GCSE SPECIFICATION

AQA

# GCSE

Specification

# Science A

**For exams January 2012 onwards**

For certification June 2012 onwards

# GCSE

Specification

# Science A
# 4405

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Vertical black lines indicate a significant change or addition to the previous version of this specification.

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# Contents

# 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 Science A?

GCSE Science A 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 and Controlled Assessment Unit. This course provides a firm foundation for progression to AS and A-level Science.

The model of Controlled Assessment, Investigative Skills Assignment (ISA), is straightforward and the previous version proved popular with teachers.

Two routes through GCSE Science A 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 Assessing of Pupils' 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
- a unitised approach to assessment, which enables staged assessment but does not require it – all assessments **could** be taken at the end of the course
- 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 subject content
- 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 Science A is one of many qualifications that AQA offers for Key Stage 4. AQA's range, which includes GCSEs, Diplomas and Entry Level qualifications, enables teachers to select and design appropriate courses for all learners. Science A 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 which 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

You have 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 090415** or e-mail **science-gcse@aqa.org.uk**

### Teacher Support meetings

Details of the full range of our Teacher Support meetings are available on our website at **aqa.org.uk/support-teachers**

There is also a link to our fast and convenient online booking system for Teacher Support meetings at **events.aqa.org.uk**

### 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, separate exams in biology, chemistry and physics are taken, together with the Controlled Assessment. For Route 2, combined exams in biology, chemistry and physics are taken, together with the Controlled Assessment.

## GCSE SCIENCE A

**EITHER 4405**

**Unit 1: Biology 1**

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 2: Chemistry 1**

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 3: Physics 1**

Written paper – **1 hour**

60 marks – **25 %**

**Structured and closed questions**

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

**OR 4406**

**Unit 5: Science A1**

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 1 (B1.1 to B1.3)

Chemistry 1 (C1.1 to C1.4)

Physics 1 (P1.1 to P1.3)

+

**Unit 6: Science A2**

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 1 (B1.4 to B1.8)

Chemistry 1 (C1.5 to C1.7)

Physics 1 (P1.4 to P1.5)

+

**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 1, Chemistry 1, Physics 1
- and 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 1**, **Chemistry 1** and **Physics 1**.

The organisation of each sub-section of the substantive content is designed to facilitate this approach. Each of the sub-sections of Biology 1, Chemistry 1 and Physics 1 starts with the statement:

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

This introduces a number of activities, for example:

- **evaluating different methods of generating electricity**

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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 of 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** 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 refers 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 the 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. It is therefore 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, as all 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 1

### B1.1 Keeping healthy

A combination of a balanced diet and regular exercise is needed to help keep the body healthy. Our bodies provide an excellent environment for many microbes which can make us ill once they are inside us. Our bodies need to stop most microbes getting in and deal with any microbes which do get in. Vaccination can be used to prevent infection.

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

- evaluate information about the effect of food on health

**Additional guidance:**
Candidates will be given data to work from.

- evaluate information about the effect of lifestyle on development of disease
- analyse and evaluate claims made by slimming programmes, and slimming products.

#### B1.1.1 Diet and exercise

**a)** A healthy diet contains the right balance of the different foods you need and the right amount of energy. Carbohydrates, fats and proteins are used by the body to release energy and to build cells. Mineral ions and vitamins are needed in small amounts for healthy functioning of the body. A person is malnourished if their diet is not balanced. This may lead to a person being overweight or underweight. An unbalanced diet may also lead to deficiency diseases or conditions such as Type 2 diabetes.

**Additional guidance:**
Knowledge and understanding of the specific functions of nutrients and the effects of any deficiency in the diet are **not** required.

**b)** A person loses mass when the energy content of the food taken in is less than the amount of energy expended by the body. Exercise increases the amount of energy expended by the body.

**c)** The rate at which all the chemical reactions in the cells of the body are carried out (the metabolic rate) varies with the amount of activity you do and the proportion of muscle to fat in your body. Metabolic rate may be affected by inherited factors.

**d)** Inherited factors also affect our health; for example cholesterol level.

**e)** People who exercise regularly are usually healthier than people who take little exercise.

**Additional guidance:**
The effect of exercise on breathing and heart rate is **not** required.

## B1.1.2 How our bodies defend themselves against infectious diseases

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

- relate the contribution of Semmelweiss in controlling infection to solving modern problems with the spread of infection in hospitals

**Additional guidance:**

Candidates will be given data to work from.

- explain how the treatment of disease has changed as a result of increased understanding of the action of antibiotics and immunity
- evaluate the consequences of mutations of bacteria and viruses in relation to epidemics and pandemics
- evaluate the advantages and disadvantages of being vaccinated against a particular disease.

**a)** Microorganisms that cause infectious disease are called pathogens.

**b)** Bacteria and viruses may reproduce rapidly inside the body and may produce poisons (toxins) that make us feel ill. Viruses damage the cells in which they reproduce.

**Additional guidance:**

Knowledge of the structure of bacteria and viruses is **not** required.

**c)** The body has different ways of protecting itself against pathogens.

**d)** White blood cells help to defend against pathogens by:

- ingesting pathogens
- producing antibodies, which destroy particular bacteria or viruses
- producing antitoxins, which counteract the toxins released by the pathogens.

**e)** The immune system of the body produces specific antibodies to kill a particular pathogen. This leads to immunity from that pathogen. In some cases, dead or inactivated pathogens stimulate antibody production. If a large proportion of the population is immune to a pathogen, the spread of the pathogen is very much reduced.

**f)** Semmelweiss recognised the importance of hand-washing in the prevention of spreading some infectious diseases. By insisting that doctors washed their hands before examining patients, he greatly reduced the number of deaths from infectious diseases in his hospital.

| | |
|---|---|
| g) Some medicines, including painkillers, help to relieve the symptoms of infectious disease, but do not kill the pathogens. | |
| h) Antibiotics, including penicillin, are medicines that help to cure bacterial disease by killing infectious bacteria inside the body. Antibiotics cannot be used to kill viral pathogens, which live and reproduce inside cells. It is important that specific bacteria should be treated by specific antibiotics. The use of antibiotics has greatly reduced deaths from infectious bacterial diseases. Overuse and inappropriate use of antibiotics has increased the rate of antibiotic resistant strains of bacteria. | **Additional guidance:** Candidates should be aware that it is difficult to develop drugs that kill viruses without also damaging the body's tissues. |
| i) Many strains of bacteria, including MRSA, have developed resistance to antibiotics as a result of natural selection. To prevent further resistance arising it is important to avoid overuse of antibiotics. | Knowledge of the development of resistance in bacteria is limited to the fact that pathogens mutate, producing resistant strains. |
| j) Mutations of pathogens produce new strains. Antibiotics and vaccinations may no longer be effective against a new resistant strain of the pathogen. The new strain will then spread rapidly because people are not immune to it and there is no effective treatment.<br><br>**Higher Tier candidates should understand that:**<br>- **antibiotics kill individual pathogens of the non-resistant strain**<br>- **individual resistant pathogens survive and reproduce, so the population of the resistant strain increases**<br>- **now, antibiotics are no longer used to treat non-serious infections, such as mild throat infections, so that the rate of development of resistant strains is slowed down.** | **HT only** |
| k) The development of antibiotic-resistant strains of bacteria necessitates the development of new antibiotics. | |
| l) People can be immunised against a disease by introducing small quantities of dead or inactive forms of the pathogen into the body (vaccination). Vaccines stimulate the white blood cells to produce antibodies that destroy the pathogens. This makes the person immune to future infections by the microorganism. The body can respond by rapidly making the correct antibody, in the same way as if the person had previously had the disease.<br><br>MMR vaccine is used to protect children against measles, mumps and rubella. | **Additional guidance:** Details of vaccination schedules and side effects associated with specific vaccines are **not** required. |

**m)** Uncontaminated cultures of microorganisms are required for investigating the action of disinfectants and antibiotics.

For this:

- Petri dishes and culture media must be sterilised before use to kill unwanted microorganisms
- inoculating loops used to transfer microorganisms to the media must be sterilised by passing them through a flame
- the lid of the Petri dish should be secured with adhesive tape to prevent microorganisms from the air contaminating the culture.

**n)** In school and college laboratories, cultures should be incubated at a maximum temperature of 25 °C, which greatly reduces the likelihood of growth of pathogens that might be harmful to humans.

**o)** In industrial conditions higher temperatures can produce more rapid growth.

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

- investigate the effectiveness of various antibiotic discs in killing bacteria
- growing microorganisms in Petri dishes to demonstrate sterile technique and growing pure cultures
- the use of pre-inoculated agar in Petri dishes to evaluate the effect of disinfectants and antibiotics
- computer simulations to model the effect of: balanced and unbalanced diets and exercise; the growth of bacterial colonies in varying conditions; action of the immune system and the effect of antibiotics and vaccines.

## B1.2 Nerves and hormones

The nervous system and hormones enable us to respond to external changes. They also help us to control conditions inside our bodies. Hormones are used in some forms of contraception and in fertility treatments. Plants also produce hormones and respond to external stimuli.

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

- evaluate the benefits of, and the problems that may arise from, the use of hormones to control fertility, including In Vitro Fertilisation (IVF)

**Additional guidance:**

Candidates will be given data to work from.

- evaluate the use of plant hormones in horticulture as weedkillers and to encourage the rooting of plant cuttings.

Subject Content 3

## B1.2.1 The nervous system

**a)** The nervous system enables humans to react to their surroundings and coordinate their behaviour.

**b)** Cells called receptors detect stimuli (changes in the environment).

Receptors and the stimuli they detect include:

- receptors in the eyes that are sensitive to light
- receptors in the ears that are sensitive to sound
- receptors in the ears that are sensitive to changes in position and enable us to keep our balance
- receptors on the tongue and in the nose that are sensitive to chemicals and enable us to taste and to smell
- receptors in the skin that are sensitive to touch, pressure, pain and temperature changes.

**Additional guidance:**

Knowledge and understanding of the structure and functions of sense organs such as the eye and the ear are **not** required.

**c)** Light receptor cells, like most animal cells, have a nucleus, cytoplasm and cell membrane.

**Additional guidance:**

A knowledge of the functions of the cell components is **not** required.

**d)** Information from receptors passes along cells (neurones) in nerves to the brain. The brain coordinates the response. Reflex actions are automatic and rapid. They often involve sensory, relay and motor neurones.

**e)** Candidates should understand the role of receptors, sensory neurones, motor neurones, relay neurones, synapses and effectors in simple reflex actions.

In a simple reflex action:

- impulses from a receptor pass along a sensory neurone to the central nervous system
- at a junction (synapse) between a sensory neurone and a relay neurone in the central nervous system, a chemical is released that causes an impulse to be sent along a relay neurone
- a chemical is then released at the synapse between a relay neurone and motor neurone in the central nervous system, causing impulses to be sent along a motor neurone to the organ (the effector) that brings about the response
- the effector is either a muscle or a gland, a muscle responds by contracting and a gland responds by releasing (secreting) chemical substances.

## B1.2.2 Control in the human body

**a)** Internal conditions that are controlled include:

- the water content of the body – water leaves the body via the lungs when we breathe out and via the skin when we sweat to cool us down, and excess water is lost via the kidneys in the urine
- the ion content of the body – ions are lost via the skin when we sweat and excess ions are lost via the kidneys in the urine
- temperature – to maintain the temperature at which enzymes work best
- blood sugar levels – to provide the cells with a constant supply of energy.

**Additional guidance:**

Details of the action of the skin and kidneys and the control of blood sugar are **not** required.

**b)** Many processes within the body are coordinated by chemical substances called hormones. Hormones are secreted by glands and are usually transported to their target organs by the bloodstream.

**c)** Hormones regulate the functions of many organs and cells. For example, the monthly release of an egg from a woman’s ovaries and the changes in the thickness of the lining of her womb are controlled by hormones secreted by the pituitary gland and by the ovaries.

**d)** Several hormones are involved in the menstrual cycle of a woman. Hormones are involved in promoting the release of an egg:

- follicle stimulating hormone (FSH) is secreted by the pituitary gland and causes eggs to mature in the ovaries. It also stimulates the ovaries to produce hormones including oestrogen
- luteinising hormone (LH) stimulates the release of eggs from the ovary
- oestrogen is secreted by the ovaries and inhibits the further production of FSH.

**Additional guidance:**

Knowledge of the role of progesterone in the natural menstrual cycle, including details of negative feedback, is **not** required.

**e)** The uses of hormones in controlling fertility include:

- giving oral contraceptives that contain hormones to inhibit FSH production so that no eggs mature
  - oral contraceptives may contain oestrogen and progesterone to inhibit egg maturation
  - the first birth-control pills contained large amounts of oestrogen. These resulted in women suffering significant side effects
  - birth-control pills now contain a much lower dose of oestrogen, or are progesterone only
  - progesterone-only pills lead to fewer side effects
- giving FSH and LH in a ‘fertility drug’ to a woman whose own level of FSH is too low to stimulate eggs to mature, for example in In Vitro Fertilisation (IVF) treatment
  - IVF involves giving a mother FSH and LH to stimulate the maturation of several eggs. The eggs are collected from the mother and fertilised by sperm from the father. The fertilised eggs develop into embryos. At the stage when they are tiny balls of cells, one or two embryos are inserted into the mother’s uterus (womb).

## B1.2.3 Control in plants

a) Plants are sensitive to light, moisture and gravity:

- their shoots grow towards light and against the force of gravity
- their roots grow towards moisture and in the direction of the force of gravity.

b) Plants produce hormones to coordinate and control growth. Auxin controls phototropism and gravitropism (geotropism).

**Additional guidance:**

Candidates should understand the role of auxin in phototropism and gravitropism.

c) The responses of plant roots and shoots to light, gravity and moisture are the result of unequal distribution of hormones, causing unequal growth rates.

d) Plant growth hormones are used in agriculture and horticulture as weed killers and as rooting hormones.

**Additional guidance:**

Names of specific weed killers and rooting hormones are **not** required.

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

- investigation into candidates' reaction times – measuring reaction times using metre rules, stop clocks or ICT
- using forehead thermometers before and after exercise
- demonstrating the speed of transmission along nerves by candidates standing in a semi-circle and holding hands and squeezing with eyes closed
- design an investigation to measure the sensitivity of the skin
- demonstrating the knee jerk reaction
- investigation to measure the amount of sweat produced during exercise
- investigate:
  - the effect of light on the growth of seedlings
  - the effect of gravity on growth in germinating seedlings
  - the effect of water on the growth of seedlings
  - using a motion sensor to measure the growth of plants and seedlings
  - the effect of rooting compounds and weed killers on the growth of plants.

## B1.3 The use and abuse of drugs

Drugs affect our body chemistry. Medical drugs are developed and tested before being used to relieve illness or disease. Drugs may also be used recreationally as people like the effect on the body. Some drugs are addictive. Some athletes take drugs to improve performance. People cannot make sensible decisions about drugs unless they know their full effects.

| Candidates should use their skills, knowledge and understanding to: | Additional guidance: |
|---|---|
| ■ evaluate the effect of statins in cardiovascular disease | Candidates will be given data to work from. |
| ■ evaluate different types of drugs and why some people use illegal drugs for recreation | Classification of drug types is **not** required. |
| ■ evaluate claims made about the effect of prescribed and non-prescribed drugs on health | |
| ■ consider the possible progression from recreational drugs to hard drugs | |
| ■ evaluate the use of drugs to enhance performance in sport and to consider the ethical implications of their use. | |

### B1.3.1 Drugs

**a)** Scientists are continually developing new drugs.

**b)** When new medical drugs are devised, they have to be extensively tested and trialled before being used. Drugs are tested in a series of stages to find out if they are safe and effective.

New drugs are extensively tested for toxicity, efficacy and dose:

- in the laboratory, using cells, tissues and live animals
- in clinical trials involving healthy volunteers and patients. Very low doses of the drug are given at the start of the clinical trial. If the drug is found to be safe, further clinical trials are carried out to find the optimum dose for the drug. In some double blind trials, some patients are given a placebo, which does not contain the drug. Neither the doctors nor the patients know who has received a placebo and who has received the drug until the trial is complete.

**Additional guidance:**

Candidates should understand that tissues and animals are used as models to predict how the drugs may behave in humans.

c) Candidates should be aware of the use of statins in lowering the risk of heart and circulatory diseases.

d) Thalidomide is a drug that was developed as a sleeping pill. It was also found to be effective in relieving morning sickness in pregnant women.

Thalidomide had not been tested for use in pregnant women. Unfortunately, many babies born to mothers who took the drug were born with severe limb abnormalities. The drug was then banned. As a result, drug testing has become much more rigorous. More recently, thalidomide has been used successfully in the treatment of leprosy and other diseases.

e) Candidates should be aware of the effects of misuse of the legal recreational drugs, alcohol and nicotine. Candidates should understand that the misuse of the illegal recreational drugs ecstasy, cannabis and heroin may have adverse effects on the heart and circulatory system.

**Additional guidance:**

Knowledge and understanding of the specific effects of recreational drugs on the body, except for cannabis are **not** required. The legal classification of specific drugs is **not** required.

f) Cannabis is an illegal drug. Cannabis smoke contains chemicals which may cause mental illness in some people.

g) The overall impact of legal drugs (prescribed and non-prescribed) on health is much greater than the impact of illegal drugs because far more people use them.

**Additional guidance:**

Awareness of the benefits of medical drugs, the impact of non-medical drugs such as alcohol and the possible misuse of legal drugs should be considered.

h) Drugs change the chemical processes in peoples' bodies so that they may become dependent or addicted to the drug and suffer withdrawal symptoms without them. Heroin and cocaine are very addictive.

i) There are several types of drug that an athlete can use to enhance performance. Some of these drugs are banned by law and some are legally available on prescription, but all are prohibited by sporting regulations. Examples include stimulants that boost bodily functions such as heart rate; and anabolic steroids which stimulate muscle growth.

**Additional guidance:**

Knowledge of the mode of action of steroids and other performance-enhancing drugs is **not** required.

## B1.4 Interdependence and adaptation

Organisms are well adapted to survive in their normal environment. Population size depends on a variety of factors including competition, predation, disease and human influences. Changes in the environment may affect the distribution and behaviour of organisms.

| Candidates should use their skills, knowledge and understanding to: | Additional guidance: |
|---|---|
| ■ suggest how organisms are adapted to the conditions in which they live | Examination questions will use examples that are unfamiliar to candidates. |
| ■ observe the adaptations, eg body shape, of a range of organisms from different habitats | |
| ■ develop an understanding of the ways in which adaptations enable organisms to survive | |
| ■ suggest the factors for which organisms are competing in a given habitat | Factors are limited to light, water, space and nutrients in plants; and to food, mates and territory in animals. |
| ■ evaluate data concerned with the effect of environmental changes on the distribution and behaviour of living organisms. | |

### B1.4.1 Adaptations

**a)** To survive and reproduce, organisms require a supply of materials from their surroundings and from the other living organisms there.

**b)** Plants often compete with each other for light and space, and for water and nutrients from the soil.

**c)** Animals often compete with each other for food, mates and territory.

**d)** Organisms, including microorganisms, have features (adaptations) that enable them to survive in the conditions in which they normally live.

**e)** Some organisms live in environments that are very extreme. Extremophiles may be tolerant to high levels of salt, high temperatures or high pressures.

**f)** Animals and plants may be adapted for survival in the conditions where they normally live, eg deserts, the Arctic.

Animals may be adapted for survival in dry and arctic environments by means of:

- changes to surface area
- thickness of insulating coat
- amount of body fat
- camouflage.

Plants may be adapted to survive in dry environments by means of:

- changes to surface area, particularly of the leaves
- water-storage tissues
- extensive root systems.

**g)** Animals and plants may be adapted to cope with specific features of their environment, eg thorns, poisons and warning colours to deter predators.

## B1.4.2 Environmental change

**a)** Changes in the environment affect the distribution of living organisms.

**Additional guidance:**

Examples might include, but are not limited to, the changing distribution of some bird species and the disappearance of pollinating insects, including bees.

**b)** Animals and plants are subjected to environmental changes. Such changes may be caused by living or non-living factors such as a change in a competitor, or in the average temperature or rainfall.

**c)** Living organisms can be used as indicators of pollution:

- lichens can be used as air pollution indicators, particularly of the concentration of sulfur dioxide in the atmosphere
- invertebrate animals can be used as water pollution indicators and are used as indicators of the concentration of dissolved oxygen in water.

**Additional guidance:**

Knowledge and understanding of the process of eutrophication is **not** required.

**d)** Environmental changes can be measured using non-living indicators such as oxygen levels, temperature and rainfall.

Candidates should understand the use of equipment to measure oxygen levels, temperature and rainfall.

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

- investigations of environmental conditions and organisms in a habitat such as a pond
- 'hunt the cocktail stick' using red and green cocktail sticks on a green background
- investigate the distribution of European banded snails
- investigate the behaviour of woodlice using choice chambers
- investigate the effect on plant growth of varying their environmental conditions, eg degrees of shade, density of sowing, supply of nutrients
- investigating particulate levels, eg with the use of sensors to measure environmental conditions
- the use of maximum–minimum thermometers, rainfall gauges and oxygen meters
- investigating the effect of phosphate on oxygen levels in water using jars with algae, water and varying numbers of drops of phosphate, then monitor oxygen using a meter
- computer simulations to model the effect on organisms of changes to the environment.

## B1.5 Energy and biomass in food chains

By observing the numbers and sizes of the organisms in food chains we can find out what happens to energy and biomass as it passes along the food chain.

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

- interpret pyramids of biomass and construct them from appropriate information.

**Additional guidance:**

An understanding of pyramids of number is **not** required.

### B1.5.1 Energy in biomass

**a)** Radiation from the Sun is the source of energy for most communities of living organisms. Green plants and algae absorb a small amount of the light that reaches them. The transfer from light energy to chemical energy occurs during photosynthesis. This energy is stored in the substances that make up the cells of the plants.

**b)** The mass of living material (biomass) at each stage in a food chain is less than it was at the previous stage. The biomass at each stage can be drawn to scale and shown as a pyramid of biomass.

**Additional guidance:**

Construction of food webs and chains, and of pyramids of numbers, is **not** required.

**c)** The amounts of material and energy contained in the biomass of organisms are reduced at each successive stage in a food chain because:

- some materials and energy are always lost in the organisms' waste materials
- respiration supplies all the energy needs for living processes, including movement. Much of this energy is eventually transferred to the surroundings.

## B1.6 Waste materials from plants and animals

Many trees shed their leaves each year and most animals produce droppings at least once a day. All plants and animals eventually die. Microorganisms play an important part in decomposing this material so that it can be used again by plants. The same material is recycled over and over again and can lead to stable communities.

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

- evaluate the necessity and effectiveness of schemes for recycling organic kitchen or garden waste.

### B1.6.1 Decay processes

**a)** Living things remove materials from the environment for growth and other processes. These materials are returned to the environment either in waste materials or when living things die and decay.

**b)** Materials decay because they are broken down (digested) by microorganisms. Microorganisms are more active and digest materials faster in warm, moist, aerobic conditions.

**c)** The decay process releases substances that plants need to grow.

**d)** In a stable community, the processes that remove materials are balanced by processes that return materials. The materials are constantly cycled.

## B1.6.2 The carbon cycle

**a)** The constant cycling of carbon is called the carbon cycle.

In the carbon cycle:

- carbon dioxide is removed from the environment by green plants and algae for photosynthesis
- the carbon from the carbon dioxide is used to make carbohydrates, fats and proteins, which make up the body of plants and algae
- when green plants and algae respire, some of this carbon becomes carbon dioxide and is released into the atmosphere
- when green plants and algae are eaten by animals and these animals are eaten by other animals, some of the carbon becomes part of the fats and proteins that make up their bodies
- when animals respire, some of this carbon becomes carbon dioxide and is released into the atmosphere
- when plants, algae and animals die, some animals and microorganisms feed on their bodies
- carbon is released into the atmosphere as carbon dioxide when these organisms respire
- by the time the microorganisms and detritus feeders have broken down the waste products and dead bodies of organisms in ecosystems and cycled the materials as plant nutrients, all the energy originally absorbed by green plants and algae has been transferred
- combustion of wood and fossil fuels releases carbon dioxide into the atmosphere.

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

- design and carry out an investigation to measure the rate of decay of bread by, for example, exposing cubes of bread to air before placing them in sealed Petri dishes at different temperatures and/or different moisture levels
- investigate the rates of decay using containers (eg thermos flasks) full of grass clippings, one with disinfectant, one with dry grass, one with wet grass and one with a composting agent. If the container is sealed, a thermometer or temperature probe can be placed through a cotton wool plug to monitor the temperature
- potato decay competition, using fresh potatoes. Candidates decide on the environmental conditions and the rate of decay is measured over a two week period
- role play exercise – A4 sheets labelled with different stages of the carbon cycle. Candidates arrange themselves in the correct order to pass a ball along labelled as carbon
- using a sensor and data logger to investigate carbon dioxide levels during the decay process.

## B1.7 Genetic variation and its control

There are not only differences between different species of plants and animals but also between individuals of the same species. These differences are due partly to the information in the cells they have inherited from their parents and partly to the different environments in which the individuals live and grow. Asexual reproduction can be used to produce individuals that are genetically identical to their parent. Scientists can now add, remove or change genes to produce the plants and animals they want.

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

- interpret information about cloning techniques and genetic engineering techniques

**Additional guidance:**

Candidates will be given data to work from.

- make informed judgements about the economic, social and ethical issues concerning cloning and genetic engineering, including genetically modified (GM) crops.

### B1.7.1 Why organisms are different

a) The information that results in plants and animals having similar characteristics to their parents is carried by genes, which are passed on in the sex cells (gametes) from which the offspring develop.

**Additional guidance:**

Candidates should understand that genes operate at a molecular level to develop characteristics that can be seen.

b) The nucleus of a cell contains chromosomes. Chromosomes carry genes that control the characteristics of the body.

c) Different genes control the development of different characteristics of an organism.

d) Differences in the characteristics of different individuals of the same kind may be due to differences in:

- the genes they have inherited (genetic causes)
- the conditions in which they have developed (environmental causes)
- or a combination of both.

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

- look at variation in leaf length or width, pod length, height. Compare plants growing in different conditions – sun/shade.

## B1.7.2 Reproduction

**a)** There are two forms of reproduction:

- sexual reproduction – the joining (fusion) of male and female gametes. The mixture of the genetic information from two parents leads to variety in the offspring
- asexual reproduction – no fusion of gametes and only one individual is needed as the parent. There is no mixing of genetic information and so no genetic variation in the offspring. These genetically identical individuals are known as clones.

**b)** New plants can be produced quickly and cheaply by taking cuttings from older plants. These new plants are genetically identical to the parent plant.

**c)** Modern cloning techniques include:

- tissue culture – using small groups of cells from part of a plant
- embryo transplants – splitting apart cells from a developing animal embryo before they become specialised, then transplanting the identical embryos into host mothers
- adult cell cloning – the nucleus is removed from an unfertilised egg cell. The nucleus from an adult body cell, eg a skin cell, is then inserted into the egg cell. An electric shock then causes the egg cell to begin to divide to form embryo cells. These embryo cells contain the same genetic information as the adult skin cell. When the embryo has developed into a ball of cells, it is inserted into the womb of an adult female to continue its development.

**d)** In genetic engineering, genes from the chromosomes of humans and other organisms can be 'cut out' using enzymes and transferred to cells of other organisms.

**e)** Genes can also be transferred to the cells of animals, plants or microorganisms at an early stage in their development so that they develop with desired characteristics:

- new genes can be transferred to crop plants
- crops that have had their genes modified in this way are called genetically modified crops (GM crops)
- examples of genetically modified crops include ones that are resistant to insect attack or to herbicides
- genetically modified crops generally show increased yields.

**f)** Concerns about GM crops include the effect on populations of wild flowers and insects, and uncertainty about the effects of eating GM crops on human health.

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

- investigate the optimum conditions for the growth of cuttings, eg Mexican hat plants, spider plants, African violets
- investigate the best technique for growing new plants from tissue cultures (eg cauliflower).

## B1.8 Evolution

Particular genes or accidental changes in the genes of plants or animals may give them characteristics which enable them to survive better. Over time this may result in entirely new species. There are different theories of evolution. Darwin's theory is the most widely accepted.

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

- interpret evidence relating to evolutionary theory

**Additional guidance:**

Candidates will be given data to work from.

- suggest reasons why Darwin's theory of natural selection was only gradually accepted
- identify the differences between Darwin's theory of evolution and conflicting theories, such as that of Lamarck
- suggest reasons for the different theories.

**Additional guidance:**

Scientists may produce different hypotheses to explain similar observations. It is only when these hypotheses are investigated that data will support or refute hypotheses.

## B1.8.1 Evolution

| Content | Additional guidance |
| --- | --- |
| a) Darwin's theory of evolution by natural selection states that all species of living things have evolved from simple life forms that first developed more than three billion years ago. | **Additional guidance:** A study of creationism is **not** required. |
| b) The theory of evolution by natural selection was only gradually accepted because:<br>■ the theory challenged the idea that God made all the animals and plants that live on Earth<br>■ there was insufficient evidence at the time the theory was published to convince many scientists<br>■ the mechanism of inheritance and variation was not known until 50 years after the theory was published. | |
| c) Other theories, including that of Lamarck, are based mainly on the idea that changes that occur in an organism during its lifetime can be inherited. We now know that in the vast majority of cases this type of inheritance cannot occur. | |
| d) Studying the similarities and differences between organisms allows us to classify living organisms into animals, plants and microorganisms, and helps us to understand evolutionary and ecological relationships. Models allow us to suggest relationships between organisms. | **Additional guidance:** Candidates should understand how evolutionary trees (models) are used to represent the relationships between organisms. |
| e) Evolution occurs via natural selection:<br>■ individual organisms within a particular species may show a wide range of variation because of differences in their genes<br>■ individuals with characteristics most suited to the environment are more likely to survive to breed successfully<br>■ the genes that have enabled these individuals to survive are then passed on to the next generation. | Candidates should develop an understanding of the timescales involved in evolution. |
| f) Where new forms of a gene result from mutation there may be relatively rapid change in a species if the environment changes. | |

## 3.4 Unit 2: Chemistry 1

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.**

## C1.1 The fundamental ideas in chemistry

Atoms and elements are the building blocks of chemistry. Atoms contain protons, neutrons and electrons. When elements react they produce compounds.

### C1.1.1 Atoms

a) All substances are made of atoms. A substance that is made of only one sort of atom is called an element. There are about 100 different elements. Elements are shown in the periodic table. The groups contain elements with similar properties.

**Additional guidance:**

Candidates should understand where metals and non-metals appear in the periodic table.

b) Atoms of each element are represented by a chemical symbol, eg O represents an atom of oxygen, and Na represents an atom of sodium.

**Additional guidance:**

Knowledge of the chemical symbols for elements other than those named in the specification is **not** required.

c) Atoms have a small central nucleus, which is made up of protons and neutrons and around which there are electrons.

d) The relative electrical charges are as shown:

| Name of particle | Charge |
|---|---|
| Proton | +1 |
| Neutron | 0 |
| Electron | –1 |

e) In an atom, the number of electrons is equal to the number of protons in the nucleus. Atoms have no overall electrical charge.

f) All atoms of a particular element have the same number of protons. Atoms of different elements have different numbers of protons.

g) The number of protons in an atom of an element is its atomic number. The sum of the protons and neutrons in an atom is its mass number.

**Additional guidance:**

Candidates will be expected to calculate the number of each sub-atomic particle in an atom from its atomic number and mass number.

**h)** Electrons occupy particular energy levels. Each electron in an atom is at a particular energy level (in a particular shell). The electrons in an atom occupy the lowest available energy levels (innermost available shells). Candidates may answer questions in terms of either energy levels or shells.

**Additional guidance:**

Candidates should be able to represent the electronic structure of the first 20 elements of the periodic table in the following forms:

sodium
2,8,1

## C1.1.2 The periodic table

**a)** Elements in the same group in the periodic table have the same number of electrons in their highest energy level (outer electrons) and this gives them similar chemical properties.

**Additional guidance:**

Knowledge is limited to the reactions of Group 1 elements with water and oxygen.

Candidates are **not** required to know of trends within each group in the periodic table, but should be aware of similarities between the elements within a group.

**b)** The elements in Group 0 of the periodic table are called the noble gases. They are unreactive because their atoms have stable arrangements of electrons.

Candidates should know that the noble gases have eight electrons in their outer energy level, except for helium, which has only two electrons.

## C1.1.3 Chemical reactions

**a)** When elements react, their atoms join with other atoms to form compounds. This involves giving, taking or sharing electrons to form ions or molecules. Compounds formed from metals and non-metals consist of ions. Compounds formed from non-metals consist of molecules. In molecules the atoms are held together by covalent bonds.

**Additional guidance:**

Further details of the types of bonding are **not** required.

Candidates should know that metals lose electrons to form positive ions, whereas non-metals gain electrons to form negative ions. Knowledge of such transfers is limited to single electrons.

**b)** Chemical reactions can be represented by word equations or by symbol equations.

Candidates should be able to write word equations for reactions in the specification. The ability to interpret given symbol equations in terms of numbers of atoms is required.

**Higher Tier candidates should be able to balance symbol equations.**

**c)** No atoms are lost or made during a chemical reaction so the mass of the products equals the mass of the reactants.

Knowledge and understanding of masses in chemical reactions is limited to conservation of mass. Calculations based on relative atomic masses are **not** required but candidates should be able to calculate the mass of a reactant or product from information about the masses of the other reactants and products in the reaction.

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

- modelling of atoms (using physical models or computer simulations) to illustrate chemical reactions at the atomic level
- precipitation reactions, such as lead nitrate with potassium iodide, to show conservation of mass.

## C1.2 Limestone and building materials

Rocks provide essential building materials. Limestone is a naturally occurring resource that provides a starting point for the manufacture of cement and concrete.

| Candidates should use their skills, knowledge and understanding to: | Additional guidance: |
| --- | --- |
| consider and evaluate the environmental, social and economic effects of exploiting limestone and producing building materials from it | Candidates should know that limestone is needed for buildings and that the positive benefits of using this material should be considered against the negative aspects of quarrying.<br><br>Knowledge of building materials is limited to limestone, cement and concrete. |
| evaluate the developments in using limestone, cement and concrete as building materials, and their advantages and disadvantages over other materials. | Knowledge of particular developments is **not** required, but information may be supplied in examination questions for candidates to evaluate.<br><br>Knowledge of the properties of other building materials is **not** required, but candidates may be provided with information about materials such as timber, stone, glass and steels in the examination so that they can make comparisons about their uses. |

### C1.2.1 Calcium carbonate

| | Additional guidance: |
| --- | --- |
| **a)** Limestone, mainly composed of the compound calcium carbonate ($CaCO_3$), is quarried and can be used as a building material. | |
| **b)** Calcium carbonate can be decomposed by heating (thermal decomposition) to make calcium oxide and carbon dioxide. | |
| **c)** The carbonates of magnesium, copper, zinc, calcium and sodium decompose on heating in a similar way. | Knowledge and understanding of metal carbonates is limited to metal carbonates decomposing on heating to give carbon dioxide and the metal oxide.<br><br>Candidates should be aware that not all carbonates of metals in Group 1 of the periodic table decompose at the temperatures reached by a Bunsen burner. |
| **d)** Calcium oxide reacts with water to produce calcium hydroxide, which is an alkali that can be used in the neutralisation of acids. | Knowledge of the common names quicklime and slaked lime is **not** required. |

| | Additional guidance: |
|---|---|
| **e)** A solution of calcium hydroxide in water (limewater) reacts with carbon dioxide to produce calcium carbonate. Limewater is used as a test for carbon dioxide. Carbon dioxide turns limewater cloudy. | Candidates should be familiar with using limewater to test for carbon dioxide gas. |
| **f)** Carbonates react with acids to produce carbon dioxide, a salt and water. Limestone is damaged by acid rain. | The reaction of carbonates with acids is limited to the reactions of magnesium, copper, zinc, calcium and sodium. |
| **g)** Limestone is heated with clay to make cement. Cement is mixed with sand to make mortar and with sand and aggregate to make concrete. | |

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

- investigation of the limestone cycle: decomposition of $CaCO_3$ to give CaO, reaction with water to give $Ca(OH)_2$, addition of more water and filtering to give limewater and use of limewater to test for $CO_2$
- thermal decomposition of $CaCO_3$ to show limelight
- honeycomb demonstration: heat sugar syrup mixture to 150 °C and add sodium bicarbonate
- making concrete blocks in moulds, investigation of variation of content and carrying out strength tests
- design and carry out an investigation of trends in the thermal decomposition of metal carbonates
- investigation of the reaction of carbonates with acids.

## C1.3 Metals and their uses

Metals are very useful in our everyday lives. Ores are naturally occurring rocks that provide an economic starting point for the manufacture of metals. Iron ore is used to make iron and steel. Copper can be easily extracted but copper-rich ores are becoming scarce so new methods of extracting copper are being developed. Aluminium and titanium are useful metals but are expensive to produce. Metals can be mixed together to make alloys.

| Candidates should use their skills, knowledge and understanding to: | Additional guidance: |
|---|---|
| consider and evaluate the social, economic and environmental impacts of exploiting metal ores, of using metals and of recycling metals | Candidates should know that metal ores are obtained by mining and that this may involve digging up and processing large amounts of rock.<br><br>Knowledge and understanding of obtaining, using and recycling metals is limited to the metals named in the subject content. |
| evaluate the benefits, drawbacks and risks of using metals as structural materials. | Knowledge and understanding of the uses and properties of metals and alloys is limited to those specified in the subject content. Information may be given in examination questions so that candidates can evaluate their uses. |

## C1.3.1 Extracting metals

| | Additional guidance: |
|---|---|
| **a)** Ores contain enough metal to make it economic to extract the metal. The economics of extraction may change over time. | Knowledge of specific examples is **not** required. Data may be provided in examination questions for candidates to analyse. |
| **b)** Ores are mined and may be concentrated before the metal is extracted and purified. | Knowledge of specific examples other than those given below is **not** required. |
| **c)** Unreactive metals such as gold are found in the Earth as the metal itself, but most metals are found as compounds that require chemical reactions to extract the metal. | |

| | Additional guidance: |
|---|---|
| **d)** Metals that are less reactive than carbon can be extracted from their oxides by reduction with carbon, for example iron oxide is reduced in the blast furnace to make iron. | Knowledge and understanding is limited to the reduction of oxides using carbon.<br><br>Knowledge of reduction is limited to the removal of oxygen.<br><br>Knowledge of the details of the extraction of other metals is **not** required. Examination questions may provide further information about specific processes for candidates to interpret or evaluate.<br><br>Details of the blast furnace are **not** required. |
| **e)** Metals that are more reactive than carbon, such as aluminium, are extracted by electrolysis of molten compounds. The use of large amounts of energy in the extraction of these metals makes them expensive. | Knowledge of the details of industrial methods of electrolysis is **not** required. |
| **f)** Copper can be extracted from copper-rich ores by heating the ores in a furnace (smelting). The copper can be purified by electrolysis. The supply of copper-rich ores is limited. | Details of industrial smelting processes are **not** required.<br><br>Candidates should know that:<br><br>■ copper is extracted from its ores by chemical processes that involve heat or electricity<br><br>■ copper-rich ores are being depleted and traditional mining and extraction have major environmental impacts. |

| | Additional guidance: |
|---|---|
| g) New ways of extracting copper from low-grade ores are being researched to limit the environmental impact of traditional mining.<br><br>Copper can be extracted by phytomining, or by bioleaching. | Candidates should know and understand that:<br>■ phytomining uses plants to absorb metal compounds and that the plants are burned to produce ash that contains the metal compounds<br>■ bioleaching uses bacteria to produce leachate solutions that contain metal compounds.<br><br>Further specific details of these processes are **not** required. |
| h) Copper can be obtained from solutions of copper salts by electrolysis or by displacement using scrap iron. | Candidates should know that during electrolysis positive ions move towards the negative electrode. They do **not** need to describe this in terms of oxidation and reduction, or to understand half equations. |
| i) Aluminium and titanium cannot be extracted from their oxides by reduction with carbon. Current methods of extraction are expensive because:<br>■ there are many stages in the processes<br>■ large amounts of energy are needed. | Candidates do **not** need to know the details of methods used to extract these metals, but should be able to comment on and evaluate information that is given about the chemical processes that can be used. |
| j) We should recycle metals because extracting them uses limited resources and is expensive in terms of energy and effects on the environment. | Candidates are **not** required to know details of specific examples of recycling, but should understand the benefits of recycling in the general terms specified here. |

## C1.3.2 Alloys

| | Additional guidance: |
|---|---|
| a) Iron from the blast furnace contains about 96% iron. The impurities make it brittle and so it has limited uses. | Knowledge of uses of blast furnace iron is limited to blast furnace iron being used as cast iron because of its strength in compression. |
| b) Most iron is converted into steels. Steels are alloys since they are mixtures of iron with carbon. Some steels contain other metals. Alloys can be designed to have properties for specific uses. Low-carbon steels are easily shaped, high-carbon steels are hard, and stainless steels are resistant to corrosion. | Knowledge and understanding of the types of steel and their properties is limited to those specified in the subject content. Information about the composition of specific types of steel may be given in examination questions so that candidates can evaluate their uses. |
| c) Most metals in everyday use are alloys. Pure copper, gold, iron and aluminium are too soft for many uses and so are mixed with small amounts of similar metals to make them harder for everyday use. | Candidates should be familiar with these specified examples but examination questions may contain information about alloys other than those named in the subject content to enable candidates to make comparisons. |

## C1.3.3 Properties and uses of metals

| | Additional guidance: |
|---|---|
| **a)** The elements in the central block of the periodic table are known as transition metals. Like other metals they are good conductors of heat and electricity and can be bent or hammered into shape. They are useful as structural materials and for making things that must allow heat or electricity to pass through them easily. | Knowledge of the properties of specific transition metals other than those named in this unit is **not** required. |
| **b)** Copper has properties that make it useful for electrical wiring and plumbing. | Candidates should know and understand that copper:<br>■ is a good conductor of electricity and heat<br>■ can be bent but is hard enough to be used to make pipes or tanks<br>■ does not react with water. |
| **c)** Low density and resistance to corrosion make aluminium and titanium useful metals. | |

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

- comparing less reactive metals (gold, silver, copper) with more reactive metals, eg in acid
- heating metal oxides with carbon to compare reactivity, eg CuO, PbO, $Fe_2O_3$
- heating copper carbonate with charcoal to produce copper
- displacement reactions, eg $CuSO_4$(aq) + Fe (using temperature sensors to investigate differences in metal reactivity)
- investigation of the physical properties of metals and alloys, eg density / thermal and electrical conductivity
- electrolysis of copper sulfate solution using copper electrodes
- ignition tube demonstration of blast furnace – potassium permanganate, mineral wool plug, iron oxide mixed with carbon
- investigation of phytomining: growing brassica plants in compost with added copper sulfate or spraying brassica plants (eg cabbage leaves) with copper sulfate solution, ashing the plants (fume cupboard), adding sulfuric acid to the ash, filtering and obtaining the metal from the solution by displacement or electrolysis.

## C1.4 Crude oil and fuels

Crude oil is derived from an ancient biomass found in rocks. Many useful materials can be produced from crude oil. Crude oil can be fractionally distilled. Some of the fractions can be used as fuels. Biofuels are produced from plant material. There are advantages and disadvantages to their use as fuels. Fuels can come from renewable or non-renewable resources.

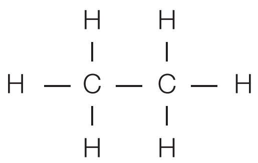
| Candidates should use their skills, knowledge and understanding to: | Additional guidance: |
|---|---|
| ■ evaluate the impact on the environment of burning hydrocarbon fuels | Knowledge and understanding of the products of burning hydrocarbon fuels and the effects of these products is limited to those named in the subject content for this section. |
| ■ consider and evaluate the social, economic and environmental impacts of the uses of fuels | Candidates may be given information and data about other fuels and their products of combustion for comparison and evaluation in the examinations. |
| ■ evaluate developments in the production and uses of better fuels, for example ethanol and hydrogen | Candidates should know and understand the benefits and disadvantages of ethanol and hydrogen as fuels in terms of:<br>■ use of renewable resources<br>■ storage and use of the fuels<br>■ their products of combustion. |
| ■ evaluate the benefits, drawbacks and risks of using plant materials to produce fuels. | |

### C1.4.1 Crude oil

| | Additional guidance: |
|---|---|
| **a)** Crude oil is a mixture of a very large number of compounds. | |
| **b)** A mixture consists of two or more elements or compounds not chemically combined together. The chemical properties of each substance in the mixture are unchanged. It is possible to separate the substances in a mixture by physical methods including distillation. | |
| **c)** Most of the compounds in crude oil consist of molecules made up of hydrogen and carbon atoms only (hydrocarbons). Most of these are saturated hydrocarbons called alkanes, which have the general formula $C_nH_{2n+2}$. | Candidates are **not** expected to know the names of specific alkanes other than methane, ethane and propane. |

## C1.4.2 Hydrocarbons

**a)** Alkane molecules can be represented in the following forms:

- $C_2H_6$
- 

**Additional guidance:**

Candidates should be able to recognise alkanes from their formulae in any of the forms but do not need to know the names of individual alkanes other than methane, ethane, propane and butane.

Candidates should know that in displayed structures — represents a covalent bond.

**b)** The many hydrocarbons in crude oil may be separated into fractions, each of which contains molecules with a similar number of carbon atoms, by evaporating the oil and allowing it to condense at a number of different temperatures. This process is fractional distillation.

Candidates should know and understand the main processes in continuous fractional distillation in a fractionating column.

Knowledge of the names of specific fractions or fuels is **not** required.

**c)** Some properties of hydrocarbons depend on the size of their molecules. These properties influence how hydrocarbons are used as fuels.

Knowledge of trends in properties of hydrocarbons is limited to:

- boiling points
- viscosity
- flammability.

## C1.4.3 Hydrocarbon fuels

**a)** Most fuels, including coal, contain carbon and / or hydrogen and may also contain some sulfur. The gases released into the atmosphere when a fuel burns may include carbon dioxide, water (vapour), carbon monoxide, sulfur dioxide and oxides of nitrogen. Solid particles (particulates) may also be released.

**Additional guidance:**

Candidates should be able to relate products of combustion to the elements present in compounds in the fuel and to the extent of combustion (whether complete or partial).

No details of how the oxides of nitrogen are formed are required, other than the fact that they are formed at high temperatures.

Solid particles may contain soot (carbon) and unburnt fuels.

**b)** The combustion of hydrocarbon fuels releases energy. During combustion the carbon and hydrogen in the fuels are oxidised.

| | Additional guidance: |
|---|---|
| **c)** Sulfur dioxide and oxides of nitrogen cause acid rain, carbon dioxide causes global warming, and solid particles cause global dimming. | Candidates are not required to know details of any other causes of acid rain or global warming. |
| **d)** Sulfur can be removed from fuels before they are burned, for example in vehicles. Sulfur dioxide can be removed from the waste gases after combustion, for example in power stations. | Knowledge of the methods of removing sulfur is **not** required. |
| **e)** Biofuels, including biodiesel and ethanol, are produced from plant material. There are economic, ethical and environmental issues surrounding their use. | Knowledge of the methods of biofuel production is **not** required but candidates may be given information from which a range of questions may be asked. |

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

- demonstration of fractional distillation of crude oil using CLEAPSS mixture (take care to avoid confusion with the continuous process in a fractionating column)
- design an investigation on viscosity, ease of ignition or sootiness of flame of oils or fuels
- comparison of the energy content of different fuels, for example by heating a fixed volume of water
- demonstration of the production of solid particles by incomplete combustion using a Bunsen burner yellow flame or a candle flame to boil a tube of cold water
- collecting and testing the products of combustion of candle wax and methane
- demonstration of burning sulfur or coal in oxygen and then testing the pH of the gas produced
- design an investigation on growing cress from seeds in various concentrations of sodium metabisulfite solution to show how acid rain affects plants.

## C1.5 Other useful substances from crude oil

Fractions from the distillation of crude oil can be broken down (cracked) to make smaller molecules including unsaturated hydrocarbons such as ethene. Unsaturated hydrocarbons can be used to make polymers and ethene can be used to make ethanol. Ethanol can also be made by fermentation.

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

- evaluate the social and economic advantages and disadvantages of using products from crude oil as fuels or as raw materials for plastics and other chemicals

**Additional guidance:**

Candidates should be aware that crude oil is used to produce fuels and chemicals, and that it is a limited resource.

Candidates should be able to evaluate information about the ways in which crude oil and its products are used. Although candidates will probably know the names of some common polymers, these are **not** required knowledge, unless they are included in the subject content for this section.

- evaluate the social, economic and environmental impacts of the uses, disposal and recycling of polymers

- evaluate the advantages and disadvantages of making ethanol from renewable and non-renewable sources.

**Additional guidance:**

Candidates should be able to compare the environmental impact of producing ethanol from renewable and non-renewable sources.

### C1.5.1 Obtaining useful substances from crude oil

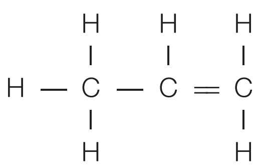
**a)** Hydrocarbons can be cracked to produce smaller, more useful molecules. This process involves heating the hydrocarbons to vaporise them. The vapours are either passed over a hot catalyst or mixed with steam and heated to a very high temperature so that thermal decomposition reactions then occur.

**b)** The products of cracking include alkanes and unsaturated hydrocarbons called alkenes. Alkenes have the general formula $C_nH_{2n}$.

**Additional guidance:**

Candidates should be able to recognise alkenes from their names or formulae, but do **not** need to know the names of individual alkenes, other than ethene and propene.

**c)** Unsaturated hydrocarbon molecules can be represented in the following forms:

- $C_3H_6$
- 

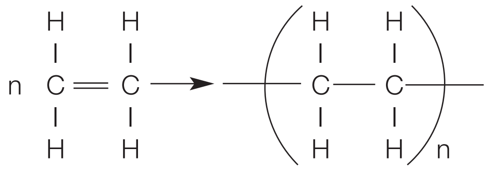
Candidates should know that in displayed structures ═ represents a double bond.

**d)** Alkenes react with bromine water, turning it from orange to colourless.

**e)** Some of the products of cracking are useful as fuels.

## C1.5.2 Polymers

**a)** Alkenes can be used to make polymers such as poly(ethene) and poly(propene). In these reactions, many small molecules (monomers) join together to form very large molecules (polymers).
For example:



ethene poly(ethene)

**Additional guidance:**

Candidates should be able to recognise the molecules involved in these reactions in the forms shown in the subject content. They should be able to represent the formation of a polymer from a given alkene monomer.

Further details of polymerisation are **not** required.

**b)** Polymers have many useful applications and new uses are being developed, for example: new packaging materials, waterproof coatings for fabrics, dental polymers, wound dressings, hydrogels, smart materials (including shape memory polymers).

Candidates should consider the ways in which new materials are being developed and used, but will **not** need to recall the names of specific examples.

**c)** Many polymers are not biodegradable, so they are not broken down by microbes and this can lead to problems with waste disposal.

Knowledge of specific named examples is **not** required, but candidates should be aware of the problems that are caused by landfill sites and by litter.

**d)** Plastic bags are being made from polymers and cornstarch so that they break down more easily. Biodegradable plastics made from cornstarch have been developed.

## C1.5.3 Ethanol

**a)** Ethanol can be produced by the hydration of ethene with steam in the presence of a catalyst.

**Additional guidance:**

No further details of these processes are required.

**b)** Ethanol can also be produced by fermentation with yeast, using renewable resources.
This can be represented by:

sugar → carbon dioxide + ethanol

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

- demonstration of the cracking of liquid paraffin using broken pottery as the catalyst
- testing for unsaturation in the alkenes using bromine water
- making a polymer from cornstarch
- demonstration of making Perspex
- molecular modelling of polymers
- design an investigation of a property of different plastics, eg strength, flexibility, biodegradability
- investigate the amount of water that can be absorbed by a hydrogel (eg those used as additives to garden composts)
- testing coated fabrics for water penetration.

## C1.6 Plant oils and their uses

Many plants produce useful oils that can be converted into consumer products including processed foods. Emulsions can be made and have a number of uses. Vegetable oils can be hardened to make margarine. Biodiesel fuel can be produced from vegetable oils.

| **Candidates should use their skills, knowledge and understanding to:** | **Additional guidance:** |
| --- | --- |
| ■ evaluate the effects of using vegetable oils in foods and the impacts on diet and health | Knowledge is limited to the high-energy content of vegetable oils, the possible health benefits of unsaturated fats compared with saturated fats, and the effects of cooking foods in oil. Information may be provided in examinations for candidates to evaluate. |
| ■ evaluate the use, benefits, drawbacks and risks of emulsifiers in foods. | Candidates do **not** need to recall the names of specific additives.<br><br>Further information will be provided in questions for evaluation and comparison. |

### C1.6.1 Vegetable oils

| | **Additional guidance:** |
| --- | --- |
| **a)** Some fruits, seeds and nuts are rich in oils that can be extracted. The plant material is crushed and the oil is removed by pressing or in some cases by distillation. Water and other impurities are removed. | Candidates should study the general principles of the extraction of vegetable oils, such as olive oil, rapeseed oil or lavender oil.<br><br>Knowledge of specific examples or processes is **not** required. |
| **b)** Vegetable oils are important foods and fuels as they provide a lot of energy. They also provide us with nutrients. | Knowledge of the details of the production of biodiesel is **not** required.<br><br>Knowledge of specific nutrients is **not** required. |

**c)** Vegetable oils have higher boiling points than water and so can be used to cook foods at higher temperatures than by boiling. This produces quicker cooking and different flavours but increases the energy that the food releases when it is eaten.

## C1.6.2 Emulsions

| | Additional guidance: |
|---|---|
| **a)** Oils do not dissolve in water. They can be used to produce emulsions. Emulsions are thicker than oil or water and have many uses that depend on their special properties. They provide better texture, coating ability and appearance, for example in salad dressings, ice creams, cosmetics and paints. | Candidates should study how emulsions are made and should understand the role of emulsifiers in producing emulsions that are more stable. Knowledge of specific names of ingredients in proprietary products is **not** required. |
| b) **Emulsifiers have hydrophilic and hydrophobic properties.** | **HT only**<br><br>**Knowledge is limited to a simple model of the structure of emulsifier molecules.** |

## C1.6.3 Saturated and unsaturated oils

| | Additional guidance: |
|---|---|
| **a)** Vegetable oils that are unsaturated contain double carbon–carbon bonds. These can be detected by reacting with bromine water. | Candidates should be familiar with a test for unsaturation using bromine water. |
| b) **Vegetable oils that are unsaturated can be hardened by reacting them with hydrogen in the presence of a nickel catalyst at about 60 °C. Hydrogen adds to the carbon–carbon double bonds. The hydrogenated oils have higher melting points so they are solids at room temperature, making them useful as spreads and in cakes and pastries.** | **HT only**<br><br>**Candidates should know how and why vegetable oils are hardened for use in foods. Knowledge of trans fats is not required.**<br><br>**Examination questions may provide further information from which candidates may be asked to make comparisons.** |

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

- pressing nuts (eg walnuts) between paper towels and studying the grease marks
- steam distillation of lavender oil, orange oil, lemon oil, olive oil, rapeseed oil or vegetable oil
- simple calorimetry investigations using small spirit burners or bottle tops to measure the energy released from various oils (weigh before and after, and measure the temperature change for a known mass of water)
- making emulsions, eg oil/water, oil/vinegar
- investigating the effect of emulsifiers on the stability of emulsions
- using bromine water to test fats and oils for unsaturation, eg testing sunflower oil against butter (using colorimeter to measure level of unsaturation).

## C1.7 Changes in the Earth and its atmosphere

The Earth and its atmosphere provide everything we need. The Earth has a layered structure. The surface of the Earth and its atmosphere have changed since the Earth was formed and are still changing. The atmosphere has been much the same for the last 200 million years and provides the conditions needed for life on Earth. Recently human activities have resulted in further changes in the atmosphere. There is more than one theory about how life was formed.

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

- recognise that the Earth's crust, the atmosphere and the oceans are the only source of minerals and other resources that humans need

| | Additional guidance: |
|---|---|
| ■ explain why Wegener's theory of crustal movement (continental drift) was not generally accepted for many years | Candidates should have studied accounts of Wegener's work. Knowledge is limited to the theories relating to mountain building and continental drift.<br><br>Candidates should know that scientists once thought that the features of the Earth's surface were the result of the shrinking of the crust as the Earth cooled down following its formation. |
| ■ explain why scientists cannot accurately predict when earthquakes and volcanic eruptions will occur | Candidates may be given information which they will be expected to interpret. |
| ■ explain and evaluate theories of the changes that have occurred and are occurring in the Earth's atmosphere | Candidates should be able to compare and evaluate different theories when given suitable information. |
| ■ explain and evaluate the effects of human activities on the atmosphere | Knowledge of the effects of human activities is limited to those in the subject content. |
| ■ **describe why we do not know how life was first formed.** | **HT only** |

### C1.7.1 The Earth's crust

| | Additional guidance: |
|---|---|
| **a)** The Earth consists of a core, mantle and crust, and is surrounded by the atmosphere. | Knowledge is limited to the names of the three major parts, and an awareness of the relative sizes of these features. |
| **b)** The Earth's crust and the upper part of the mantle are cracked into a number of large pieces (tectonic plates). | Knowledge of the names, shapes or locations of specific plates is **not** required. |
| **c)** Convection currents within the Earth's mantle driven by heat released by natural radioactive processes cause the plates to move at relative speeds of a few centimetres per year. | Candidates should know that the mantle is mostly solid, but that it is able to move slowly. |

**d)** The movements can be sudden and disastrous. Earthquakes and / or volcanic eruptions occur at the boundaries between tectonic plates.

**Additional guidance:**

Knowledge of the changes that occur at plate boundaries is limited to earthquakes and volcanic eruptions.

Knowledge of the mechanism of these changes is **not** required.

## C1.7.2 The Earth's atmosphere

**a)** For 200 million years, the proportions of different gases in the atmosphere have been much the same as they are today:

- about four-fifths (80 %) nitrogen
- about one-fifth (20 %) oxygen
- small proportions of various other gases, including carbon dioxide, water vapour and noble gases.

**b)** During the first billion years of the Earth's existence there was intense volcanic activity. This activity released the gases that formed the early atmosphere and water vapour that condensed to form the oceans.

**c)** There are several theories about how the atmosphere was formed.

One theory suggests that during this period the Earth's atmosphere was mainly carbon dioxide and there would have been little or no oxygen gas (like the atmospheres of Mars and Venus today). There may also have been water vapour and small proportions of methane and ammonia.

**Additional guidance:**

No knowledge of other theories is required. Information may be given in questions which candidates will be expected to interpret.

**d)** There are many theories as to how life was formed billions of years ago.

**e) One theory as to how life was formed involves the interaction between hydrocarbons, ammonia and lightning.**

**Additional guidance:**

**HT only**

**Candidates should be aware of the Miller Urey experiment and the 'primordial soup' theory, but they should know that this is not the only theory.**

**f)** Plants and algae produced the oxygen that is now in the atmosphere.

Candidates should be aware that plants and algae produce oxygen by a process called photosynthesis and that this process uses carbon dioxide from the atmosphere.

Knowledge of the process of photosynthesis is **not** required.

| | |
|---|---|
| g) Most of the carbon from the carbon dioxide in the air gradually became locked up in sedimentary rocks as carbonates and fossil fuels. | **Additional guidance:** Candidates should know that carbon dioxide dissolves in the oceans and that limestone was formed from the shells and skeletons of marine organisms. Fossil fuels contain carbon and hydrocarbons that are the remains of plants and animals. |
| h) The oceans also act as a reservoir for carbon dioxide but increased amounts of carbon dioxide absorbed by the oceans has an impact on the marine environment. | |
| i) Nowadays the release of carbon dioxide by burning fossil fuels increases the level of carbon dioxide in the atmosphere. | **Additional guidance:** Candidates should be aware that this increase in carbon dioxide is thought to be causing global warming but, for this unit, candidates do **not** need to know how $CO_2$ causes this effect. |
| **j) Air is a mixture of gases with different boiling points and can be fractionally distilled to provide a source of raw materials used in a variety of industrial processes.** | **HT only**<br><br>**Knowledge of the boiling points of the different gases is not required.** |

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

- investigating the composition of air by passing air over heated copper using gas syringes and measuring the percentage of oxygen. Then burning magnesium in the nitrogen to form $Mg_3N_2$. Add water to produce ammonia (nitrogen must have come from the air)
- collecting gas produced by aquatic plants and testing for oxygen (using dissolved oxygen sensor)
- measuring the amount of carbon dioxide in inhaled and exhaled air (using carbon dioxide sensor)
- testing the products of combustion of fuels to show that carbon dioxide is produced
- design an investigation to compare the amount of carbon dioxide released by reacting crushed shells (eg cockle, oyster) with dilute hydrochloric acid.

## 3.5 Unit 3: Physics 1

### P1.1 The transfer of energy by heating processes and the factors that affect the rate at which that energy is transferred

Energy can be transferred from one place to another by work or by heating processes. We need to know how this energy is transferred and which heating processes are most important in a particular situation.

| Candidates should use their skills, knowledge and understanding to: | Additional guidance: |
|---|---|
| compare ways in which energy is transferred in and out of objects by heating and ways in which the rates of these transfers can be varied | Examples should include the design of a vacuum flask, how to reduce the energy transfer from a building and how humans and animals cope with low temperatures. |
| evaluate the design of everyday appliances that transfer energy by heating, including economic considerations | Examples include radiators and heat sinks. |
| evaluate the effectiveness of different types of material used for insulation, including U-values and economic factors including payback time | Examples include loft insulation and cavity wall insulation. |
| evaluate different materials according to their specific heat capacities. | Examples include the use of water, which has a very high specific heat capacity, oil-filled radiators and electric storage heaters containing concrete or bricks. |

#### P1.1.1 Infrared radiation

**a)** All objects emit and absorb infrared radiation.

**b)** The hotter an object is the more infrared radiation it radiates in a given time.

**c)** Dark, matt surfaces are good absorbers and good emitters of infrared radiation.

**d)** Light, shiny surfaces are poor absorbers and poor emitters of infrared radiation.

**e)** Light, shiny surfaces are good reflectors of infrared radiation.

## P1.1.2 Kinetic theory

| | Additional guidance: |
| --- | --- |
| a) The use of kinetic theory to explain the different states of matter. | Candidates should be able to recognise simple diagrams to model the difference between solids, liquids and gases. |
| b) The particles of solids, liquids and gases have different amounts of energy. | An understanding of specific latent heat is **not** required. |

## P1.1.3 Energy transfer by heating

| | Additional guidance: |
| --- | --- |
| a) The transfer of energy by conduction, convection, evaporation and condensation involves particles, and how this transfer takes place. | Candidates should understand in simple terms how the arrangement and movement of particles determine whether a material is a conductor or an insulator.<br><br>Candidates should understand the role of free electrons in conduction through a metal.<br><br>Candidates should be able to use the idea of particles moving apart to make a fluid less dense, to explain simple applications of convection. |
| b) The factors that affect the rate of evaporation and condensation. | Candidates should be able to explain evaporation and the cooling effect this causes using the kinetic theory.<br><br>Candidates should be able to explain the design of devices in terms of energy transfer, for example, cooling fins. |
| c) The rate at which an object transfers energy by heating depends on:<br>■ surface area and volume<br>■ the material from which the object is made<br>■ the nature of the surface with which the object is in contact. | Candidates should be able to explain animal adaptations in terms of energy transfer, for example, relative ear size of animals in cold and warm climates. |
| d) The bigger the temperature difference between an object and its surroundings, the faster the rate at which energy is transferred by heating. | |

## P1.1.4 Heating and insulating buildings

**a)** U-values measure how effective a material is as an insulator.

**Additional guidance:**

Knowledge of the U-values of specific materials is **not** required, nor is the equation that defines a U-value.

**b)** The lower the U-value, the better the material is as an insulator.

**c)** Solar panels may contain water that is heated by radiation from the Sun. This water may then be used to heat buildings or provide domestic hot water.

**d)** The specific heat capacity of a substance is the amount of energy required to change the temperature of one kilogram of the substance by one degree Celsius.

$E = m \times c \times \theta$

**Additional guidance:**

$E$ is energy transferred in joules, J

$m$ is mass in kilograms, kg

$\theta$ is temperature change in degrees Celsius, °C

$c$ is specific heat capacity in J / kg °C

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

- passing white light through a prism and detecting the infrared radiation with a thermometer
- demonstration using balls in a tray to show the behaviour of particles in substances in different states
- measuring the cooling effect produced by evaporation: putting wet cotton wool over the bulb of a thermometer or temperature probe
- plan and carry out an investigation into factors that affect the rate of cooling of a can of water, eg shape, volume, and colour of can
- using Leslie's cube to demonstrate the effect on radiation of altering the nature of the surface
- plan and carry out an investigation using immersion heaters in a metal block to measure specific heat capacity
- investigating thermal conduction using rods of different materials.

## P1.2 Energy and efficiency

Appliances transfer energy but they rarely transfer all of the energy to the place we want. We need to know the efficiency of appliances so that we can choose between them, including how cost effective they are, and try to improve them.

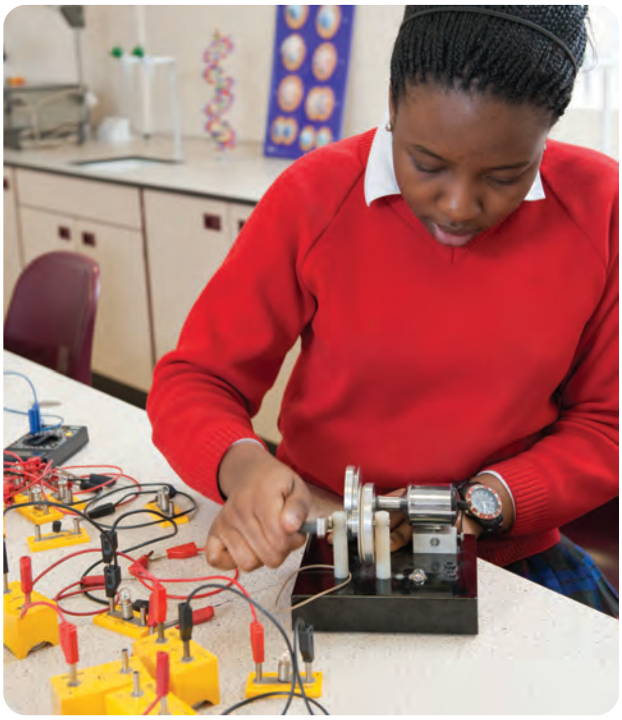
| Candidates should use their skills, knowledge and understanding to: | Additional guidance: |
| --- | --- |
| ■ compare the efficiency and cost effectiveness of methods used to reduce 'energy consumption' | The term 'payback time' should be understood.<br><br>Given relevant data, candidates should be able to make judgements about the cost effectiveness of different methods of reducing energy consumption over a set period of time. This is **not** restricted to a consideration of building insulation but may include:<br>■ low energy light bulbs and LED lighting<br>■ replacing old appliances with energy efficient ones<br>■ ways in which 'waste' energy can be useful, eg heat exchangers. |
| ■ describe the energy transfers and the main energy wastages that occur with a range of appliances | Common electrical appliances found in the home will be examined. Examples will **not** be limited to electrical appliances; however, in this case all the information would be given in the question. |
| ■ interpret and draw a Sankey diagram. | Candidates should be able to use a Sankey diagram to calculate the efficiency of an appliance. |

### P1.2.1 Energy transfers and efficiency

a) Energy can be transferred usefully, stored, or dissipated, but cannot be created or destroyed.

b) When energy is transferred, only part of it may be usefully transferred; the rest is 'wasted'.

c) Wasted energy is eventually transferred to the surroundings, which become warmer. The wasted energy becomes increasingly spread out and so becomes less useful.



d) To calculate the efficiency of a device using:

$$\text{efficiency} = \frac{\text{useful energy out}}{\text{total energy in}} (\times 100\%)$$

$$\text{efficiency} = \frac{\text{useful power out}}{\text{total power in}} (\times 100\%)$$

**Additional guidance:**

Candidates may be required to calculate efficiency as a decimal or as a percentage.

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

- an energy 'circus' to demonstrate various energy transfers
- plan and carry out an investigation by constructing a model house, using sensors and data logger to measure temperatures with and without various types of insulation.

## P1.3 The usefulness of electrical appliances

We often use electrical appliances because they transfer energy at the flick of a switch. We can calculate how much energy is transferred by an appliance and how much the appliance costs to run.

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

- compare the advantages and disadvantages of using different electrical appliances for a particular application

**Additional guidance:**

Candidates will be required to compare different electrical appliances, using data provided.

- consider the implications of instances when electricity is not available.

### P1.3.1 Transferring electrical energy

a) Examples of energy transfers that everyday electrical appliances are designed to bring about.

b) The amount of energy an appliance transfers depends on how long the appliance is switched on and its power.

c) To calculate the amount of energy transferred from the mains using:

$E = P \times t$

**Additional guidance:**

Candidates will **not** be required to convert between kilowatt-hours and joules.

*E* is energy transferred in kilowatt-hours, kWh

*P* is power in kilowatts, kW

*t* is time in hours, h

This equation may also be used when:

*E* is energy transferred in joules, J

*P* is power in watts, W

*t* is time in seconds, s

d) To calculate the cost of mains electricity given the cost kilowatt-hour.

This includes both the cost of using individual appliances and the interpretation of electricity meter readings to calculate total cost over a period of time.

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

- candidates reading the electricity meter at home on a daily or weekly basis. They could then look for trends in usage and try to explain these, eg in terms of weather conditions
- plan and carry out an investigation using an electrical joulemeter to measure the energy transferred by low voltage bulbs of different powers, low voltage motors and low voltage immersion heaters.

## P1.4 Methods we use to generate electricity

Various energy sources can be used to generate the electricity we need. We must carefully consider the advantages and disadvantages of using each energy source before deciding which energy source(s) it would be best to use in any particular situation. Electricity is distributed via the National Grid.

| **Candidates should use their skills, knowledge and understanding to:** | **Additional guidance:** |
|---|---|
| evaluate different methods of generating electricity | Candidates should be able to evaluate different methods of generating electricity given data including start-up times, costs of electricity generation and the total cost of generating electricity, when factors such as building and decommissioning are taken into account. The reliability of different methods should also be understood.<br><br>Knowledge of the actual values of start-up times and why they are different is **not** needed, but the implications of such differences are important. |
| evaluate ways of matching supply with demand, either by increasing supply or decreasing demand | Candidates should be aware of the fact that, of the fossil fuel power stations, gas-fired have the shortest start-up time. They should also be aware of the advantages of pumped storage systems in order to meet peak demand, and as a means of storing energy for later use. |
| compare the advantages and disadvantages of overhead power lines and underground cables. | |

### P1.4.1 Generating electricity

a) In some power stations an energy source is used to heat water. The steam produced drives a turbine that is coupled to an electrical generator.

Energy sources include:

- the fossil fuels (coal, oil and gas) which are burned to heat water or air
- uranium and plutonium, when energy from nuclear fission is used to heat water
- biofuels that can be burned to heat water.

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| | Additional guidance: |
|---|---|
| **b)** Water and wind can be used to drive turbines directly. | Energy sources used in this way include, but are not limited to, wind, waves, tides and the falling of water in hydroelectric schemes. |
| **c)** Electricity can be produced directly from the Sun's radiation. | Candidates should know that solar cells can be used to generate electricity and should be able to describe the advantages and disadvantages of their use. |
| **d)** In some volcanic areas hot water and steam rise to the surface. The steam can be tapped and used to drive turbines. This is known as geothermal energy. | |

| | Additional guidance: |
|---|---|
| **e)** Small-scale production of electricity may be useful in some areas and for some uses, eg hydroelectricity in remote areas and solar cells for roadside signs. | Candidates should understand that while small-scale production can be locally useful it is sometimes uneconomic to connect such generation to the National Grid. |
| **f)** Using different energy resources has different effects on the environment. These effects include:<br>■ the release of substances into the atmosphere<br>■ the production of waste materials<br>■ noise and visual pollution<br>■ the destruction of wildlife habitats. | Candidates should understand that carbon capture and storage is a rapidly evolving technology. To prevent carbon dioxide building up in the atmosphere we can catch and store it. Some of the best natural containers are old oil and gas fields, such as those under the North Sea. |

## P1.4.2 The National Grid

| | Additional guidance: |
|---|---|
| **a)** Electricity is distributed from power stations to consumers along the National Grid. | Candidates should be able to identify and label the essential parts of the National Grid. |
| **b)** For a given power, increasing the voltage reduces the current required and this reduces the energy losses in the cables. | Candidates should know why transformers are an essential part of the National Grid. |
| **c)** The uses of step-up and step-down transformers in the National Grid. | Details of the structure of a transformer and how a transformer works are **not** required. |

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

- investigating the effect of changing different variables on the output of solar cells, eg distance from the light source, the use of different coloured filters and the area of the solar cells
- planning and carrying out an investigation into the effect of changing different variables on the output of model wind turbines, eg the number or pitch of the blades, the wind velocity
- demonstrating a model water turbine linked to a generator
- modelling the National Grid.

## P1.5 The use of waves for communication and to provide evidence that the universe is expanding

Electromagnetic radiations travel as waves and move energy from one place to another. They can all travel through a vacuum and do so at the same speed. The waves cover a continuous range of wavelengths called the electromagnetic spectrum.

Sound waves and some mechanical waves are longitudinal, and cannot travel through a vacuum.

Current evidence suggests that the universe is expanding and that matter and space expanded violently and rapidly from a very small initial 'point', ie the universe began with a 'big bang'.

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

- compare the use of different types of waves for communication

**Additional guidance:**

Knowledge and understanding of waves used for communication is limited to sound, light, microwaves, radio waves and infrared waves.

- evaluate the possible risks involving the use of mobile phones
- consider the limitations of the model that scientists use to explain how the universe began and why the universe continues to expand.

### P1.5.1 General properties of waves

**a)** Waves transfer energy.

**b)** Waves may be either transverse or longitudinal.

**Additional guidance:**

Candidates should understand that in a transverse wave the oscillations are perpendicular to the direction of energy transfer. In a longitudinal wave the oscillations are parallel to the direction of energy transfer.

**c)** Electromagnetic waves are transverse, sound waves are longitudinal and mechanical waves may be either transverse or longitudinal.

**d)** All types of electromagnetic waves travel at the same speed through a vacuum (space).

**e)** Electromagnetic waves form a continuous spectrum.

**Additional guidance:**

Candidates should know the order of electromagnetic waves within the spectrum, in terms of energy, frequency and wavelength.

Candidates should appreciate that the wavelengths vary from about $10^{-15}$ metres to more than 104 metres.

| | |
|---|---|
| f) Longitudinal waves show areas of compression and rarefaction. | |
| g) Waves can be reflected, refracted and diffracted. | **Additional guidance:** Candidates should appreciate that significant diffraction only occurs when the wavelength of the wave is of the same order of magnitude as the size of the gap or obstacle. |
| h) Waves undergo a change of direction when they are refracted at an interface. | Waves are not refracted if travelling along the normal.<br><br>Snell's law and the reason why waves are refracted are **not** required. |
| i) The terms frequency, wavelength and amplitude. | |
| j) All waves obey the wave equation:<br><br>$v = f \times \lambda$ | **Additional guidance:** $v$ is speed in metres per second, m/s<br><br>$f$ is frequency in hertz, Hz<br><br>$\lambda$ is wavelength in metres, m<br><br>Candidates are **not** required to recall the value of the speed of electromagnetic waves through a vacuum. |
| k) Radio waves, microwaves, infra red and visible light can be used for communication. | Candidates will be expected to be familiar with situations in which such waves are typically used and any associated hazards, eg:<br><br>■ radio waves – television, and radio (including diffraction effects)<br><br>■ microwaves – mobile phones and satellite television<br><br>■ infra red – remote controls<br><br>■ visible light – photography. |

## P1.5.2 Reflection

| | |
|---|---|
| a) The normal is a construction line perpendicular to the reflecting surface at the point of incidence. | |
| b) The angle of incidence is equal to the angle of reflection. | |
| c) The image produced in a plane mirror is virtual, upright and latterally inverted. | **Additional guidance:** Candidates will be expected to be able to construct ray diagrams. |

## P1.5.3 Sound

a) Sound waves are longitudinal waves and cause vibrations in a medium, which are detected as sound.

**Additional guidance:**

Sound is limited to human hearing and **no** details of the structure of the ear are required.

b) The pitch of a sound is determined by its frequency and loudness by its amplitude.

c) Echoes are reflections of sounds.

## P1.5.4 Red-shift

a) If a wave source is moving relative to an observer there will be a change in the observed wavelength and frequency. This is known as the Doppler effect.

**Additional guidance:**

The following should be included:

- the wave source could be light, sound or microwaves
- when the source moves away from the observer, the observed wavelength increases and the frequency decreases
- when the source moves towards the observer, the observed wavelength decreases and the frequency increases.

b) There is an observed increase in the wavelength of light from most distant galaxies. The further away the galaxies are, the faster they are moving, and the bigger the observed increase in wavelength. This effect is called red-shift.

c) How the observed red-shift provides evidence that the universe is expanding and supports the 'Big Bang' theory (that the universe began from a very small initial point).

d) Cosmic microwave background radiation (CMBR) is a form of electromagnetic radiation filling the universe. It comes from radiation that was present shortly after the beginning of the universe.

e) The 'Big Bang' theory is currently the only theory that can explain the existence of CMBR.

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

- reflecting light off a plane mirror at different angles
- using a class set of skipping ropes to investigate frequency and wavelength
- demonstrating transverse and longitudinal waves with a slinky spring
- carrying out refraction investigations using a glass block
- carrying out investigations using ripple tanks, including the relationship between depth of water and speed of wave
- investigating the range of Bluetooth or infrared communications between mobile phones and laptops
- demonstrating the Doppler effect for sound.

## 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.

## SA4.1 Planning an investigation

### Candidates should be able to:

| SA4.1.1 **plan practical ways to answer scientific questions, by:** | Additional guidance: | AF/thread |
|---|---|---|
| **a)** stating the purpose of an investigation | Candidates should be able to state the purpose of an investigation in terms of the possible relationship between two variables. These will usually be the independent and the dependent variables. Often there may be a quantitative relationship between these variables. | 4/2 |
| **b)** recognise significant variables in an investigation | The variables may be identified as continuous or categoric. | 4/2 |
| **c)** recognising a control variable in an investigation | Candidates should be able to identify variables that have been controlled, those that have not been controlled and those that cannot be controlled but should be monitored. | 4/2 |
| **d)** understanding the purpose of a control group | Candidates should be able to identify a control group that is being used, explain the benefit of using a control group and suggest how a control group could be set up. Examples may include the use of placebos in testing new drugs. | 4/2 |
| **e)** identifying intervals in measurements. | Candidates should be able to identify the interval between readings and suggest, with reason, a suitable interval for the independent variable. | 4/3 |

### Candidates should understand:

| SA4.1.2 **test scientific ideas by:** | Additional guidance: | AF/thread |
|---|---|---|
| **a)** understanding the meaning of the term hypothesis | Candidates should understand the difference between a hypothesis and a fact. | 1/3 |
| **b)** being able to test a hypothesis | Candidates should be able to plan a fair test to investigate a hypothesis. | 1/4 |
| **c)** planning a fair test. | A fair test will normally involve changing one variable (the independent variable) to see what effect this has on another variable (the dependent variable) while keeping all other variables (control variables) constant. | 4/2 |

**SA4.1.3 devise appropriate methods for the collection of numerical and other data, by:**

| | Additional guidance: | AF/thread |
|---|---|---|
| a) carrying out preliminary work | Candidates should appreciate when a trial run would be appropriate and be able to suggest the values of the variables to be used in a trial run. | 5/1 |
| b) understanding sample size | Sample size is important and candidates should be able to suggest why a particular sample size is the most appropriate. | 4/3 |
| c) using appropriate technology. | Candidates should appreciate that technology such as data logging may provide a better means of obtaining data. They should be able to suggest appropriate technology for collecting data and explain why a particular technology is the most appropriate. Candidates should use ICT whenever appropriate. | 4/1 |

## SA4.2 Assess and manage risks when carrying out practical work

**Candidates should be able to:**

**SA4.2.1 assess and manage risks when carrying out practical work, by:**

| | Additional guidance: | AF/thread |
|---|---|---|
| a) identifying some possible hazards in practical situations | Candidates will be expected to independently recognise a range of familiar hazards and consult appropriate resources and expert advice. | 4/4 |
| b) suggesting ways of managing risks. | Candidates should assess risks to themselves and others and take action to reduce these risks by adapting their approaches to practical work in order to control risk. | 4/4 |

## SA4.3 Collect primary and secondary data

**Candidates should be able to:**

**SA4.3.1 make observations, by:**

| | AF/thread |
|---|---|
| a) making simple observations from first hand evidence of an object or an event | 4/3 |
| b) carrying out practical work and research. | |

**Candidates should be able to:**

| SA4.3.2 **demonstrate the correct use of equipment, by:** | Additional guidance: | AF/thread |
|---|---|---|
| a) choosing the most appropriate equipment or technique for the task | | 4/1 |
| b) understanding why a particular technique or piece of equipment is the most suitable for the task | | 4/1 |
| c) knowing that a measuring instrument needs to be calibrated before use | Candidates should appreciate why a measuring instrument needs to be calibrated accurately and be able to describe how an instrument could be calibrated. | 4/1 |
| d) understanding the meaning of the term resolution when applied to a measuring instrument. | Candidates should be able to choose the correct scale to use for the intended measurement, and recognise whether the chosen instrument has the required resolution. | 4/1 |

**Candidates should be able to:**

| SA4.3.3 **demonstrate an understanding of the need to acquire high-quality data, by:** | Additional guidance: | AF/thread |
|---|---|---|
| a) appreciating that, unless certain variables are controlled, the results may not be valid | Candidates should be able to explain whether results can be considered valid and recognise when an instrument or technique might not be measuring the variable intended. | 4/3 |
| b) identifying when repeats are needed in order to improve reliability | Candidates should recognise that a second set of readings with another instrument or by a different observer could be used to cross check results. | 4/3 |
| c) recognising the value of repeated readings to establish accuracy | Candidates should understand that accuracy is a measure of how close the measured value is to the true value. | 4/3 |
| d) considering the resolution of the measuring device | Candidates should understand that resolution is the smallest change in the quantity being measured (input) of a measuring instrument that gives a perceptible change in the indication (output). | 4/3 |
| 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 accuracy and precision when applied to an instrument's readings. | 4/3 |
| f) identifying the range of the measured data. | Candidates should be able to identify the upper and lower limits of the range and which extra results, within or outside the range, would be appropriate. | 4/3 |

## SA4.4 Select and process primary and secondary data

**Candidates should be able to:**

| SA4.4.1 **show an understanding of the value of means, by:** | Additional guidance: | AF/thread |
|---|---|---|
| a) appreciating when it is appropriate to calculate a mean | | 5/1 |
| b) calculating the mean of a set of at least three results. | Candidates should be able to calculate the mean of a set of at least three results, recognising the need to exclude anomalies before calculating means to an appropriate number of decimal places. | 5/1 |

**Candidates should be able to:**

| SA4.4.2 **demonstrate an understanding of how data may be displayed, by:** | Additional guidance: | AF/thread |
|---|---|---|
| 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 |

## SA4.5 Analyse and interpret primary and secondary data

**Candidates should be able to:**

| SA4.5.1 **distinguish between a fact and an opinion, by:** | Additional guidance: | AF/thread |
|---|---|---|
| a) recognising that an opinion might be influenced by factors other than scientific fact | Candidates should recognise that opinion may be influenced by economic, ethical, moral, social or cultural considerations. | 2/1 |
| b) identifying scientific evidence that supports an opinion. | | 1/2 |

**Candidates should be able to:**

| SA4.5.2 **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. | 5/2 |
| b) recognising and identifying the cause of random errors | Candidates should appreciate that if a data set contains random errors, repeating the readings and calculating a new mean can reduce their effect.<br><br>Candidates should appreciate that human error might be the cause of inaccurate measurements and explain how human error might have influenced the accuracy of a measurement or might have introduced bias into a set of readings. | 5/2 |
| 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. | 5/2 |
| 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.<br><br>Candidates should realise that a zero error is a type of systematic error. Candidates should be able to identify whether a scale has been incorrectly used and suggest how to compensate for a zero error. | 5/2 |

**Candidates should be able to:**

| SA4.5.3 **identify patterns in data, by:** | **Additional guidance:** | **AF/thread** |
|---|---|---|
| a) describing the relationship between two variables. | Candidates should be able to use terms such as linear or directly proportional, or describe a complex relationship. | 5/3 |

| SA4.5.4 **draw conclusions using scientific ideas and evidence, by:** | **Additional guidance:** | **AF/thread** |
|---|---|---|
| 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 reliability and validity. | 5/3 |
| c) identifying extra evidence that is required for a conclusion to be made | 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 |

## 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 Science A, the regulations state: | For this specification, this means: |
|---|---|
| Task setting – high control | ■ We prepare equivalent Investigative Skills Assignments (ISAs) each year. |
| 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.<br>■ If more than one lesson is used, candidates' data and research work must be collected at the end of each lesson.<br>■ Candidates can work together during the investigation, but each candidate must contribute to the collection of the data and process the data individually.<br>■ Results should be pooled for research. |
| Task taking (analysis and evaluation of findings) – high control | ■ ISA tests should be taken under formal supervision, in silence, without cooperation between candidates.<br>■ 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.<br>■ Teachers should not help candidates answer the questions.<br>■ Each ISA has a fixed time limit unless the candidate is entitled to access arrangements.<br>■ Candidates' processed data and their ISA tests are collected by the teacher at the end of each test. |
| Task marking – medium control | ■ We provide 'marking guidelines' for each ISA test.<br>■ 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 consider the hypothesis they have been given and research possible methods for carrying out an experiment to test it. During this research, candidates need to do a risk assessment and also research the context of the investigation for use in Section 2 of the ISA. Candidates are allowed to make brief notes on one side of A4 which they can use during their answering of Sections 1 and 2 of the ISA paper.

**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 own experiment 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 the hypothesis.

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 within a one year period. There are two moderation windows – June and January. They may not be submitted in more than one year.

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: Science A1

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

- Biology 1 sections B1.1 to B1.3
- Chemistry 1 sections C1.1 to C1.4
- Physics 1 sections P1.1 to P1.3

See sections 3.3, 3.4 and 3.5 for required content.

## 3.8 Unit 6: Science A2

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

- Biology 1 sections B1.4 to B1.8
- Chemistry 1 sections C1.5 to C1.7
- Physics 1 sections P1.4 to P1.5

See sections 3.3, 3.4 and 3.5 for required content.

## 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 =, <, >, ~.

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

An equation sheet will be provided 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

A data sheet will be provided 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 science should encourage learners to be inspired, motivated and challenged by following a broad, coherent, practical, satisfying and worthwhile course of study. They should provide insight into and experience of how science works, stimulating learners' curiosity and encouraging them to engage with science in their everyday lives and to make informed choices about further study and about career choices.

GCSE specifications in science must enable learners to:

- develop their knowledge and understanding of the material, physical and living worlds
- develop their understanding of the nature of science and its applications and the inter-relationships between science and society
- develop an understanding of the importance of scale in science
- 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, 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
- 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 Science A

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

**Route 1 (4405)**

| Assessment Objectives | Unit Weightings (%) | | | | Overall weighting of AOs (%) |
|---|---|---|---|---|---|
| | UNIT | | | | |
| | 1 | 2 | 3 | 4 | |
| **AO1** | 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 (4406)**

| Assessment Objectives | Unit Weightings (%) | | | 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 and 4 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 above.

## 4.3 National criteria

This specification complies with:

- the Subject Criteria for GCSE 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 provides further details.

# Administration

## 5.1 Availability of assessment units and certification

Examinations and certification for this specification are available as follows.

Two routes to GCSE Science A are available:

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

| Route 1 (4405) | Availability of units | | | | Availability of certification |
|---|---|---|---|---|---|
| | UNIT | | | | |
| | 1 Biology 1 | 2 Chemistry 1 | 3 Physics 1 | 4 | GCSE |
| January 2012 | ✓ | ✓ | ✓ | | |
| June 2012 | ✓ | ✓ | ✓ | ✓ | ✓ |
| January 2013 and after | ✓ | ✓ | ✓ | ✓ | ✓ |
| June 2013 and after | ✓ | ✓ | ✓ | ✓ | ✓ |

| Route 2 (4406) | Availability of units | | | Availability of certification |
|---|---|---|---|---|
| | UNIT | | | |
| | 5 | 6 | 4 | GCSE |
| January 2012 | ✓ | ✓ | | |
| June 2012 | ✓ | ✓ | ✓ | ✓ |
| January 2013 and after | ✓ | ✓ | ✓ | ✓ |
| June 2013 and after | ✓ | ✓ | ✓ | ✓ |

## 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 – BL1FP or BL1HP

Unit 2 – CH1FP or CH1HP

Unit 3 – PH1FP or PH1HP

Unit 4 – SCA4P

Unit 5 – SCA1FP or SCA1HP

Unit 6 – SCA2FP or SCA2HP

GCSE certification – 4405 (Route 1) 4406 (Route 2)

The 40% terminal rule for GCSE means that 40% of the assessment must be taken in the examination series in which the qualification is awarded. Therefore, in this specification:

- candidates following Route 1 must take a minimum of two units in the series in which the qualification is awarded
- candidates following Route 2 must take a minimum of either Unit 6 or Units 5 and 4 in the series in which the qualification is awarded.

The results from 40% terminal assessment must contribute to the candidate's final grade, even if a candidate has a better result from a previous series.

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

- GCSE Science A (Route 1) and GCSE Biology
- GCSE Science A (Route 1) and GCSE Chemistry
- GCSE Science A (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 Science A.

## 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.

**Unit 1: Biology 1**
(maximum uniform mark = 100)

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

**Unit 2: Chemistry 1**
(maximum uniform mark = 100)

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

**Unit 3: Physics 1**
(maximum uniform mark = 100)

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

**Unit 4: Controlled Assessment**
(maximum uniform mark = 100)

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

**Unit 5: Science A 1**
(maximum uniform mark = 140)

| Grade | Uniform Mark Range |
|---|---|
| A* | 126–140 |
| A | 112–125 |
| B | 98–111 |
| C | 84–97 |
| D | 70–83 |
| E | 56–69 |
| F | 42–55 |
| G | 28–41 |
| U | 0–27 |

**Unit 6: Science A 2**
(maximum uniform mark = 160)

| Grade | Uniform Mark Range |
|---|---|
| A* | 144–160 |
| A | 128–143 |
| B | 112–127 |
| C | 96–111 |
| D | 80–95 |
| E | 64–79 |
| F | 48–63 |
| G | 32–47 |
| 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 Science A**
(maximum uniform mark = 400)

| Grade | Uniform Mark Range |
|---|---|
| A* | 360–400 |
| A | 320–359 |
| B | 280–319 |
| C | 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 the relationship between raw marks and UMS score is decided for each tier separately. Where a grade is available on two tiers, for example grade C, the two raw marks chosen as the boundary for the grade on the two tiers are given the same UMS score. Therefore, candidates receive the same UMS score for the same achievement whether this is demonstrated on the Foundation or the Higher Tier assessments.

## 5.9 Re-sits and shelf life of unit results

Unit results remain available to count towards certification within the shelf life of the specification, whether or not they have already been used.

Candidates may re-sit a unit once only.

The better result for each unit will count towards the final qualification **provided that the 40% rule is satisfied**.

Candidates may re-sit the qualification an unlimited number of times.

Candidates will be graded on the basis of the work submitted for assessment.

Candidates must take units comprising at least 40% of the total assessment in the series in which they enter for certification.

Candidates' grades are based on the work they submit for assessment.

# 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**

## 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, the marking guidelines 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 marking guidelines.

Annotation includes:

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

## 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 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. They demonstrate a comprehensive understanding of the nature of science, its laws, its applications, and the influences of society on science and science on society. They understand the relationships between scientific advances, their ethical implications and the benefits and risks associated with them. They use scientific and technical knowledge, terminology and conventions appropriately and consistently showing a detailed understanding of scale in terms of time, size and space.

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

Candidates analyse, interpret and critically evaluate a broad range of quantitative and qualitative data and information. They evaluate information systematically to develop arguments and explanations, taking account of the limitations of the available evidence. They make reasoned judgements consistently and draw detailed, evidence-based 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 influence of society on science and science on society. They understand that scientific advances may have ethical implications, benefits and risks. They use scientific and technical knowledge, terminology and conventions appropriately, showing understanding of scale in terms of time, size and space.

They apply appropriate skills, including communication, mathematical 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. They use a range of appropriate methods, sources of information and data, applying their skills to address scientific questions, solve problems and test hypotheses.

Candidates analyse, interpret and evaluate a range of quantitative and qualitative data and information. They understand the limitations of evidence and 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 show 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 limited quantitative and qualitative data and information from a narrow 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

The Unit 1 content of each of GCSE Biology, Chemistry and Physics is contained within GCSE Science A.

GCSE Science A covers similar content to GCSE Science B and both cover the programme of study.

# D The replacement of Key and Basic Skills with Functional Skills

## Introduction

The Key Skills Qualification requires candidates to demonstrate levels of achievement in the Key Skills of Communication, Application of Number and Information and Communication Technology.

The Wider Key Skills of Improving own Learning and Performance, Working with Others and Problem Solving are also available. The acquisition and demonstration of ability in these 'wider' Key Skills is deemed highly desirable for all candidates.

The units for each key skill comprise three sections:

- What you need to know
- What you must do
- Guidance.

Candidates following a course of study based on this specification for Science A can be offered opportunities to develop and generate evidence of attainment in aspects of the Key Skills of:

- Communication
- Application of Number
- Information and Communication Technology
- Working with Others
- Improving own Learning and Performance
- Problem Solving.

Areas of study and learning that can be used to encourage the acquisition and use of Key Skills, and to provide opportunities to generate evidence, are provided in the Teachers' Resource Bank for this specification.

The above information is given in the context of the knowledge that Key Skills at levels 1 and 2 will be replaced by Functional Skills.

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

The Key and Basic Skills qualifications will gradually be replaced by Functional Skills (**aqa.org.uk/functionalskills**) which will be available in centres from September 2010. All Examination Officers in centres offering AQA Key Skills, Wider Key Skills and Basic 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 or Basic Skills coordinator. This is a brief outline of that information. It is correct as of October 2010.

### 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 will be June 2011 with last certification in 2012. Centres are asked to ensure that their funding is still available after accreditation ends on 31 August 2010. An exception is that Key Skills in Apprenticeship Frameworks will be extended until March 2011. This will allow providers and employers the choice of offering either Functional Skills or Key Skills until 31 March 2011. For further information see **http://nationalemployerservice.org.uk/news/story/extension-of-key-skills-for-apprenticeships**

### 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 the June 2012 series.

### Wider Key Skills

The AQA Wider Key Skills qualifications in their present form will continue to be available until June 2011. However, funding may be limited after June 2010.

# GCSE Science A
# Specification

## For exams January 2012 onwards

For certification June 2012 onwards

**Qualification Accreditation Number: 600/0892/1**

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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