboratory then they may be provided with a method – an example of which will be provided by AQA. For plans that are otherwise good, but unworkable for a good reason (ie logistical) candidates should not lose any marks. However, where the plan is dangerous or unworkable (from a scientific perspective) this will be reflected in the marking.

**Section 2** of the ISA test (50 minutes, 30 marks) consists of questions related to the experiment candidates have carried out. They are also provided with a data sheet of secondary data by AQA, from which they select appropriate data to analyse and compare with their own results.

Candidates will be asked to suggest how ideas from their investigation and research could be used within a new context.

#### Using ISAs

The documents provided by AQA for each ISA are:

- a set of Teachers' Notes
- the ISA Section 1 and Section 2 which are to be copied for each candidate
- the marking guidelines for the teacher to use.

The Teachers' Notes provide suggestions on how to incorporate ISAs into the scheme of work. About five lessons should be allowed for the ISA: one lesson for discussion, research and planning; one lesson for the completion of Section 1; one or two lessons for completing the experiment and processing their results and one lesson for completing Section 2 of the ISA.

Candidates will be expected to plan their investigation independently and should each draw up an appropriate table for recording their results. While carrying out the investigation, candidates should make and record observations. They should make measurements with precision and accuracy. They should record data as it is obtained in a table. They should use ICT where appropriate. Candidates are also required to process the data into a graph or chart.

Candidates' tables of data and graphs or charts must be collected by the teacher at the end of each lesson. Candidates must **not** be allowed to work on the presentation or processing of their data between lessons, because marks are available for these skills.

The paper containing Section 2 of the ISA should be taken as soon as possible after completion of the investigation.

During the test, candidates should work on their own and in silence. When candidates have completed the test the scripts must be collected. Teachers are required to mark the tests, using the marking guidelines provided by AQA. Tests should be marked in red ink with subtotals placed in the margin.

Teachers are expected to use their professional judgement in applying the marking guidelines: for example, applying it sensibly where candidates have given unexpected answers. When teachers have marked the scripts, they may tell candidates their marks but they must not return the scripts. Completed ISAs must be kept under secure conditions while the ISA is valid.

#### Other guidance

Teachers' Notes will be put on to the AQA website prior to the ISAs becoming valid. ISA tests and marking guidelines will be published in advance.

If ISAs are to be used with different classes, centres must ensure security between sessions.

ISAs have specific submission dates. They may not be submitted in more than one year. The submission dates are stated on the front cover of each ISA.

Candidates may attempt any number of the ISAs supplied by AQA for a particular subject. The best mark they achieve from a complete ISA is submitted.

A candidate is only allowed to have **one** attempt at each ISA, and this may only be submitted for moderation on **one** occasion. It would constitute **malpractice** if the candidate is found to have submitted the same ISA more than once and they could be excluded from at least this qualification.

Specimen ISAs or ISAs that are no longer valid may be given to candidates so that they can practise the skills required. In these cases, candidates can be given back their completed and marked scripts. However, ISAs that are currently valid must **not** be given back to candidates.

## 3.7 Unit 5 Additional Science 1

Additional Science 1 is half of Biology 2, half of Chemistry 2 and half of Physics 2, as follows:

- Biology 2 Sections B2.1 to B2.4
- Chemistry 2 Sections C2.1 to C2.3
- Physics 2 Sections P2.1 to P2.3

See Sections 3.3, 3.4 and 3.5 above.

## 3.8 Unit 6 Additional Science 2

Additional Science 2 is half of Biology 2, half of Chemistry 2 and half of Physics 2, as follows:

- Biology 2 Sections B2.5 to B2.8
- Chemistry 2 Sections C2.4 to C2.7
- Physics 2 Sections P2.4 to P2.6

See Sections 3.3, 3.4 and 3.5 above.

## 3.9 Mathematical and other requirements

## Mathematical requirements

One learning outcome of this specification is to provide learners with the opportunity to develop their skills in communication, mathematics and the use of technology in scientific contexts. In order to deliver the mathematical element of this outcome, assessment materials for this specification contain opportunities for candidates to demonstrate scientific knowledge using appropriate mathematical skills.

The areas of mathematics that arise naturally from the science content in science GCSEs are listed below. This is not a checklist for each question paper or Controlled Assessment, but assessments reflect these mathematical requirements, covering the full range of mathematical skills over a reasonable period of time.

Candidates are permitted to use calculators in all assessments.

Candidates are expected to use units appropriately. However, not all questions reward the appropriate use of units.

All candidates should be able to:

- 1 Understand number size and scale and the quantitative relationship between units.
- 2 Understand when and how to use estimation.
- 3 Carry out calculations involving +, -, x, ÷, either singly or in combination, decimals, fractions, percentages and positive whole number powers.
- 4 Provide answers to calculations to an appropriate number of significant figures.
- 5 Understand and use the symbols =, <, >,  $\sim$ .
- 6 Understand and use direct proportion and simple ratios.
- 7 Calculate arithmetic means.
- 8 Understand and use common measures and simple compound measures such as speed.
- 9 Plot and draw graphs (line graphs, bar charts, pie charts, scatter graphs, histograms) selecting appropriate scales for the axes.
- **10** Substitute numerical values into simple formulae and equations using appropriate units.
- **11** Translate information between graphical and numeric form.

- **12** Extract and interpret information from charts, graphs and tables.
- 13 Understand the idea of probability.
- 14 Calculate area, perimeters and volumes of simple shapes.

In addition, Higher Tier candidates should be able to:

- **15** Interpret, order and calculate with numbers written in standard form.
- **16** Carry out calculations involving negative powers (only –1 for rate).
- 17 Change the subject of an equation.
- **18** Understand and use inverse proportion.
- **19** Understand and use percentiles and deciles.

### Units, symbols and nomenclature

Units, symbols and nomenclature used in examination papers will normally conform to the recommendations contained in the following:

- The Language of Measurement: Terminology used in school science investigations. Association for Science Education (ASE), 2010.
   ISBN 978 0 86357 424 5.
- Signs, Symbols and Systematics the ASE companion to 16–19 Science. Association for Science Education (ASE), 2000.
   ISBN 978 0 86357 312 5.
- Signs, Symbols and Systematics the ASE companion to 5–16 Science. Association for Science Education (ASE), 1995.
   ISBN 0 86357 232 4.

### **Equation sheet**

We will provide an equation sheet for the physics unit and for the combined papers in Units 5 and 6.

Candidates will be expected to select the appropriate equation to answer the question.

#### Data sheet

We will provide a data sheet for the chemistry unit and for the combined papers in Units 5 and 6. This includes a periodic table and other information. Candidates will be expected to select the appropriate information to answer the question.

# **Scheme of Assessment**

## 4.1 Aims and learning outcomes

GCSE specifications in additional science should offer learners a broad, coherent and practical course of study that will inspire, motivate and challenge them. They should encourage learners to develop their curiosity about the living, material and physical worlds and should provide insight into and experience of how science works. They should enable learners to engage with science and to make informed decisions about further study in science and related subjects and about career choices.

GCSE specifications in additional science must enable learners to:

- develop their knowledge and understanding of the material, physical and living worlds
- develop their understanding of the effects of science on society
- develop an understanding of the importance of scale in science
- develop and apply their knowledge and understanding of the nature of science and of the scientific process
- develop and apply their knowledge and understanding of the scientific process through hypotheses, theories and concepts
- develop their understanding of the relationships between hypotheses, evidence, theories and explanations
- develop their awareness of risk and the ability to assess potential risk in the context of potential benefits



- develop and apply their observational, practical, modelling, enquiry and problem-solving skills and understanding in laboratory, field and other learning environments
- develop their ability to evaluate claims based on science through critical analysis of the methodology, evidence and conclusions both qualitatively and quantitatively
- develop their skills in communication, mathematics and the use of technology in scientific contexts.
# 4.2 Assessment Objectives

The assessment units assess the following Assessment Objectives (AOs) in the context of the content and skills set out in Section 3 (Subject Content).

- 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.

### Weighting of Assessment Objectives for GCSE Additional Science

The table below shows the approximate weighting of each of the Assessment Objectives in the GCSE units.

### Route 1 (4408)

Assessment Objectives	Unit Weightings (%)							Overall weighting of AOs (%)
	UNIT							
	1		2		3		4	
A01	12.5		12.5		12.5		0	37.5
AO2	7.5		7.5		7.5		12.5	35.0
AO3	5.0		5.0		5.0		12.5	27.5
Overall weighting of units (%)	25		25		25		25	100

### Route 2 (4409)

Assessment Objectives	Unit	W	eightin	gs	(%)	Overall weighting of AOs (%)	
	UNIT						
	5		6		4		
AO1	17.5		20		0	37.5	
AO2	10.5		12.0		12.5	35.0	
AO3	7.0		8.0		12.5	27.5	
Overall weighting of units (%)	35		40		25	100	

### **Quality of Written Communication**

In GCSE specifications that require candidates to produce written material in English, candidates must do the following:

- ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

In this specification Quality of Written Communication (QWC) is assessed in Units 1, 2, 3, 4, 5 and 6 by means of longer response questions. These questions are clearly indicated in each question paper. In these questions, candidates cannot obtain full marks unless they address the three bullet points in this section.

### 4.3 National criteria

This specification complies with:

- the Subject Criteria for GCSE Additional Science including the rules for Controlled Assessment
- the Code of Practice
- the GCSE Qualification Criteria

- the Arrangements for the Statutory Regulation of External Qualifications in England, Wales and Northern Ireland: Common Criteria
- the requirements for qualifications to provide access to Levels 1 and 2 of the National Qualification Framework.

### 4.4 Previous Learning requirements

There are no previous learning requirements. However, any requirements set for entry to a course based on this specification are at your centre's discretion.

### 4.5 Access to assessment: diversity and inclusion

GCSEs often need to assess a wide range of competences. This is because they are general qualifications designed to prepare candidates for a wide range of occupations and further study.

The revised GCSE Qualification and Subject Criteria were reviewed to see whether any of the skills or knowledge needed by the subject presented a possible difficulty to any candidates, whatever their ethnic background, religion, sex, age, disability or sexuality. If there were difficulties, the situation was reviewed again to make sure that such tests of specific competences were only included if they were important to the subject. The findings were discussed with groups who represented the interests of a diverse range of candidates.

Arrangements are made for candidates with special needs to help them access the assessments as long as the competences being tested are not changed. Because of this, most candidates will be able to access any part of the assessment. Section 5.4 gives more details.



# **Administration**

# 5.1 Availability of assessment units and certification

Ofqual's revisions to the Code of Practice mean that from June 2014: assessments (both external assessments and moderation of controlled assessment) will only be available once a year in June with 100% of the assessment being taken in the examination series in which the qualification is awarded.

### 5.2 Entries

Please check the current version of *Entry Procedures and Codes* for up-to-date entry procedures. You should use the following entry codes for the units and for certification.

Unit 1 – BL2FP or BL2HP

Unit 2 – CH2FP or CH2HP

Unit 3 – PH2FP or PH2HP

Unit 4 – AS4P

Unit 5 – AS1FP or AS1HP

Unit 6 – AS2FP or AS2HP

GCSE certification - 4408 (Route 1) or 4409 (Route 2)

Candidates have to enter all the assessment units at the end of the course, at the same time as they enter for the subject award.

Please note that entries are not allowed in the same examination series for the following combination of GCSE certifications:

- GCSE Additional Science (Route 1) and GCSE Biology
- GCSE Additional Science (Route 1) and GCSE Chemistry
- GCSE Additional Science (Route 1) and GCSE Physics.

## 5.3 Private candidates

This specification is available to private candidates under certain conditions. Because of the Controlled Assessment, candidates must attend an AQA centre, which will supervise and mark the Controlled Assessment. Private candidates should write to us for a copy of *Supplementary Guidance for Private Candidates* (for Controlled Assessment specification with practical activities).

# **5.4** Access arrangements, reasonable adjustments and special consideration

We have taken note of the equality and discrimination legislation and the interests of minority groups in developing and administering this specification.

We follow the guidelines in the Joint Council for Qualifications (JCQ) document: Access Arrangements, Reasonable Adjustments and Special Consideration: General and Vocational Qualifications. This is published on the JCQ website (www.jcq.org.uk) or you can follow the link from our website aqa.org.uk

#### Access arrangements

We can arrange for candidates with special needs to access an assessment. These arrangements must be made **before** the examination. For example, we can produce a Braille paper for a candidate with sight problems.

#### **Reasonable adjustments**

An access arrangement which meets the needs of a particular disabled candidate would be a reasonable adjustment for that candidate. For example, a Braille paper would be a reasonable adjustment for a Braille reader but not for a candidate who did not read Braille. The Disability Discrimination Act requires us to make reasonable adjustments to remove or lessen any disadvantage affecting a disabled candidate.

#### **Special consideration**

We can give special consideration to candidates who have had a temporary illness, injury or serious problem such as the death of a relative, at the time of the examination. We can only do this **after** the examination.

The Examinations Officer at the centre should apply online for access arrangements and special consideration by following the e-AQA link from our website **aqa.org.uk** 

## 5.5 Examination language

We will only provide units for this specification in English.

## 5.6 Qualification titles

Qualifications based on this specification are:

AQA GCSE in Additional Science.

# 5.7 Awarding grades and reporting results

This GCSE will be graded on an eight-grade scale: A\*, A, B, C, D, E, F and G. Candidates who fail to reach the minimum standard for grade G will be recorded as 'U' (unclassified) and will not receive a qualification certificate.

We will publish the minimum raw mark for each grade and for each unit when we issue candidates' results. We will report a candidate's unit results to your centre in terms of uniform marks and qualification results in terms of uniform marks and grades.

For each unit, the uniform mark corresponds to a grade as follows.

l <b>nit 1 Biology 2</b> naximum uniform mark = 100)		<b>Unit 2 Chemistry 2</b> (maximum uniform mark = 100)			
Grade	Uniform Mark Range	Grade	Uniform Mark Range		
A*	90-100	A*	90-100		
A	80-89	A	80-89		
В	70–79	В	70–79		
С	60-69	С	60-69		
D	50-59	D	50-59		
E	40-49	E	40-49		
F	30-39	F	30-39		
G	20-29	G	20-29		
U	0-19	U	0-19		

#### Unit 3 Physics 2

(maximum uniform mark = 100)

#### **Unit 4 Controlled Assessment**

(maximum uniform mark = 100)

Grade	Uniform Mark Range
A*	90-100
A	80-89
В	70-79
С	60-69
D	50-59
Е	40-49
F	30-39
G	20-29
U	0–19

Grade	Uniform Mark Range
A*	90-100
А	80-89
В	70–79
С	60-69
D	50-59
E	40-49
F	30-39
G	20-29
U	0-19

#### Unit 5 Additional Science 1

#### (maximum uniform mark = 140)

### Unit 6 Additional Science 2

•	.l.,	11.12
(maximum	uniform mark =	160)

Grade	Uniform Mark Range	Grade	Uniform Mark Range
A*	126-140	A*	144–160
А	112-125	A	128–143
В	98-111	В	112–127
С	84-97	С	96-111
D	70-83	D	80-95
E	56-69	E	64–79
F	42-55	F	48-63
G	28-41	G	32-47
U	0-27	U	0-31
•••••••••••••••••••••••••••••••••••••••			

We calculate a candidate's total uniform mark by adding together the uniform marks for the units. We convert this total uniform mark to a grade as follows.

#### **GCSE Additional Science**

(maximum uniform mark = 400)

Grade	Uniform Mark Range
A*	360-400
A	320-359
В	280-319
С	240-279
D	200-239
E	160–199
F	120–159
G	80-119
U	0-79

### 5.8 Grading and tiers

The Controlled Assessment is not tiered and the full range of grades A\*–G is available to candidates for this unit.

For the other units, candidates take either the Foundation Tier or the Higher Tier. For candidates entered for the Foundation Tier, grades C-G are available; for candidates entered for the Higher Tier,  $A^*-D$  are available. There is a safety net for candidates entered for the Higher Tier, where an allowed grade E will be awarded if candidates just fail to achieve grade D. Candidates who fail to achieve a grade E on the Higher Tier or grade G on the Foundation Tier will be reported as unclassified.

For the tiered units, candidates cannot obtain a Uniform Mark Scale (UMS) score corresponding to a grade that is above the range for the tier entered. The maximum UMS score for candidates on the Foundation Tier written paper for Units 1, 2 and 3 is 69. For Unit 5, the maximum UMS on the Foundation Tier paper is 97 and for Unit 6 it is 111. In other words, they cannot achieve a UMS score corresponding to a grade B. Candidates who just fail to achieve grade E on the Higher Tier paper receive the UMS score corresponding to their raw mark (ie they do not receive a UMS score of zero).

During the awarding procedures we decide the relationship between raw marks and UMS score for each tier separately. Where a grade is available on two tiers, for example grade C, we give the two raw marks chosen as the boundary for the grade on the two tiers the same UMS score. Therefore, candidates receive the same UMS score for the same achievement whether they have taken the Foundation or the Higher Tier assessment.

### 5.9 Examination series

Candidates have to enter all the assessment units at the end of the course, at the same time as they enter for the subject award. As a consequence of the move to linear assessment, candidates will be allowed to carry forward their controlled assessment unit result(s) following the initial moderation and aggregation during the lifetime of the specification.

# **Controlled Assessment administration**

The Head of Centre is responsible for making sure that Controlled Assessment work is conducted in line with our instructions and JCQ instructions.

# 6.1 Authentication of Controlled Assessment work

To meet the requirements of the Code of Practice, we need the following.

- Candidates must sign the Candidate Record Form to confirm that the work they have handed in is their own.
- Teachers and assessors must confirm on the Candidate Record Form that the work marked is only that done by that candidate and was conducted in line with the conditions in the specification document (authentication declaration).
- Centres must give a mark of zero if candidates cannot confirm the work handed in for assessment is their own.

You should attach the completed Candidate Record Form for each candidate to his or her work. All teachers who have marked the work of any candidate entered for each component must sign the declaration that the work is genuine. If you have doubts about signing the authentication declaration, you should follow these guidance points.

- If you believe that a candidate had additional assistance and that this is acceptable within the guidelines for the relevant specification, you should award a mark which covers only the candidate's achievement without any help. (You should sign the authentication declaration and give information on the relevant form.)
- If you cannot sign the authentication declaration, the candidate's work cannot be accepted for assessment.

If, during the external moderation process, there is no evidence that the work has been authenticated, we will award a mark of zero.

# 6.2 Malpractice

You should let candidates know about our malpractice regulations.

#### Candidates must not:

- submit work that is not their own
- lend work to other candidates
- give other candidates access to, or the use of, their own independently sourced research material (this does not mean that candidates cannot lend their books to another candidate, but that candidates should be stopped from copying other candidates' research)
- include work copied directly from books, the Internet or other sources without acknowledgement of the source
- hand in work typed or word-processed by someone else without acknowledgement.

These actions are considered malpractice, for which a penalty (for example being disqualified from the exam) will be applied.

If you suspect malpractice, you should consult your Examinations Officer about the procedure to be followed.

Where you suspect malpractice in Controlled Assessments after the candidate has signed the declaration of authentication, your Head of Centre must submit full details of the case to us at the earliest opportunity. The form JCQ/M1 should be used. Copies of the form can be found on the JCQ website www.jcq.org.uk

Malpractice in Controlled Assessments discovered prior to the candidate signing the declaration of authentication need not be reported to us, but should be dealt with in accordance with your centre's internal procedures. We would expect you to treat such cases very seriously. Details of any work which is not the candidate's own must be recorded on the Candidate Record Form or other appropriate place.

## 6.3 Teacher standardisation

We will hold standardising meetings for teachers each year, usually in the autumn term, for Controlled Assessment. At these meetings we will provide support in explaining tasks in context and using the marking criteria.

If your centre is new to this specification, you must send a representative to one of the meetings. If you have told us you are a new centre, either by sending us an *Intention to Enter* or an *Estimate of Entry*, or by contacting the subject team, we will contact you to invite you to a meeting.

We will also contact centres in the following cases:

 if the moderation of Controlled Assessment work from the previous year has shown a serious misinterpretation of the Controlled Assessment requirements if a significant adjustment has been made to a centre's marks.

In these cases, you will be expected to send a representative to one of the meetings. If your centre does not fall into one of these categories you can choose whether or not to come to a meeting. If you cannot attend and would like a copy of the written materials used at the meeting, you should contact the subject administration team at science-gcse@aqa.org.uk

It is likely that during the lifetime of this specification AQA will move to online teacher standardisation.

## 6.4 Internal standardisation of marking

Centres must have consistent marking standards for all candidates. One person must be responsible for ensuring that work has been marked to the same standard, and they need to sign the *Centre Declaration Sheet* to confirm that internal standardisation has taken place.

Internal standardisation may involve:

- all teachers marking some sample pieces of work and identifying differences in marking standards
- discussing any differences in marking at a training meeting for all teachers involved in the assessment
- referring to reference and archive material, such as previous work or examples from our teacher standardising meetings.

## 6.5 Annotation of Controlled Assessment work

The Code of Practice states that the awarding body must make sure that teachers marking Controlled Assessments clearly show how the marks have been awarded in line with the guidance provided. For this specification, marking guidelines are provided by AQA and teachers must use these guidelines to annotate candidates' work.

Annotation helps our moderators to see as precisely as possible where the teacher has identified that candidates have met the requirements of the mark scheme. Annotation includes:

- ticks and numbers showing how many marks have been awarded
- comments on the work that refer to the mark scheme.

# 6.6 Submitting marks and sample work for moderation

The total mark for each candidate must be sent to us and the moderator on the mark forms provided or electronically by Electronic Data Interchange (EDI) by the date given (see www.aqa.org.uk/deadlines/ coursework\_deadlines.php). Our moderator will contact you to let you know which pieces of work must be sent to them as part of the sample (please see Section 7.1 for more guidance on sending in samples).

# 6.7 Factors affecting individual candidates

You should be able to accept the occasional absence of candidates by making sure they have the chance to make up missed Controlled Assessments. (You may organise an alternative supervised time session for candidates who are absent at the time the centre originally arranged).

If work is lost, you must tell us immediately the date it was lost, how it was lost, and who was responsible. Inform our Centre and Candidate Support Services using the JCQ form *Notification of Lost Coursework JCQ/LCW form 15*.

Where special help that goes beyond normal learning support is given, use the Candidate Record Form to inform us so that this help can be taken into account during moderation. Candidates who move from one centre to another during the course sometimes need additional help to meet the requirements of a scheme of Controlled Assessment work. How this can be dealt with depends when the move takes place. If it happens early in the course the new centre should be responsible for Controlled Assessment work. If it happens late in the course it may be possible to arrange for the moderator to assess the work as a candidate who was 'Educated Elsewhere'. Centres should contact us by e-mailing **science-gcse@aqa.org.uk** as early as possible for advice about appropriate arrangements in individual cases.

### 6.8 Keeping candidates' work

From the time the work is marked, your centre must keep the work of all candidates, with Candidate Record Forms attached, under secure conditions, to allow the work to be available during the moderation period or should there be an Enquiry about Results. You may return the work to candidates after the deadline for Enquiries about Results, or once any enquiry is resolved.

### 6.9 Grade boundaries on Controlled Assessment

The grade boundaries for the Controlled Assessment will be decided at the grade award meeting for each examination series and may, therefore, vary over time.

# **Moderation**

### 7.1 Moderation procedures

Controlled Assessment work is moderated by inspecting a sample of candidates' work sent (by post or electronically) from the centre to a moderator appointed by us. The centre marks must be sent to us and the moderator by the deadline given (see www.aqa.org.uk/deadlines/coursework\_ deadlines.php). Centres entering fewer candidates than the minimum sample size (and centres submitting work electronically) should send the work of all of their candidates. Centres entering larger numbers of candidates will be told which candidates' work must be sent as part of the sample sent in for moderation.

Following the re-marking of the sample work, the moderator's marks are compared with the centre

marks to check whether any changes are needed to bring the centre's assessments in line with our agreed standards. In some cases the moderator may need to ask for the work of other candidates in the centre. To meet this request, centres must keep the Controlled Assessment work and Candidate Record Forms of every candidate entered for the examination under secure conditions, and they must be prepared to send it to us or the moderator when it is requested. Any changes to marks will normally keep the centre's rank order, but where major differences are found, we reserve the right to change the rank order.

### 7.2 Consortium arrangements

If you are a consortium of centres with joint teaching arrangements (where candidates from different centres have been taught together but where they are entered through the centre at which they are on roll), you must tell us by filling in the JCQ/CCA form *Application for Centre Consortium Arrangements for Centre-assessed Work*. You must choose a consortium coordinator who can speak to us on behalf of all centres in the consortium. If there are different coordinators for different specifications, a copy of the JCQ/CCA form must be sent in for each specification.

We will allocate the same moderator to each centre in the consortium and the candidates will be treated as a single group for moderation.

### 7.3 Procedures after moderation

When the results are published, we will give centres details of the final marks for the Controlled Assessment work.

We will return candidates' work to you after the exam. You will receive a report, at the time results are issued, giving feedback on any adjustments that were made to your marks.

We may keep some candidates' work for awarding, archive or standardising purposes and will inform you if this is the case.

# Appendices

### A Grade descriptions

Grade descriptions are provided to give a general indication of the standards of achievement likely to have been shown by candidates who were 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 candidates' performance in the assessment may be balanced by better performances in others.

#### Grade A

Candidates recall, select and communicate precise knowledge and detailed understanding of science and its applications, and of the effects and risks of scientific developments and its applications on society, industry, the economy and the environment. They demonstrate a clear understanding of why and how scientific applications, technologies and techniques change over time and the need for regulation and monitoring. They use terminology and conventions appropriately and consistently.

They apply appropriate skills, including communication, mathematical and technological skills, knowledge and understanding effectively to a wide range of practical contexts and to explain applications of science. They apply a comprehensive understanding of practical methods, processes and protocols to plan and justify a range of appropriate methods to solve practical problems. They apply appropriate skills, including mathematical, technical and observational skills, knowledge and understanding in a wide range of practical contexts. They follow procedures and protocols consistently, evaluating and managing risk and working accurately and safely.

Candidates analyse and interpret critically a broad range of quantitative and qualitative information. They reflect on the limitations of the methods, procedures and protocols they have used and the data they have collected and evaluate information systematically to develop reports and findings. They make reasoned judgements consistent with the evidence to develop substantiated conclusions.

#### 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.

#### 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 quantitative and qualitative data and information from a limited range of sources. They can draw elementary conclusions having collected limited evidence. **B** Spiritual, moral, ethical, social, legislative, sustainable development, economic and cultural issues, and health and safety considerations

We have taken great care to make sure that any wider issues (for example, spiritual, moral, ethical, social, legal, sustainable development, economic and cultural issues), including those relevant to the education of candidates at Key Stage 4, have been taken into account when preparing this specification. They will only form part of the assessment requirements where they are relevant to the specific content of the specification. In Section 3 (Subject Content), aspects of the wider issues that may be assessed are introduced with the phrase: 'Candidates should use their skills, knowledge and understanding to:'. Additionally, health and safety considerations are addressed in the Controlled Assessment.

#### **European Dimension**

We have taken the 1988 Resolution of the Council of the European Community into account when preparing this specification and associated specimen units.

#### **Environmental Education**

We have taken the 1988 Resolution of the Council of the European Community and the Report 'Environmental Responsibility: An Agenda for Further and Higher Education' (1993) into account when preparing this specification and associated specimen units.

#### Avoiding Bias

We have taken great care to avoid bias of any kind when preparing this specification and specimen units.

# C Overlaps with other qualifications

One-third of the content of each of GCSE Biology, Chemistry and Physics is contained within GCSE Additional Science.

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### D Wider Key Skills

#### The replacement of Key Skills with Functional Skills

The Key Skills qualifications have been replaced by the Functional Skills. However, centres may claim proxies for Key Skills components and/or certification in the following series: January, March and June 2012. The Administration Handbook for the Key Skills Standards 2012 has further details. All Examination Officers in centres offering AQA Key Skills and Wider Key Skills have been sent a letter outlining the details of the end dates of these subjects. Copies of the letters have also been sent to the Head of Centre and Key Skills coordinator. This is a brief outline of that information. It is correct as at August 2011 and replaces the information on the same subject found in other documents on the AQA website:

- Key Skills Levels 1, 2 and 3 Test and Portfolio The final opportunity for candidates to enter for a level 1, 2 or 3 Key Skills test or portfolio was June 2011 with the last certification in 2012.
- Key Skills Level 4 The last series available to candidates entering for the Key Skills Level 4 test and portfolio was June 2010 with the last certification in the June series 2012.
- Basic Skills Adult Literacy Levels 1 and 2, Adult Numeracy Levels 1 and 2 AQA Basic Skills qualifications will now be available until, at least, the June 2012 series.

#### Funding

We have received the following advice on the funding of learners undertaking these qualifications:

- Currently the Skills Funding Agency funds Basic Skills in literacy and numeracy for adult, 19 plus, learners only. There are various support funds for learners aged 16–18 administered by the Young People's Learning Agency (YPLA). These include EMA (until the end of the 2010/11 academic year), Care to Learn and discretionary learner support hardship funding for learners living away from home.
- This information is correct at the time of publication. If you would like to check the funding provision post-June 2011, please call the Skills Funding Agency helpdesk on 0845 377 5000.

#### Wider Key Skills

The AQA Wider Key Skills qualifications are no longer available. The last portfolio moderation took place in June 2011.

Further updates to this information will be posted on the website as it becomes available.

#### http://web.aqa.org.uk/qual/keyskills/wider\_notice board.php



### GCSE Additional Science Specification

For exams June 2014 onwards

For certification June 2014 onwards

#### Qualification Accreditation Number: 600/0885/4

Centres should be aware that candidates who enter for more than one GCSE qualification with the same classification code will have only one grade counted for the purpose of the School and College Performance Tables. In the case of a candidate taking two qualifications with the same classification code that are of the same size and level, eg two full course GCSEs, the higher grade will count.

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 check with the institution to which they wish to progress before embarking on their programmes.

To obtain specification updates, access our searchable bank of frequently asked questions, or to ask us a question, register with Ask AQA: aqa.org.uk/ask-aqa/register

You can also download a copy of the specification and support materials from our website: **sciencelab.org.uk/subjects** for all your subject resources.

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