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Specification September 2007

GCSE

Edexcel GCSE in Science (2101)

First examination November 2007, first certification November 2007

Edexcel GCSE in Additional Science (2103)

First examination November 2007, first certification June 2008

Edexcel GCSE in Biology (2105)

Edexcel GCSE in Chemistry (2107)

Edexcel GCSE in Physics (2109)

First examination November 2007, first certification June 2008

Issue 2

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We deliver 9.4 million exam scripts each year, with over 3.8 million marked onscreen in 2006. As part of Pearson, Edexcel has been able to invest in cutting-edge technology that has revolutionised the examinations system, this includes the ability to provide detailed performance data to teachers.

This specification is Issue 2. Key changes are sidelined. We will inform centres of any changes to this issue. The latest issue can be found on the Edexcel website: www.edexcel.org.uk

Acknowledgements

This specification has been produced by Edexcel on the basis of consultation with teachers, examiners, consultants and other interested parties. Edexcel recognises and values all those who contributed their time and expertise to the development of GCSE specifications.

References to third party material made in this specification are made in good faith. Edexcel does not endorse, approve or accept responsibility for the content of materials, which may be subject to change, or any opinions expressed therein. (Material may include textbooks, journals, magazines and other publications and websites.)

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Contents

Introduction to 360Science

The student-centred curriculum

360Science is the new portfolio of qualifications from Edexcel. It encompasses the following qualifications:

- GCSE Science
- GCSE Additional Science
- GCSE Biology
- GCSE Chemistry
- GCSE Physics
- Entry Level Certificate in Science

and the following specialist work-related qualifications:

- Level 1 BTEC Introductory Certificate in Applied Science
- Level 1 BTEC Introductory Diploma in Applied Science
- Level 2 BTEC First Certificate in Applied Science
- Level 2 BTEC First Diploma in Applied Science.

Most importantly, it refers to the range of opportunities in science that is accessible to all students. 360Science is designed to meet the diverse aims and ambitions of students — from those who simply want to understand the world around them, to those who want to progress onto further, in-depth study.

For teachers, it means a flexible curriculum that allows you to select the most appropriate teaching approach for the situation. 360Science provides clear guidance on planning and delivering effective teaching, and values the importance of teachers' professional judgement.

360Science:

- offers exciting and engaging content
- is accessible to students of all abilities
- is designed to meet students' needs
- is designed to meet teachers' needs
- enables flexible teaching
- provides full and ongoing support
- offers truly vocational qualifications through BTEC.

The redevelopment has been driven by:

- the '14–19: Opportunity and Excellence' policy document published by the DfES (www.dfes.gov.uk)
- the announcement of changes to the National Curriculum at Key Stage 4
- a new Programme of Study for Key Stage 4 Science
- new Criteria for GCSE Science (www.qca.org.uk)
- the redevelopment of Key Stage 3 and the need for smooth progression between Key Stages
- the requirement to continue to provide work-related learning for all students
- the success of context orientated science qualifications, in terms of student motivation and achievement.

The new Criteria for GCSE Science incorporate the Key Stage 4 Programme of Study and place far greater emphasis on the skills, knowledge and understanding of how science works and much less emphasis on knowing scientific facts.

This suite of qualifications has a new, innovative approach that provides an applied, contextualised route as well as a concept-driven approach. This makes for a very flexible model to suit the needs and constraints of individual students.

GCSE Science

This is a new qualification based on the Key Stage 4 Programme of Study for Science. The content is relevant to students in their everyday life. The specification content allows teachers the opportunity to explore work-related learning in science where appropriate.

GCSE Additional Science

This is a new qualification equivalent to one GCSE and builds on the work covered in GCSE Science. Successful completion of GCSE Additional Science along with GCSE Science will allow progression to GCE, BTEC Nationals and other post-16 science and science-related programmes.

GCSE Biology, GCSE Chemistry and GCSE Physics

These are single GCSEs which when taken together cover the Programme of Study for Science. They include the relevant subject matter from GCSE Science and GCSE Additional Science, along with specialist extension units.

Entry Level Certificate in Science

The Entry Level Certificate in Science allows students to achieve at National Curriculum Levels 1, 2 and 3. It covers the Key Stage 4 Programme of Study and aims at developing skills rather than depth of knowledge. It is designed to be co-teachable with GCSE Science and students may be entered for both the Entry Level Certificate in Science and the GCSE Science; or students can progress to GCSE Science having taken the Entry Level Certificate in Science.

The Entry Level Certificate in Science:

- recognises small steps of achievement
- is 100% internally assessed, based on test and classroom activities.

The Entry Level Certificate in Science June 2006 specification (publication code: W018353) is available on the Edexcel website.

BTEC First Certificate and Diploma in Applied Science

The BTEC First Certificate in Applied Science is equivalent to two GCSEs at A* to C, the BTEC First Diploma is equivalent to four GCSEs at A* to C both incorporate the new Key Stage 4 Programme of Study. The qualification offers an approach based on the student taking on the identity of an employee within the science industry. Teaching strategies reflect the nature of the work within science based industries using a series of assignments and activities, encouraging students to take responsibility and ownership for their own learning. The qualification is 100% internally-assessed. Students may progress on to BTEC Nationals in Applied Science or related BTEC Nationals, GCEs or related NVQ qualifications, or enter employment.

The BTEC First Certificate in Applied Science specification (publication code: BF017226) is available on the Edexcel website.

BTEC Introductory Certificate and Diploma in Applied Science

This is a new qualification equivalent to two GCSEs D to G and incorporate the new Key Stage 4 Programme of Study. The qualification offers an approach based on the student taking on the identity of an employee within the science industry. Teaching strategies reflect the nature of the work within science based industries using a series of assignments and activities, encouraging students to take responsibility and ownership for their own learning. The qualification is 100% internally-assessed. Students may progress on to BTEC First Certificate and Diploma in Applied Science or related NVQ qualifications, or enter employment.

The BTEC Introductory Certificate and Diploma in Applied Science specification (publication code: BD018368) is available on the Edexcel website.

GCSE Science, GCSE Additional Science, GCSE Biology, GCSE Chemistry and GCSE Physics

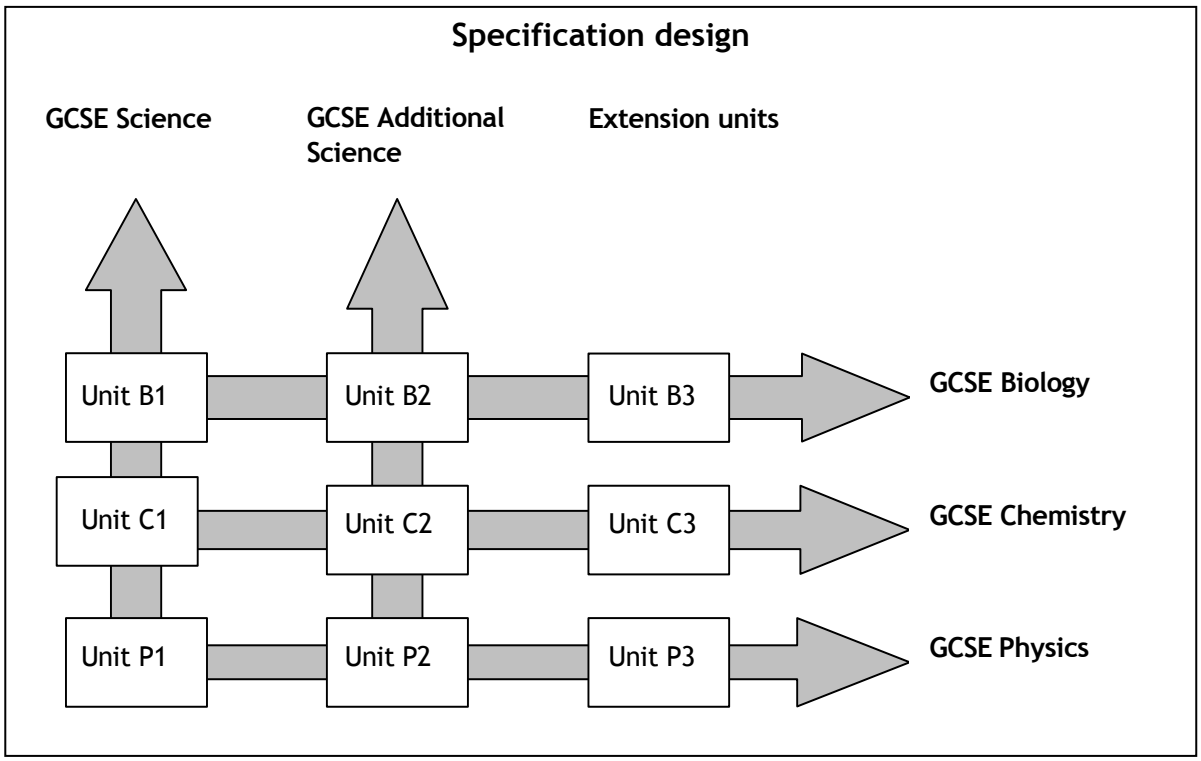
Aims

- To develop students' understanding of the science around them that affects them in their everyday life.
- To develop students' questioning, analytical and evaluative approach to scientific problems and issues.
- To develop students' practical skills in science and an understanding of how science works.
- To encourage enthusiasm about science leading to continued study.

Key features

- Centres can choose a content-orientated or context-orientated approach.
- A framework of co-teachable qualifications, designed to meet student needs.
- Encourages an understanding of scientific concepts rather than recall of detailed facts.
- Choice of weighting of internal and external assessment.
- Flexible approach to tiering.
- Encourages science teaching through practical learning activities.
- Practical skills are assessed by the teacher and non-moderated.
- Internal assessment prepared by Edexcel, designed to support formative assessment/Assessment for Learning.
- All assessment components worth 10% of GCSE or multiples thereof.
- Gives teachers an opportunity to discuss real science issues, including the science behind stories in the media, with their students.
- Teaching schemes indicate opportunities for ICT and key skills development.
- Endorsed textbooks and online resources.
- Professional development and training which covers all aspects of the course.

Rationale



The Criteria for GCSE Science (March 2005) identify three approaches to teaching science at this level:

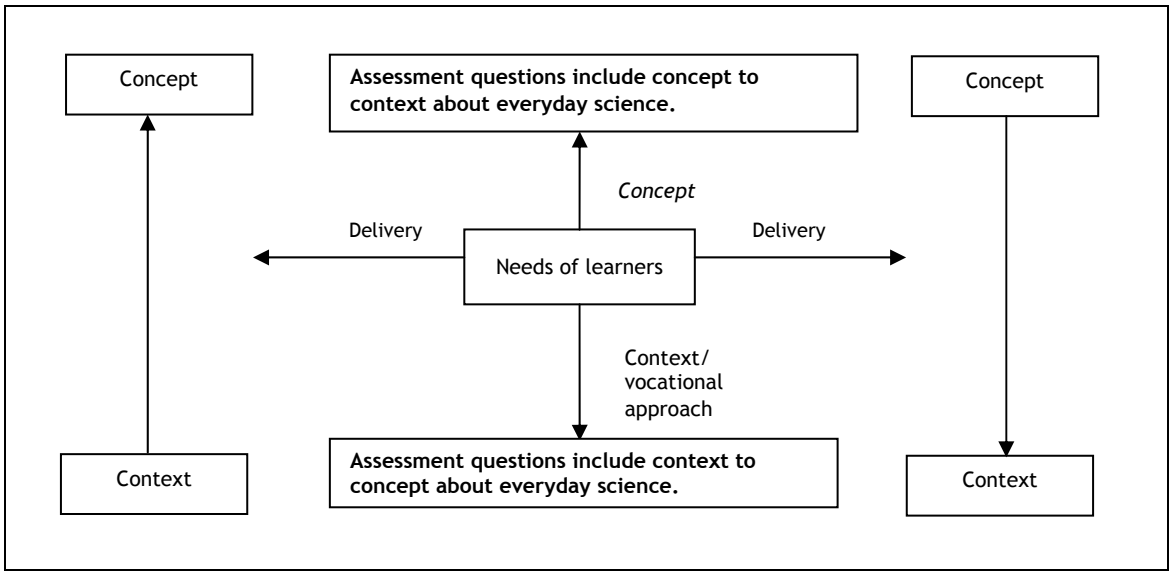
- evaluating evidence and the implications of science for society
- explaining, theorising and modelling in science
- procedural and technical knowledge of science.

This suite of specifications has been designed to address equally all of these approaches, to give a full, balanced approach to science at GCSE level.

Teachers will be able to select an approach for delivery and assessment that meets their students' needs. This suite of qualifications gives students the opportunity to explore how science works in a range of interesting and relevant subject areas.

To support the flexible delivery of these specifications in a school, it offers subject-specific units with two examination series a year available for external assessment. Internal assessment is integral to delivery and approach, and should arise from the day-to-day teaching of the qualification.

These specifications, along with sample assessment material and tutor support materials, will help teachers to implement the flexibility that this suite of qualifications provides.



A context-orientated or content-orientated approach is possible.

Students can, within Key Stage 4, prepare for certification in GCSE Science, GCSE Additional Science, GCSE Biology, GCSE Chemistry and GCSE Physics. Post-16 students may wish to follow a single separate science qualification only.

How science works

'How science works' (HSW) is a new requirement in the Criteria for GCSE Science. The specification identifies opportunities to make 'how science works' accessible to all students.

'How science works' is primarily about helping students to engage with and challenge the science they meet in everyday life. Students need to adopt a critical, questioning frame of mind, going 'behind the scenes' to understand the workings of science and how it impacts on society and their lives. It will help students to:

- identify questions that science can, and cannot, address and how scientists look for the answers
- evaluate scientific claims by judging the reliability and validity of the evidence appropriately
- question the scientific reports they see in the media and communicate their own findings
- consider scientific findings in a wider context — recognising their tentative nature
- make informed judgements about science and technology, including any ethical issues that may arise.

The specification highlights a range of contemporary and historical science contexts through which to explore how science works. Students need, also, to build on their own experience — planning, carrying out and reflecting on their own scientific investigations.

The wider curriculum

There are opportunities for generating evidence to support the key skills in application of number, information and communication technology, working with others, improving own learning and performance and problem solving; these are mapped to the GCSE Science suite of qualifications in *Annexe 2*.

Students are encouraged to develop and apply their ICT skills throughout these qualifications and there are many clearly-indicated areas in which students can do this. It builds on and further develops the students' experience of ICT at Key Stage 3 (Key Stage 3 National Strategy: ICT across the curriculum).

Quality of written communication (QWC) is assessed in the internal assessments, where students have the opportunity to express themselves freely when writing about the applications and implications of science.

The specifications also offer opportunities to address other areas of the wider curriculum including development of mathematical skills, education for citizenship, environmental education, health and safety education and the European and global dimension.

Qualification structure: unit titles

	Unit number		Topic title
GCSE Science	B1	a	1 Environment 2 Genes
		b	3 Electrical and Chemical Signals 4 Use, Misuse and Abuse
	C1	a	5 Patterns in Properties 6 Making Changes
		b	7 There's One Earth 8 Designer Products
	P1	a	9 Producing and Measuring Electricity 10 You're in Charge
		b	11 Now You See it, Now You Don't 12 Space and its Mysteries
GCSE Additional Science	B2		1 Inside Living Cells 2 Divide and Develop 3 Energy Flow 4 Interdependence
	C2		5 Synthesis 6 In Your Element 7 Chemical Structures 8 How Fast? How Furious?
	P2		9 As Fast as You Can! 10 Roller Coasters and Relativity 11 Putting Radiation to Use 12 Power of the Atom
Extension units	B3		1 Biotechnology 2 Behaviour in Humans and Other Animals
	C3		3 Chemical Detection 4 Chemistry Working for Us
	P3		5 Particles in Action 6 Medical Physics

See *Annexe 9* page 197 for unit entry codes.

	Unit number		Topic title
GCSE Biology	B1	a	1 Environment 2 Genes
		b	3 Electrical and Chemical Signals 4 Use, Misuse and Abuse
	B2		1 Inside Living Cells 2 Divide and Develop 3 Energy Flow 4 Interdependence
	B3		1 Biotechnology 2 Behaviour in Humans and Other Animals
GCSE Chemistry	C1	a	5 Patterns in Properties 6 Making Changes
		b	7 There's One Earth 8 Designer Products
	C2		5 Synthesis 6 In Your Element 7 Chemical Structures 8 How Fast? How Furious?
	C3		3 Chemical Detection 4 Chemistry Working for Us
GCSE Physics	P1	a	9 Producing and Measuring Electricity 10 You're in Charge
		b	11 Now You See it, Now You Don't 12 Space and its Mysteries
	P2		9 As Fast as You Can! 10 Roller Coasters and Relativity 11 Putting Radiation to Use 12 Power of the Atom
	P3		5 Particles in Action 6 Medical Physics

See *Annexe 9* page 197 for unit entry codes.

Summary of scheme of assessment

GCSE Science

Internal assessment (40%)

- Assessment of practical skills (10%), where the teacher is assessing the student's ability to follow instructions, collect data (by taking readings and measurements, making observations and by using ICT) and to present their raw results. Non-moderated.
- Assessment activities (3 x 10%), devised by Edexcel, marked by the teacher and externally moderated by an examiner appointed by Edexcel.

External assessment (60%)

- 60% based on six tiered multiple-choice tests available in November, March and June.

Further details can be found in the *Scheme of assessment* section on page 151.

GCSE Additional Science

Internal assessment (40%)

- Assessment of practical skills (10%), where the teacher is assessing the student's ability to follow instructions, collect data (by taking readings and measurements, making observations and by using ICT) and to present their raw results. Non-moderated.
- Assessment activities (3 x 10%), devised by Edexcel, marked by the teacher and externally moderated by an examiner appointed by Edexcel.

A choice of further assessment routes available (60%)

Students must attempt two out of the three routes for each of biology, chemistry and physics; each assessment contributes 10%.

- internally-assessed centre-devised
- externally-assessed multiple-choice tiered tests available in November, March and June
- externally-assessed structured tiered examination papers available in November, March and June.

Possible assessment routes	% Internal assessment	% External assessment
Route giving maximum external assessment: Compulsory internally-assessed unit plus two externally-assessed units	**40**	**60**
Route giving maximum internal assessment: Compulsory internally-assessed unit plus externally-assessed unit plus centre-devised internally-assessed unit	**70**	**30**

Further details can be found in the *Scheme of assessment* section on page 153.

GCSE Biology, GCSE Chemistry and GCSE Physics

The appropriate subject-based units from GCSE Science and GCSE Additional Science contribute to GCSE Biology, GCSE Chemistry and GCSE Physics.

Assessment of extension units

Either

- Structured single-tiered examination paper available in June only.

or

- Centre-devised internal assessment. The centre-devised internal assessment will be set by the centre and assessed using criteria provided by Edexcel.

Route	GCSE Science units	GCSE Additional Science units assessment	Extension units assessment	Internal weighting	External weighting
1	Appropriate subject units	Compulsory internally-assessed unit **plus two externally-assessed** units.	**Internal** assessment for extension units.	**60%**	**40%**
2	Appropriate subject units	Compulsory internally-assessed unit **plus two externally-assessed** units.	**External** assessment for extension units.	**30%**	**70%**
3	Appropriate subject units	Compulsory internally-assessed unit **plus centre-devised internally-assessed** unit **plus externally-assessed** unit.	**Internal** assessment for extension units.	**70%**	**30%**
4	Appropriate subject units	Compulsory internally-assessed unit **plus centre-devised internally-assessed** unit **plus externally-assessed** unit.	**External** assessment for extension units.	**40%**	**60%**

NB: There is no need for a student/centre to follow the same model for each of the separate sciences. For example, a student could be assessed externally for the GCSE Biology extension units and internally for GCSE Chemistry extension units and GCSE Physics extension units.

Further details can be found in the *Scheme of assessment* section from page 150 onwards.

See *Annexe 9* page 197 for unit entry codes.

Availability of external assessment

GCSE Science will be first awarded in November 2007. From June 2008 all titles within the specification suite will be available:

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

Edexcel has trialled on-screen assessment for multiple-choice tests in GCSE Science. The option of on-screen examinations will be introduced at the earliest opportunity.

Availability of internal and external assessment for GCSE Science

Unit		November 2006	March 2007	June 2007	November 2007	March 2008	June 2008
GCSE Science internal assessment, including non-moderated practical skills		×	×	✓	×	×	✓
B1	A	✓	✓	✓	✓	✓	✓
	B	✓	✓	✓	✓	✓	✓
C1	A	✓	✓	✓	✓	✓	✓
	B	✓	✓	✓	✓	✓	✓
P1	A	✓	✓	✓	✓	✓	✓
	B	✓	✓	✓	✓	✓	✓

From November 2008 onwards, availability will be the same as for 2007–08.

The internal assessment will be submitted only in the June series of examinations, ie in early-May.

The subject award may be claimed in November or June, provided all of the contributing units have been entered and assessed.

Availability of internal and external assessment for GCSE Additional Science

Unit	Assessment mode	Nov 2006	March 2007	June 2007	Nov 2007	March 2008	June 2008
GCSE Additional Science internal assessment, including non-moderated practical skills and centre-devised internal assessment	Internal	×	×	×	×	×	✓
B2	External	×	×	×	✓	✓	✓
C2	External	×	×	×	✓	✓	✓
P2	External	×	×	×	✓	✓	✓

From November 2008 onwards, availability will be the same as for 2007-08.

External assessment refers to the availability of both the multiple-choice question paper and the structured question paper.

The internal assessment will be submitted only in the June series of examinations, ie in early-May.

The subject award may be claimed in November or June, provided all of the contributing units have been entered and assessed.

Availability of internal and external assessment for GCSE extension units

Unit	Assessment mode	Nov 2007	March 2008	June 2008
GCSE Biology				
B3	Internal	×	×	✓
	External	×	×	✓
GCSE Chemistry				
C3	Internal	×	×	✓
	External	×	×	✓
GCSE Physics				
P3	Internal	×	×	✓
	External	×	×	✓

From November 2008 onwards, availability will be the same as for 2007-08.

The internal assessment will be submitted only in the June series of examinations, ie in early-May.

The subject award may be claimed in November or June, provided all of the contributing units have been entered and assessed.

Qualification codes

Each qualification title is allocated a QCA National Qualifications Framework (NQF) code.

QCA NQF codes

The QCA National Qualifications Framework (NQF) code is known as a Qualification Accreditation Number (QAN). This is the code that features in the DfES Funding Schedule, Sections 96 and 97, and is to be used for all qualification funding purposes. The QCA QAN is the number that will appear on the candidate's final certification documentation.

The QANs for the qualifications in this publication are:

- GCSE Science — 100/5544/7
- GCSE Additional Science — 100/5545/9
- GCSE Biology — 100/5546/0
- GCSE Chemistry — 100/5547/2
- GCSE Physics — 100/5548/4.

National classification codes

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

Centres should be aware that students who enter for more than one GCSE qualification with the same classification code, will have only one grade (the highest) counted for the purpose of the school and college performance tables.

The classification codes for these specifications are:

- GCSE Science — 1310
- GCSE Additional Science — 1320
- GCSE Biology — 1010
- GCSE Chemistry — 1110
- GCSE Physics — 1210.

Prior learning and progression

GCSE Science, GCSE Additional Science, GCSE Biology, GCSE Chemistry and GCSE Physics provide clear progression from the National Curriculum Key Stage 3 Programme of Study. The qualifications also offer progression from the Entry Level Certificate in Science.

Students embarking on GCSEs in Science, Additional Science, Biology, Chemistry and/or Physics should have achieved a general educational level equivalent to Level 3 of the National Curriculum or Entry Level 3 in the National Qualifications Framework.

Students achieving GCSE Science and GCSE Additional Science or GCSE Biology, GCSE Chemistry and GCSE Physics, can progress on to further education, training or employment. Appropriate further education includes:

- GCE AS and Advanced Biology
- GCE AS and Advanced Chemistry
- GCE AS and Advanced Physics
- GCE AS and Advanced Psychology
- GCE AS and Advanced Health and Social Care
- BTEC Firsts and Nationals in related subjects.

Links with other subjects

The content of this specification complements other Level 2 qualifications such as:

- GCSE Astronomy
- GCSE Citizenship Studies (Short Course)
- GCSE Engineering
- GCSE Geography
- GCSE Health and Social Care
- GCSE History
- GCSE Mathematics
- GCSE Physical Education.

National Qualifications Framework criteria

These specifications are based on the GCSE Common Criteria and the GCSE Criteria for Science, which are prescribed by the regulatory authorities, including QCA, and which are mandatory for all awarding bodies.

Specification content

Each unit begins with a rationale that describes the unit content and addresses how science works (this rationale is aimed at the teacher). The rest of the unit is set out under the following headings.

Guidance for students

This section informs students of the content of the topic on which they are about to embark. The section can be photocopied and given to students as an introduction.

Have you ever wondered?

These are questions to engage students with the topic content; they might be questions that the student has pondered or, having been asked, they are interested in finding out the answer.

These questions are intended to be used to introduce the topic; they are **not** examples of assessment questions. Answers to these questions will be provided in the tutor support material.

Learning objectives

What the student will know/understand at the end of the topic. Students will be able to expand on these statements, explaining the science behind them, using examples where appropriate.

Glossary

These are words used in the delivery of the topic and with which students are expected to become familiar. Any or all of these words may be used in assessment activities (internal or external) and could be required in answering examination questions.

Student Course Companion

Edexcel has produced a Course Companion for students for GCSE Science and GCSE Additional Science for further details see the Edexcel website.

Information for teachers

Learning outcomes

Students will be assessed on their ability to:

In GCSE Science and GCSE Additional Science, these are a series of referenced statements that students are expected to know and understand. Learning outcomes may be used for internal and external assessment.

The learning outcomes in each unit show the subject, unit number, component, topic number and the learning outcome number in sequence. For example, GCSE Science unit number C1 — Making New Products, component 'b', Topic 7 — There's One Earth, learning outcome statement 7 — 'explain the importance of recycling waste products such as glass, metal and paper', is numbered C1 b 7.7 (see page 49).

Learning outcomes, words or statements in **bold** indicate that this content is designated for higher tier students only

A glossary of terms used in the specification and in written tests can be found in Annexe 8, on page 195.

GCSE Science

B1 a

Topic 1: Environment

Topic 2: Genes

B1 b

Topic 3: Electrical and Chemical Signals

Topic 4: Use, Misuse and Abuse

C1 a

Topic 5: Patterns in Properties

Topic 6: Making Changes

C1 b

Topic 7: There's One Earth

Topic 8: Designer Products

P1 a

Topic 9: Producing and Measuring Electricity

Topic 10: You're in Charge

P1 b

Topic 11: Now You See it, Now You Don't

Topic 12: Space and its Mysteries

Unit B1 a

Topic 1 — Environment

Environmental issues have become more important in people's lives and feature regularly in the media, even affecting local and national elections. This topic looks at human impact on the environment and how it can be measured. Ways in which plants and animals can be improved in order to feed the world are at the forefront of modern agriculture and students will consider the energetics of food production. As usual, new food production techniques raise new ethical, social and environmental questions.

Organisms are classified according to how closely they are related and students will learn to appreciate that 'rules' change as new evidence emerges. It is a competitive world, all organisms compete for resources and only those that are best adapted will survive in a changing environment.

There is an opportunity to study populations using computer models and also to use secondary data to explore how human activity affects populations and the environment. Students will also discuss the evidence for natural selection, examining how Darwin's ideas were received by his contemporaries and comparing this with how current scientific theory is received by today's scientific community.

Guidance for students

Have you ever wondered?

How can the Sun's energy support all life on Earth?

Why don't food chains go on forever?

Which grows more quickly — grass or cow?

How do different organisms make different changes to solve the same environmental problem?

Does the number of foxes control the number of rabbits or does the number of rabbits control the number of foxes?

Is evolution still taking place?

What would happen to the human race if we were all the same?

How does natural selection 'know' how to create a new species?

Why are so many people worried about GM technology?

Why did a cartoon of Charles Darwin drawn as an ape appear in a national newspaper when he proposed his theory of evolution?

Learning objectives

- Animals and plants depend on each other.
- All organisms are adapted to their environment.
- There is often competition between organisms for resources.
- Natural selection is a long process over many generations.

Glossary

You will be expected to be able to recall, explain, describe and use appropriately the following words and phrases:

adaptation	evolution	intra-species	prey
biomass	extinct	mutation	quantitatively
characteristic	food chain	natural selection	reproduction
classification	fossil	organic	selective breeding
competition	genetic engineering	organism	species
ecosystem	genetically modified	population	
environment	interdependence	predator	

Information for teachers

ICT is an integral part of the way science works, and students should be given opportunities to experience and explore its use. It is expected that ICT will be used where it enhances the learning and teaching of science and helps to make scientific concepts easier to understand.

Some of the learning outcomes have been written deliberately in order to promote discussion and expression of opinion. Where contentious, unresolved or other scientific issues are discussed, it is expected that students will be exposed to the facts, evidence and opinions from all sides of the argument.

Learning outcomes

Learning outcomes, words or statements in **bold** indicate that this content is designated for higher tier students only.

Students will be assessed on their ability to:

- interpret food chains quantitatively using pyramids of biomass and consider why this is more accurate than a pyramid of numbers — B1 a 1.1
- describe how organisms in an ecosystem compete with each other for resources — B1 a.1.2
- explain why it is more cost effective, in terms of energy, to produce a field of wheat rather than a field of beef cows — B1 a 1.3
- explain population data in terms of predator-prey interdependence and intra-species competition — B1 a 1.4
- **use secondary data to explain how human activity can affect the environment, especially changes in population size and in economic and industrial conditions** — B1 a 1.5
- demonstrate an understanding of how computer models can be used to study populations, and show an awareness of the advantages and disadvantages of these models compared with real data — B1 a 1.6
- demonstrate an understanding of the principles of natural selection, to include: — B1 a 1.7
  - how individuals within a species can have characteristics that promote more successful reproduction (survival of the fittest)
  - how, over generations, the effects of natural selection result in changes within species and the formation of new species from genetic variants or mutants that are better adapted to their environment
  - how species that are less well-adapted to a changing environment can become extinct
- explain how fossils provide evidence for evolution — B1 a 1.8
- explain, compare and contrast selective breeding and genetic engineering in terms of changing the characteristics of a species — B1 a 1.9

continued...

- **discuss why Charles Darwin experienced difficulty in getting his theory of evolution through natural selection accepted by the scientific community in the 19th century** B1 a 1.10
- explain the principles of classifying organisms and the difficulties encountered in attempting to do so, as illustrated by the five kingdoms, the use of phylum, class, order, family, genus, species and the main characteristics of the five vertebrate groups B1 a 1.11
- discuss the ethics and principles of organic farming and explain why organic products are more expensive than non-organic produce B1 a 1.12
- **demonstrate an understanding of how crop plants can be genetically modified and the reasons for doing so and the ethical concerns this raises.** B1 a 1.13

Topic 2 — Genes

We are living in an age of an explosion in the use and understanding of genetics. The Human Genome Project may now be followed by many new medical treatments.

The activities of any organism are determined by the genes they possess. Chemical reactions in the cell depend on the cell's proteins. The structure of these proteins is determined by the cell's DNA. Genes are passed from parent to child in predictable ways, but sometimes these mutate. Variation is produced by a combination of genes and environment. There is now even more genetic manipulation of living organisms for food production. Scientists are able to extract and modify genes in order to change the properties of crops and animals used as food. Scientists are also able to clone organisms and some scientists hope to produce cloned body parts for transplantation surgery.

Studying this topic gives students opportunities to interpret data produced through breeding experiments. Students can use various kinds of resources to consider the benefits, drawbacks and risks of scientific opportunities in gene therapy, cloning and genetic modification. Students can also investigate how scientific decisions are made and how the ethical concerns of society can be considered, for example in relation to cloning.

Guidance for students

Have you ever wondered?

Why can we not just breed a racehorse that will win every race?

Are clones really like they are in the movies?

Is it possible that Old English Sheepdogs and Yorkshire Terriers both came originally from wolves?

How can cows make drugs in their milk?

When will I be able to get medicines especially made for just me?

How can genetics be used to cure diseases?

Learning objectives

- Characteristics of organisms are dependent on their genes.
- Sexual reproduction leads to variation.
- Genetic modifications are used for a range of purposes.
- There are many ethical considerations associated with advances in genetic modification.

Glossary

You will be expected to be able to recall, explain, describe and use appropriately the following words and phrases:

allele	cystic fibrosis	gene therapy	nucleus
antibody	diploid	genetics	phenotype
asexual reproduction	DNA	generation	
cancer	dominant	genotype	recessive
carrier	environment	haploid	sexual reproduction
cell	fertilisation	heterozygous	transgenic
characteristic	forensic	homozygous	transplant
chromosome	gamete	Human Genome Project (HGP)	variation
clone	gene	inheritance	

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Learning outcomes

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Students will be assessed on their ability to:

• describe genes as parts of chromosomes which are found within the nucleus and which control the cell's activity	B1 a 2.1
• explain that the unit of inheritance is the gene which is a section of a long chain (DNA) molecule	B1 a 2.2
• appreciate the emerging outcomes of the Human Genome Project (HGP) and discuss some of their implications, including the use of DNA evidence in forensic science and medicine	B1 a 2.3
• **discuss how gene therapy could change the lives of two people, one suffering from cystic fibrosis and the other from breast cancer, if these diseases could be treated genetically**	B1 a 2.4
• describe how asexual reproduction leads to genetically identical individuals called clones, including *Chlorophytum* (spider plant)	B1 a 2.5
• explain how sexual reproduction, involving fertilisation, leads to variation in the new generation (including the use of a monohybrid cross diagram)	B1 a 2.6
• **explain how some inherited characteristics can be modified by environmental conditions, including the influence of diet on human growth and mineral resources on plant growth**	B1 a 2.7
• explain, how alternative forms (dominant and recessive alleles) of a gene cause variation in a characteristic	B1 a 2.8
• demonstrate an understanding of how some alleles can cause diseases which can be inherited, for example, sickle cell anaemia, Huntington's disease and haemophilia	B1 a 2.9
• **evaluate the potential for using transgenic animals, including the production of 'designer milk', for example milk containing human antibodies and low cholesterol milk**	B1 a 2.10
• describe the social and ethical concerns of cloning mammals, including the possibility of the cloning of human body parts for transplant surgery	B1 a 2.11
• **consider the contemporary scientific theory of 'designer babies' and explain why today's scientists are finding so much opposition to the use of this approach being publicly acceptable.**	B1 a 2.12

Unit B1 b

Topic 3 — Electrical and Chemical Signals

People have always wanted to know how the brain works. Speedy responses are possible through electrical impulses in nerve cells, and some are linked to muscles by reflex arcs. Hormones can co-ordinate body functions, including the female menstrual cycle. The contraceptive pill and fertility treatments are examples of the ways in which sex hormones can be used medically. Some hormones can be produced by genetic modification of bacteria for medical purposes, eg in insulin production.

In this topic there are opportunities to measure and interpret data on body reactions such as reaction times and reflex actions. The development of a scientific explanation of diabetes through experiments on animals can be demonstrated and its ethical implications discussed. The application of science in controlling fertility and helping infertile couples to conceive can be considered, and the benefits, risks and drawbacks discussed.

Guidance for students

Have you ever wondered?

How does my brain tell my body what to do?

How do my hormones 'know' where to go?

How do contraceptive pills work?

Why do people with diabetics inject themselves with products from bacteria?

When travelling in a car, why do I duck down when a bird flies low over me?

Learning objectives

- The body needs to be maintained in an optimum state.
- The central nervous system lets your body respond to changes in its surroundings.
- Hormones regulate the functions of cells and organs.
- Artificial hormones can be used to control reproduction and alter body functions.

Glossary

You will be expected to be able to recall, explain, describe and use appropriately the following words and phrases:

bacteria	hormone	pancreas	sensory neurone
brain	infertility	Parkinson's disease	stimulus
central nervous system (CNS)	insulin	peripheral nervous system (PNS)	stroke
contraception	in-vitro fertilisation (IVF)	pregnancy	target organ
diabetes	luteinising hormone (LH)	progesterone	tumour
electrical impulse	iris reflex	reaction time	voluntary
follicle stimulating hormone (FSH)	menstrual cycle	receptor	
genetically modified	motor neurone	reflex	
genetically modified organism (GMO)	muscle	reflex arc	
glucose	nerve	relay neurone	
grand mal epilepsy	oestrogen	sense organs	

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Learning outcomes

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Students will be assessed on their ability to:

- explore ways of measuring reaction times — B1 b 3.1
- demonstrate an understanding of the structure of the central and peripheral nervous systems, including the main regions of the brain and their functions (memory and thinking, hearing, touch, smell, taste, vision) — B1 b 3.2
- explain how nerves carry electrical impulses from sense organs to muscles — B1 b 3.3
- **describe how strokes, brain tumours, Parkinson's disease and grand mal epilepsy disrupt the functioning of the brain** — B1 b 3.4
- explain that receptors in sense organs detect internal and external changes, allowing the body to respond to these stimuli — B1 b 3.5
- describe the difference between voluntary and reflex responses and the advantages of reflex responses in helping to safeguard the body: — B1 b 3.6
  - the iris reflex
  - accommodation
  - 'ducking' reaction to objects travelling close to the head
- explain how the composition and function of the blood is related to its function — B1 b 3.7
- explain how hormones act as chemical messages affecting target organs and/or cells — B1 b 3.8
- **demonstrate understanding of the role and interpret data to explain that oestrogen causes the lining of the uterus to thicken during the early part of the menstrual cycle** — B1 b 3.9
- **demonstrate understanding of the role and interpret data to explain that progesterone maintains the lining of the uterus during the middle part of the menstrual cycle and during pregnancy** — B1 b 3.10

- explain how manufactured sex hormones can be used for contraception and to treat infertility in women, including the roles of follicle stimulating hormone (FSH) and luteinising hormone (LH) B1 b 3.11
- discuss the social and ethical implications of IVF treatment, including its use in mature clients B1 b 3.12
- explain how insulin produced by the pancreas regulates glucose concentrations in the blood B1 b 3.13
- explain how human insulin is produced from genetically modified bacteria and the advantages of this method compared to extracting insulin from mammals. B1 b 3.14

Topic 4 — Use, Misuse and Abuse

Young people in Britain are offered the opportunity of a 'BCG' vaccination to protect them from Tuberculosis (TB). The body can be attacked and disrupted by the actions of disease-causing organisms (pathogens), such as the bacteria that cause TB. The body has three lines of defence against pathogens — physical, non-specific mechanisms and the immune system. Natural defences can be assisted with drugs. Some drugs affect the pathogen, others change the reactions of the body. Some drugs may be misused to alter the state of mind or body.

This topic will look particularly at the use of pain-relieving drugs and the difficulties associated with them. There are opportunities to interpret data on the effectiveness of different drugs. Students can present information and develop arguments on the use of drugs in a range of contexts. They can also collect and interpret data from secondary sources and discuss the social, economic and ethical implications of drug misuse and abuse.

Guidance for students

Have you ever wondered?

Are there more 'good' microorganisms than disease-causing ones?

What is the difference between an infection and a disease?

Why is TB in the news again?

Why won't your doctor give you antibiotics for a cold?

Why it is so expensive to produce a new drug?

Why are the uses of some substances controlled by law?

Why are some drugs considered good for your body and others bad?

How do different drugs affect people differently?

Learning objectives

- The human body has three lines of defence against invading microorganisms.
- Immunisation and antibiotics are used against diseases caused by microorganisms.
- The use and misuse of substances can affect the normal functioning of the body systems, affecting mental and physical health.
- There are socio-economic reasons that contribute to ill health and ethical considerations for the development of treatments.

Glossary

You will be expected to be able to recall, explain, describe and use appropriately the following words and phrases:

addiction	circulatory system	microbe	sedative
alcohol	depressants	microorganism	solvent
antibody	disease	neurone	stimulant
antigen	drug	opiate	synapse
bacteria	foreign body	organism	tobacco
barbiturate	gaseous exchange	overdose	transmission
barrier	immune system	pain-relief	tuberculosis
caffeine	infection	paracetamol	vector-borne
cannabis	inflammation	pathogen	viral infection
cilia	lysozyme	reaction time	white blood cell

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Learning outcomes

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Students will be assessed on their ability to:

- describe the main physical and mental effects of: B1 b 4.1
  - solvents (on lungs and neurones)
  - alcohol (on reaction times, liver and brain)
  - tobacco (on gaseous exchange and circulatory systems)
- describe how the use of drugs may: B1 b 4.2
  - affect activities such as driving
  - produce abnormal behaviour
  - create the risk of viral infections
- explain the effects on nerve transmission (including synapses) on reaction times of: B1 b 4.3
  - stimulants, including caffeine
  - sedatives, including barbiturates
  - painkillers, including paracetamol
  - depressants, including alcohol and solvent
- discuss the use of opiates and cannabinoids in pain-relief for terminally-ill patients, and the dangers of addiction B1 b 4.4
- describe the uses of paracetamol and the dangers of overdose B1 b 4.5
- discuss why medical opinion on the use of cannabis for pain-relief has fluctuated over the years B1 b 4.6
- describe a pathogen as a disease-causing organism B1 b 4.7
- explore, using secondary data, the main physical and mental effects of the misuse of drugs and their impact on behaviour B1 b 4.8
- explain that microbes can be transmitted by direct contact (including vertical (mother to fetus) and horizontal), and indirect contact (vehicle and vector-borne) B1 b 4.9

continued...

- describe the physical barriers as the body's first line of defence against microorganisms, including the role of the skin, nasal hairs and cilia in the gaseous exchange tract and chemical barriers, namely lysozyme, found in tears — B1 b 4.10
- describe the second line of defence against infection as non-specific: — B1 b 4.11
  - white blood cells ingest bacteria
  - inflammatory response
- describe the third line of defence as the specific immune system — when the immune system recognises a foreign body (antigen) and prepares a specific reaction to it (antibody production by white blood cells) — B1 b 4.12
- explain what causes tuberculosis (TB) and how it is spread — B1 b 4.13
- **describe, using secondary data, the prevention and control (drug therapy) of TB including the emergence of drug-resistant TB, financing, supply of drugs and treatment regimes** — B1 b 4.14
- **interpret data on the number of cases of TB in the UK over a period of time** — B1 b 4.15
- explore, using secondary data, the costs of developing new drugs. — B1 b 4.16

Unit C1 a

Topic 5 — Patterns in Properties

In this topic there are opportunities for students to use scientific symbols and terminology to present information

In studying this topic students should appreciate that there are a large number of elements that combine to make a much larger number of compounds. There is a pattern to all the information about these elements and compounds, which allows chemists to make use of the information and data. Students should understand that the information becomes readily manageable by realising that patterns and trends exist in the periodic table and that they can, therefore, use primary and secondary data to make predictions about the properties of elements and compounds. Students' practical and enquiry skills can be developed by exploring the properties of materials and chemical reactions covered in this topic. This topic provides opportunities for the collection and interpretation of data about elements in groups 1, 7, 0 and the transition metals.

Guidance for students

Have you ever wondered?

How can forensic scientists identify traces of substance at a crime scene?

Is the periodic table really a map of what you're made of?

Why are 'chemical' formulae such as 'J_2O' and 'O_2' so good for advertising?

If potassium is like sodium, can you put potassium chloride on your chips?

Can chemists turn cheap metal into gold?

Which combination of chemicals makes the most violent explosion?

Why is chlorine so good at protecting you from other people's bugs in a swimming pool?

What chemicals do they use in laser light shows?

Learning objectives

- All chemical elements are made up of atoms which consist of nuclei and electrons.
- Different elements have different properties related to their position in the periodic table.
- Atoms join together to form molecules and compounds.
- The names of simple chemical compounds can be predicted from their formulae.

Glossary

You will be expected to be able to recall, explain, describe and use appropriately the following words and phrases:

alkali metal	elements	inert	positive
analytical	endothermic	molecules	precipitation
atomic number	exothermic	negative	proton
atoms	flame test	neutral	solution
compound	formula	neutron	symbol
diatomic molecule	group	noble gas	transition metal
electron	halogen	period	

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Learning outcomes

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Students will be expected to:

- recall the formulae of elements and simple compounds in the topic
- represent chemical reactions by word equations **and simple balanced equations and use state symbols (s), (l), (g) and (aq)**
- **write balanced equations to describe and explain a wide range of reactions.**

Students will be assessed on their ability to:

- recall and explain how to use flame tests to identify metals in compounds C1 a 5.1
- use given analytical data to identify substances covered in this topic area, eg crime scene analysis C1 a 5.2
- interpret data to describe the properties of chlorine, iodine, helium, neon, argon, iron, copper, silver and gold and explain their uses C1 a 5.3
- interpret data of the colours formed by transition metal compounds reacting with sodium hydroxide solution to identify iron, copper and zinc in these compounds C1 a 5.4
- use the periodic table to find the symbol of an element C1 a 5.5
- identify and recall the position of metals and non-metals in the periodic table C1 a 5.6
- locate the positions in the periodic table of: C1 a 5.7
  - alkali metals
  - halogens
  - noble gases
  - transition metals
- recall that elements with similar properties appear in the same vertical column (group) in the periodic table C1 a 5.8

continued...

• using secondary data, explore why elements are arranged in rows (periods) and columns (groups) in the periodic table	C1 a 5.9
• explain that atoms consist of protons (positively charged) and neutrons (no charge) in a nucleus surrounded by electrons (negatively charged)	C1 a 5.10
• demonstrate understanding that the periodic table is an example of how a scientific theory can predict the possible existence and properties of new elements	C1 a 5.11
• **use secondary data to explore how the periodic table was devised and how the idea of atomic number developed**	C1 a 5.12
• explain that all atoms of the same element have the same number of protons in their nuclei and demonstrate understanding that the atomic number of an element is unique to that element and is the number of protons in the nucleus of an atom of that element	C1 a 5.13
• recall the variations in reactivity of the alkali metals with increasing atomic number, as shown by their reactivity with water	C1 a 5.14
• recall that chemical reactions happen at different rates	C1 a 5.15
• recall that some chemical reactions give out heat (exothermic) and some take in heat (endothermic)	C1 a 5.16
• recall that, within a group in the periodic table, there is usually a gradual change in properties of the elements with increasing atomic number	C1 a 5.17
• recall the variation in colour, physical states at room temperature and boiling points of the halogens with increasing atomic number	C1 a 5.18
• describe the variation in reactivity of the halogens with increasing atomic number, as shown by displacement reactions when the halogens react with solutions of the other halides	C1 a 5.19
• describe the noble gases as chemically unreactive compared with other elements	C1 a 5.20
• explain that elements in the same group of the periodic table have similar chemical properties, as exemplified by the halogens	C1 a 5.21
• **explain the use of the endings –ide and –ate in the names of common chemical compounds.**	C1 a 5.22

Topic 6 — Making Changes

This topic provides opportunities to investigate the applications of chemical reactions to produce products used in everyday life. Students can develop their practical and enquiry skills when investigating different types of reactions

As well as learning how to carry out a variety of reactions, students should also learn how to handle, collect and purify substances. Students will learn to appreciate the need for accuracy when producing pure chemical compounds. Students will also learn to appreciate the hazards associated with some chemical compounds and some of the general principles of carrying out practical work safely, for example being able to recognise hazard labels for household chemicals.

Guidance for students

Have you ever wondered?

How do you make a firework?

Did people always have metals?

Could you tell the difference between ice cream made with artificial vanilla and natural vanilla?

Are artificial sweeteners good for you?

How can sweeteners taste like sugar but have no 'calories'?

How do the bubbles, that make cakes so light, actually get there?

Can you get cancer from eating too many food additives?

How do you collect and test gases?

Learning objectives

- Similar elements or compounds react in similar ways.
- Predictions can be made about the products of reactions, based on knowledge of similar situations.
- Addition of oxygen to a substance is oxidation and loss of oxygen from a substance is reduction.
- Extraction of metals depends on their reactivity.

Glossary

You will be expected to be able to recall, explain, describe and use appropriately the following words and phrases:

carbohydrate	dehydration	oxidation
caustic soda	dilute	precipitate
citric acid	hydration	salt
combustion	insoluble salt	soluble salt
decomposition	neutralisation	thermal decomposition

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Learning outcomes

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Students will be expected to:

- recall the formulae of elements and simple compounds in the topic
- represent chemical reactions by word equations **and simple balanced equations and use state symbols (s), (l), (g) and (aq)**
- **write balanced equations to describe and explain a wide range of reactions.**

Students will be assessed on their ability to:

- describe how neutralisation can be used to make salts, some of which may be used in fertilisers, and as colouring agents in fireworks — C1 a 6.1
- describe the reactions of dilute hydrochloric and sulphuric acids with metal oxides, carbonates and hydroxides — C1 a 6.2
- describe the preparation of pure, dry samples of insoluble salts from solutions of soluble salts — C1 a 6.3
- explain that most metals have to be extracted from their ores, which are found in the Earth's crust — C1 a 6.4
- explain that some metals occur as their oxides and can be extracted by using carbon, eg iron, copper and lead — C1 a 6.5
- explain that when a substance combines with oxygen oxidation occurs, eg the formation of magnesium oxide from magnesium and oxygen — C1 a 6.6
- explain that when oxygen is removed from a substance reduction occurs, eg the formation of copper from copper oxide — C1 a 6.7
- recall that the least reactive metals are found uncombined in the Earth's crust — C1 a 6.8
- relate the order of reactivity of metals to the stability of their ores and the method used for their extraction — C1 a 6.9
- discuss the differences between 'natural' and 'artificial' substances, including whether they can be distinguished or are chemically different, and any impacts on health — C1 a 6.10

continued...

- recall that baking powder contains sodium hydrogencarbonate and an acidic substance, and describe how during cooking these compounds react to produce carbon dioxide — C1 a 6.11
- recall that when carbonates and hydrogencarbonates are heated they release carbon dioxide gas and that this is called thermal decomposition — C1 a 6.12
- describe the processes of hydration and dehydration — C1 a 6.13
- recognise cooking processes as chemical changes leading to new products — C1 a 6.14
- **interpret data linking a chemical in food with a health impact, recognising that a correlation does not imply a cause** — C1 a 6.15
- know how to test for the gases: — C1 a 6.16
  - hydrogen
  - oxygen
  - carbon dioxide
  - ammonia
  - chlorine
- know how to collect gases produced in reactions by upward and downward delivery, over water and using a gas syringe and relate this to the solubility and density of the gas — C1 a 6.17
- describe the use of hazard labels in the chemistry laboratory — C1 a 6.18
- investigate and identify the uses of the following common compounds: — C1 a 6.19
  - ammonia
  - carbohydrates
  - carbon dioxide
  - caustic soda
  - citric acid
  - ethanoic (acetic) acid
  - hydrochloric acid
  - phosphoric acid
  - sodium chloride (common table salt)
  - water.

Unit C1 b

Topic 7 — There's One Earth

This topic provides an opportunity to show how chemists attempt to satisfy demand for useful substances whilst doing all they can to limit the use of natural resources, limit energy consumption and avoid pollution.

Students should consider how useful substances are obtained from the natural resources of the Earth. They should appreciate that these resources are finite and understand that, for the sake of future generations, there is a need to use the resources wisely, recycling whenever possible.

While studying how useful substances are obtained from natural resources, students should understand that, although physical processes are all that are needed in some cases, in the majority of cases chemical reactions are required. These reactions may result in the formation of waste products, which may create environmental problems. A vital contribution from chemists is dealing with these problems and preventing pollution.

As global demand for the use of fossil fuels increases, students need to appreciate the implications of this and the need to identify and use alternative fuels. It is essential that humans take ownership of the need for sustainable energy sources and that they are implemented in all aspects of life.

There are opportunities for students to investigate the properties of a useful fuel and therefore why some fuels are chosen for usage in specific applications.

Finally the topic provides an opportunity to widen students' knowledge of the relative advantages and disadvantages of different fuels by introducing the idea of bio-fuels.

Guidance for students

Have you ever wondered?

Why do some scientists need to do their work in exotic locations like Hawaii and Antarctica?

Will the UK freeze over one day, like in the film 'The Day After Tomorrow'?

Could we stop global warming by capturing the carbon dioxide we generate instead of letting it escape into the atmosphere?

Why do we recycle so little of our rubbish in this country?

What is the cleanest, greenest fuel for a car?

When oil starts running out, will petrol cost as much as gold?

Did you know that carbon monoxide can suffocate you to death before you realise it?

Is there really enough pollution in the air to kill people?

Learning objectives

- All substances are obtained or made from substances in the Earth's crust, sea or atmosphere.
- Many natural resources are mixtures of substances.
- Products obtained from crude oil are essential to modern life.
- Production and disposal of substances have environmental impacts.

Glossary

You will be expected to be able to recall, explain, describe and use appropriately the following words and phrases:

acid rain	desalination	hydrocarbon	sootiness
bio-fuel	fossil fuel	ignition	sustainability
combustion	fractional distillation	incomplete combustion	toxic
complete combustion	fractionating column	recycle	viscosity
crude oil	global warming	residue	

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Learning outcomes

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Students will be expected to:

- recall the formulae of elements and simple compounds in the topic
- represent chemical reactions by word equations **and simple balanced equations and use state symbols (s), (l), (g) and (aq)**
- **write balanced equations to describe and explain a wide range of reactions.**

Students will be assessed on their ability to:

• discuss how the idea of global warming went from a single scientist's idea to a widely accepted theory	C1 b 7.1
• recall that hydrocarbons contain carbon and hydrogen only and explain that the products of complete combustion of hydrocarbons are carbon dioxide and water and that energy is released in the reaction	C1 b 7.2
• explain how burning fossil fuels may lead to global warming	C1 b 7.3
• discuss how the composition of the Earth's atmosphere and its temperature have varied over time	C1 b 7.4
• recognise that predictions about the amount of warming of the Earth are based on computer models, which carry uncertainties	C1 b 7.5
• **suggest how to combat the effects of global warming, based on the precautionary principle (which means those proposing the action must demonstrate that the actions suggested are not harmful)**	C1 b 7.6
• explain the importance of recycling waste products such as glass, metal and paper	C1 b 7.7
• evaluate a range of economic and environmental considerations when recycling materials, such as glass and metal, or desalinating sea water in hot countries	C1 b 7.8
• explore how sustainable development involves balancing economic development, maintenance of standards of living, and respect for the environment	C1 b 7.9

continued...

- demonstrate an understanding of how the internet can be used to research up-to-date data and information about acid rain or global warming, how to check this data for authenticity and bias, and how to critically analyse and incorporate such data and information into the students' own work — C1 b 7.10
- describe the properties of a useful fuel, including: — C1 b 7.11
  - the sootiness and colour of the flame
  - the heat energy produced
  - the residue
- explain why bio-fuels are sometimes an attractive alternative to fossil fuels — C1 b 7.12
- discuss the benefits and drawbacks of car fuel being changed from petrol to hydrogen fuel — C1 b 7.13
- explain that ethanol obtained from sugar cane or sugar beet is a useful bio-fuel and can be used to reduce the demand for petrol, but it requires large areas of fertile land to produce sufficient quantity — C1 b 7.14
- describe the fractional distillation of crude oil and understand that crude oil is a mixture of substances, most of which are hydrocarbons — C1 b 7.15
- describe the uses of the main fractions of crude oil (gases, petrol, naphtha, kerosene, diesel oil, fuel oil, bitumen) — C1 b 7.16
- **explain where the main fractions of crude oil (gases, petrol, naphtha, kerosene, diesel oil, fuel oil, bitumen) are produced on a fractionating column and relate this to their boiling points, sizes of their molecules, viscosity, ease of ignition and uses** — C1 b 7.17
- explain that incomplete combustion can occur in faulty gas appliances and other heating appliances and that this can be dangerous — C1 b 7.18
- explain that incomplete combustion can produce carbon and carbon monoxide — C1 b 7.19
- recall that carbon monoxide is a toxic gas and explain that it lowers the ability of blood to carry oxygen — C1 b 7.20
- **interpret and evaluate given data relating respiratory diseases such as asthma to atmospheric pollutants** — C1 b 7.21
- describe how nitrogen and oxygen can be obtained by fractional distillation of liquid air — C1 b 7.22
- identify the following substances obtained from seawater and rock salt and recall their uses: — C1 b 7.23
  - sodium
  - chlorine
  - sodium chloride
  - hydrogen
  - sodium hydroxide.

Topic 8 — Designer Products

In studying this topic students should come to understand how chemists produce products with particular properties which enable them to be used for specific purposes.

Students should understand that the techniques used to manufacture some substances can affect the properties of the products and that new techniques are being developed in the fields of smart materials and nanotechnology.

Students should understand how ethanol is made and should appreciate that all alcoholic drinks contain ethanol and be aware of the possible consequences and social issues regarding excess consumption.

Guidance for students

Have you ever wondered?

How do those glasses that remember their shape work?

Will scientists one day create toasters that feel 'cuddly' if you touch them gently?

Why is Gore-Tex™ 'breathable'?

How can modern body armour, made of soft clothing, stop bullets?

How do they keep the oil and water in mayonnaise from separating?

Why do sunscreens now rub in better and no longer leave your skin white?

Are the new sunscreens that contain nanoparticles safe?

How do you make beer?

How does 'intelligent packaging' keep food fresh?

What would the properties of a perfect hair gel be?

Learning objectives

- Materials differ in their properties and so are suitable for different purposes.
- New materials are developed to meet specific requirements.
- Useful substances are made by chemical reactions.
- Chemical processes use energy and have environmental consequences.

Glossary

You will be expected to be able to recall, explain, describe and use appropriately the following words and phrases:

alcohol	fermentation	Lycra™	sugar
breathability	Gore-Tex™	nanocomposites	Teflon™
carbon fibre	hydrophilic	nanoparticle	Thinsulate™
emulsifier	hydrophobic	nanotechnology	
ethanol	Kevlar™	smart material	

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Learning outcomes

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Students will be expected to:

- recall the formulae of elements and simple compounds in the topic
- represent chemical reactions by word equations **and simple balanced equations and use state symbols (s), (l), (g) and (aq)**
- **write balanced equations to describe and explain a wide range of reactions.**

Students will be assessed on their ability to:

- use given information to relate properties to some of the uses of modern (carbon fibres, Thinsulate™, Lycra™, etc) and smart materials in clothing, extreme sports and sports equipment — C1 b 8.1
- explain that smart materials can change their properties in response to an external stimulus — C1 b 8.2
- demonstrate understanding that scientists sometimes create new materials with novel properties, such as Teflon™ and the adhesives on Post-it™ notes, when the applications only become apparent afterwards — C1 b 8.3
- explain the breathability of fabrics like Gore-Tex™ in terms of their structure — C1 b 8.4
- demonstrate understanding that the properties of materials dictate their uses, for example, Kevlar™ — C1 b 8.5
- compare the size of nanoparticles to that of conventional industrially produced materials, and relate this to their present uses, such as sunscreens and future applications — C1 b 8.6
- **explore the risks and uncertainties of nanotechnologies and how they are presented in the media** — C1 b 8.7
- describe how beer and wine can be made by fermentation reactions using yeast to convert sugars into ethanol — C1 b 8.8
- discuss the social issues and possible harmful effects of ethanol in alcoholic drinks — C1 b 8.9

continued...

- use information on intelligent packaging to explain ways of keeping food fresh, for example, by removal of water or preventing reactions with oxygen C1 b 8.10
- describe how emulsifiers, that have a hydrophilic ('water loving') part and a hydrophobic ('water hating') part, are effective in foods like mayonnaise C1 b 8.11
- **design a list of properties for a product, based on its end use.** C1 b 8.12

Unit P1 a

Topic 9 — Producing and Measuring Electricity

In a world without electricity, cars, computers and essential equipment used in hospitals could not exist; we would forgo the pleasures of televisions and personal stereos; we would lose the convenience of appliances such as mobile phones, microwaves and washing machines. Hence electricity is at the heart of the modern world. It provides a very convenient form of energy to power a wide variety of both portable and fixed equipment. Technological developments led to the production of devices that are used to maintain a constant temperature in industrial processes and devices that respond to changes in light intensity.

This topic is designed to extend the student's knowledge of electricity from Key Stage 3. It gives students the opportunity to explore different sources of electric current and to investigate the relationship between voltage and current in a resistor and a filament lamp. This will give students experience in building circuits and using a voltmeter and ammeter. Students will also have the opportunity to investigate devices that respond to changes in temperature and light intensity, possibly with the aid of data-logging equipment.

Guidance for students

Have you ever wondered?

Why is my phone wireless, but I have to plug my hairdryer into the wall?

How does my digital camera take great pictures automatically?

How can I make the batteries in my MP3 player last longer?

Why did people believe electricity could cure all your aches and pains?

Which invention changed the world the most?

How can a train possibly go at 500 kilometres per hour?

Is it true my clothes will soon become wearable computers?

Learning objectives

- There is a variety of ways we can produce electricity.
- Electrical quantities can be measured.
- The voltage, current and resistance in a circuit are related.
- The change in resistance of electrical devices is used in a variety of applications.

Glossary

You will be expected to be able to recall, explain, describe and use appropriately the following words and phrases:

ammeter	dry-cell	potential difference	solar cell
ampere-hours (amp-hours)	dynamo	rechargeable	superconductivity
battery	light-dependent resistor (LDR)	resistance (ohms/Ω)	thermistor
battery capacity (ampere-hours)	magnet	resistor	voltage (volts/V, millivolts/mV)
current (amperes/amps/A, milliamps/mA)	parallel circuit	series circuit	

Information for teachers

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Learning outcomes

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Students will be assessed on their ability to:

- explain the differences between alternating and direct current — P1 a 9.1
- describe and compare sources of direct current, including batteries, solar cells and generators — P1 a 9.2
- explain how to produce an electric current by the relative movement of a magnet and a coil of wire, eg in a dynamo, in a generator — P1 a 9.3
- state the factors that affect the size and direction of an induced voltage — P1 a 9.4
- explain how changing the resistance in a series circuit **and a parallel circuit** changes the current for a given voltage — P1 a 9.5
- describe how the resistance of a light-dependent resistor (LDR) changes with light intensity and the resistance of a thermistor changes with temperature — P1 a 9.6
- recognise and explain applications depending on resistance change, eg controlling the exposure time for a digital camera, controlling central heating — P1 a 9.7
- explain that current in a wire is a rate of flow of negatively charged electrons and that it can be measured by an ammeter placed in series in a circuit — P1 a 9.8
- demonstrate understanding that a battery has a stated capacity in amp-hours and use this to predict the number of hours a battery should last when supplying a given current — P1 a 9.9
- use data to describe and explain how current varies with voltage for fixed value resistors and filament lamps and describe how this can be investigated experimentally — P1 a 9.10
- use the relationship between the voltage, current and resistance: — P1 a 9.11

  $V = I \times R$
- investigate practically or otherwise the voltage and current output, and the advantages and disadvantages of different batteries (both dry cell and rechargeable), including considerations of their cost, performance and impact on the environment — P1 a 9.12

continued...

- discuss the impact that the electric telephone and electricity has had on the development of the modern world — P1 a 9.13
- **use data to explain how new technology develops as a result of scientific advances, eg Maglev trains developed from the use of electromagnets and, in some cases, the discovery of superconductivity** — P1 a 9.14
- use data relating the size of electric circuits to the processing speed of computers to suggest future applications and implications — P1 a 9.15
- explain how ICT can be used to collect and display data from electric circuits for analysis, and compare this with traditional methods in terms of reliability and validity of data, and ease of use. — P1 a 9.16

Topic 10 — You're in Charge

Electric power is transferred to the home and industries from power stations via the national grid. The efficiency of this process is always less than 100% because electrical energy is lost in the form of heat energy; this affects the environment as well as increasing the cost of electricity. To cost electricity, the electrical energy used by homes and industries needs to be measured. Electric currents can be lethal so precautions need to be taken to protect users, including the use of double insulation and an earth wire. Devices such as fuses and residual current circuit breakers (RCCBs) can also protect equipment and protect users from severe electrical shocks. There is some opportunity for practical work, eg investigating the factors that affect the rating of a fuse. Conclusions drawn from this investigation could be used to design a fuse that blows at a particular current. Electrical machines perform many manual tasks allowing us many social benefits, for example, more leisure time.

Guidance for students

Have you ever wondered?

What if all the electricity in the world went off and stayed off?

Why don't many people in rural Africa have electricity at the flick of a switch?

What kind of car will you be driving in 10 years time?

Could your bedroom be powered by renewable energy?

Could you increase your pocket-money allowance by saving electricity?

Will a 240V electric shock kill you?

How many devices can you safely plug into one wall socket?

Learning objectives

- The rate of transfer of electrical energy and its efficiency can be calculated.
- A motor may be controlled using electricity.
- It is important to consider the economical costs and environmental effects of energy use.
- Safety issues must be fully considered when working with electricity.

Glossary

You will be expected to be able to recall, explain, describe and use appropriately the following words and phrases:

double insulation	energy (joules/J, kWh)	power (watts/kilowatts/kW)	voltage (volts/V, millivolts/mV)
earth wire	fuse	residual current circuit breaker (RCCB)	wind power
efficiency	insulation	solar cell	
electricity	motor	solar power	

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Learning outcomes

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Students will be assessed on their ability to:

- use data to evaluate the economic, environmental and social impact of renewable and non-renewable energy/power sources, and discuss their use in meeting the UK's future electricity needs — P1 a 10.1
- **evaluate the benefits and drawbacks of implementing technology, such as a new national grid for distribution of electricity** — P1 a 10.2
- **describe how scientific ideas change over time, eg changes in the medical uses of electricity** — P1 a 10.3
- describe and explain how a DC electric motor works — P1 a 10.4
- demonstrate understanding that electrical power is the rate of transfer of electrical energy — P1 a 10.5
- use the equation to calculate electrical power: — P1 a 10.6

  $\text{power} = \text{current} \times \text{voltage}$
- use the term 'efficiency' and calculate efficiency using the equation: — P1 a 10.7

  $$\text{efficiency} = \frac{\text{useful output}}{\text{total input}} \times 100\%$$
- interpret data about solar cells, including their efficiency, and suggest why they are not yet in widespread use — P1 a 10.8
- use the equation to calculate the cost of electricity: — P1 a 10.9

  $\text{cost} = \text{power} \times \text{time} \times \text{cost of 1kWh}$

  where power is measured in kilowatts and time is measured in hours
- discuss whether an energy efficiency measure is cost effective, eg insulating a home, using energy-saving bulbs, and use data to compare energy efficiency measures — P1 a 10.10
- explain how the earth wire, together with a fuse, provides protection for the user, and a fuse provides protection for the appliance and the circuit including the connecting wires — P1 a 10.11
- **describe the advantages of a residual current circuit breaker (RCCB) and understand that it works by detecting any difference between the currents in the live and neutral wires.** — P1 a 10.12

Unit P1 b

Topic 11 — Now You See it, Now You Don't

There are many different types of waves and these have many uses. For example, in the natural world, light waves enable us to see objects; sound waves enable us to communicate aurally; infrared waves from the Sun provide the Earth with the thermal energy that is needed to sustain life. This topic explores how specific types of waves are suited for particular applications, for example, X-rays for examining the human body, ultrasound for scanning a fetus in the womb, ultraviolet waves for detecting forged banknotes and microwaves and infrared waves to monitor the weather.

This topic provides the opportunity to demonstrate that there are some questions that cannot yet be answered by science, for example, is the radiation used by mobile phones safe? This can lead to ethical considerations, for example, the building and positioning of mobile phone masts.

Guidance for students

Have you ever wondered?

Why does helium make your voice go high?

Why do scientists believe there could be an even more catastrophic tsunami than the last one in 2004?

How do we know the Moon is 380,000 km away?

How do you see an unborn baby?

How can forged bank notes be detected?

How do X-rays work?

How can microwaves be used to forecast the weather?

Is too much exposure to mobile phone radiation dangerous?

Why is the picture better on a digital TV?

Do the night vision goggles you see in the movies and on TV really work?

Why does your skin burn quicker in the midday Sun?

Why is music often saved in a digital format, eg on CDs?

Learning objectives

- Different types of waves have similar properties.
- Waves carry energy.
- The reflection and absorption of waves can be used for a variety of scanning applications.
- Wave energy can be a risk to health.

Glossary

You will be expected to be able to recall, explain, describe and use appropriately the following words and phrases:

absorption	frequency	radiation	ultraviolet
amplitude	gamma-rays	reflection	vacuum
analogue	infrared	refraction	wavelength
digital	longitudinal	scanning	waves
electromagnetic spectrum	microwave	seismic waves	X-rays
emission	mutation	transverse	
fluorescent	optical fibres	ultrasound	

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Learning outcomes

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Students will be assessed on their ability to:

- evaluate the evidence that microwave radiation from mobile phones or masts may pose health risks, and discuss how this has been reported in the media — P1 b 11.1
- explain the characteristics of ultraviolet light in terms of amplitude, frequency, energy and wavelength and relate them to the dangers of over-exposure, eg UVA, UVB, UVC — P1 b 11.2
- describe the detrimental effects to a person, of excessive exposure to the following waves **and explain this in terms of increasing frequency and energy**: — P1 b 11.3
  - microwaves: internal heating of body tissue
  - infrared: skin burns
  - X-rays and gamma-rays: mutation or destruction of cells in the body
- describe the factors that cause waves to be reflected/refracted — P1 b 11.4
- explain scanning by reflection in different applications using: — P1 b 11.5
  - ultrasound, eg medical uses, sonar
  - optical, eg iris recognition, fingerprint recognition

  and evaluate the advantages/disadvantages of such technology
- explain how scanning by absorption enables: — P1 b 11.6
  - X-rays to see bone fractures
  - microwaves to monitor rain
  - ultraviolet light to detect forged bank notes by fluorescence
- explain how scanning by emission enables the use of infrared sensors to monitor temperature — P1 b 11.7
- **discuss the benefits and drawbacks to society of a technology that is based on the properties of waves** — P1 b 11.8
- describe the advantages of sending information in the form of a digital signal compared with an analogue signal — P1 b 11.9

continued...

- describe how the production of digital signals has created a range of music technologies, including synthesised instruments and the effect that this has had on the way we listen to and distribute music — P1 b 11.10
- explain how the property of total internal reflection of light waves allowed optical fibres to transfer large amounts of information over longer distances — P1 b 11.11
- compare the properties of longitudinal and transverse waves, giving examples of each type, including sound waves, ultrasound, seismic waves and electromagnetic waves — P1 b 11.12
- **suggest reasons why scientists find it difficult to predict earthquakes and tsunami waves even with suitable data** — P1 b 11.13
- explain the terms: — P1 b 11.14
  - amplitude
  - frequency
  - wavelength
  - speed of a wave
- use the relationship: — P1 b 11.15

  speed = frequency × wavelength
- use the equation: — P1 b 11.16

  speed = distance/time

  including applications where waves are reflected back to source
- **use data about seismic waves passing through the Earth to explain its structure** — P1 b 11.17
- describe similarities and differences of waves in the electromagnetic spectrum — P1 b 11.18
- recall that all electromagnetic waves travel at the same speed in a vacuum. — P1 b 11.19

Topic 12 — Space and its Mysteries

Scientists have made it possible for people to land on the Moon and have launched missions to explore Mars and other planets and moons. It may not be long before people are able to take holidays in space, perhaps on the Moon! This topic encourages students to think about conditions that space travellers will meet, how spacecraft will be powered, and the problems associated with space travel including the maintenance of medical fitness. Students will be able to use data sources to investigate conditions on different planets and draw conclusions on requirements for survival — it is important to be able to find out information about the Universe without travelling there. To navigate, pilots will need to recognise that the solar system is part of the Milky Way and relate this to other galaxies in the Universe. An understanding of the motion of asteroids and meteors will help the navigator to avoid the paths of these potentially dangerous objects. Navigators will also need to take into account the orbital motion of moons and planets caused by gravity. Strong gravitational regions in space caused by black holes and other objects will need to be avoided!

The study of the Big Bang theory, the expanding Universe and the evolution of a star is also included in this topic.

There is scope for discussing the social and economical benefits of knowledge about the Universe and the technological developments that may be gained from its exploration.

Guidance for students

Have you ever wondered?

Is it worth £25 billion to put astronauts on Mars, when we could just send robots?

How do we know black holes exist when they're completely black?

The risk of dying from an asteroid impact is the same as being in an air crash. How can this be?

The Universe is full of planets where intelligent life could start, so where is everybody?

Do physicists really have no idea what most of the Universe is made from?

Learning objectives

- Planets in our solar system have different characteristics.
- The formation and evolution of the Universe and its stars.
- Requirements for travelling in space and taking a holiday on different planets.
- How we explore the Universe and the benefits this can bring.

Glossary

You will be expected to be able to recall, explain, describe and use appropriately the following words and phrases:

acceleration	extraterrestrial	oscillating theory	stellar
action	galaxy	planet	Sun
asteroid	gravitational field	radiation	temperature
atmosphere	gravity	reaction	Universe
Big Bang	interplanetary	red shift	weight
black hole	mass	SETI	weightlessness
comet	nebula	star	
dark matter	orbit	steady state theory	

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Learning outcomes

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Students will be assessed on their ability to:

- describe conditions in interplanetary space in terms of atmosphere, temperature and weightlessness — P1 b 12.1
- **explain how these conditions can be partly allowed for in spacecraft, including supply of air, heating/cooling, artificial gravity, exercise machines, etc** — P1 b 12.2
- explain the difference between mass and weight — P1 b 12.3
- use the equation: — P1 b 12.4

  weight = mass × gravitational field strength

  W = mg
- explain how a spacecraft might be propelled in terms of action and reaction and understand the energy changes which take place as a spacecraft is being launched — P1 b 12.5
- predict the behaviour of an object using the equation: — P1 b 12.6

  force = mass × acceleration
- **discuss the possible social and economic benefits of knowledge about the Universe and the technological advances which might ensue from its exploration** — P1 b 12.7
- describe and explain how data-logging and remote sensing can provide information about the Universe without us travelling there, for example, soil experiments on landers (Viking/NASA Spirit and Opportunity rovers), the Hubble Space Telescope (HST) and Search for Extraterrestrial Intelligence (SETI) — P1 b 12.8
- explain the problems of long space flights, including the deterioration of bones and heart, and the dangers of radiation and suggest possible solutions — P1 b 12.9
- outline the role of gravity both on Earth and in astronomy, **including the idea of black holes** — P1 b 12.10
- use the unit of gravitational field strength — Newton per kilogram (N/kg) — P1 b 12.11

continued...

- describe stellar evolution from the nebula stage for stars like our Sun and for more massive stars — P1 b 12.12
- discuss the possibility of a comet hitting the Earth, taking into account the consequences, the chance of it occurring and any uncertainties — P1 b 12.13
- describe how the orbit of a comet differs from that of a planet or an asteroid — P1 b 12.14
- use data sources provided to compare the relative sizes of and distances between Earth, our Moon, the planets, the Sun, galaxies and the Universe — P1 b 12.15
- describe the solar system as part of the Milky Way galaxy and how this is related to other galaxies and the Universe — P1 b 12.16
- **evaluate the argument for and against the idea that intelligent life exists elsewhere in the galaxy, using scientific evidence, and suggest ways to find such life** — P1 b 12.17
- recognise that there are unanswered scientific questions, such as the existence of extraterrestrial life and the **nature of 'dark matter' that makes up much of the Universe's mass** — P1 b 12.18
- describe the origin, current state and possible fate of the Universe using the main theories (Big Bang, oscillating and steady state); **and outline the supporting evidence for these theories, including microwave background radiation and red shift** — P1 b 12.19
- **describe how the existence of life on a planet is determined by the nature of the planet, its position in its solar system and the position of its star in its life-cycle.** — P1 b 12.20

GCSE Additional Science

B2

Topic 1: Inside Living Cells

Topic 2: Divide and Develop

Topic 3: Energy Flow

Topic 4: Interdependence

C2

Topic 5: Synthesis

Topic 6: In Your Element

Topic 7: Chemical Structures

Topic 8: How fast? How furious?

P2

Topic 9: As Fast as You Can!

Topic 10: Roller Coasters and Relativity

Topic 11: Putting Radiation to Use

Topic 12: Power of the Atom

Unit B2

Topic 1 — Inside Living Cells

DNA in the nucleus controls the whole cell and therefore the whole organism. Students will appreciate that our understanding of how cells work owes a lot to our search for cures for cancer. Energy for the cell is provided by the chemical reaction called respiration, which is driven by proteins. Proteins are important components of the cell and their production is determined by the genes: genes contain codes that determine the sequence of amino acids in proteins.

In this topic, there are opportunities to measure body functions and investigate how they are affected by physical activities. The data can be interpreted in relation to theories about respiration and oxygen debt. Students can practise measuring accurately and understand that they need to consider safety when collecting data.

There is an opportunity to consider the industrial use and benefits of technological developments, including the cultivation of microorganisms in fermenters. How scientific ideas develop can be demonstrated by the DNA story, from data collection to the leap of imagination.

Guidance for students

Have you ever wondered?

What processes in cells keep you alive?

Why are plants and animals so different?

How does my body know which enzymes to produce?

Why does my heart beat faster when I exercise?

Why do I get cramp?

Learning objectives

- The chemical reactions essential for life take place inside cells.
- Respiring cells require a supply of glucose and oxygen, producing carbon dioxide as a waste product.
- Genes are the template for protein synthesis inside cells.
- The digestive, circulatory and respiratory systems provide cells with the basic materials they need to carry out their functions.

Glossary

You will be expected to be able to recall, explain, describe and use appropriately the following words and phrases:

adenine
aerobic
amino acid
anaerobic
aseptic
bases
capillary
coding
cramp
cultivated
cytosine
diffusion
DNA
double helix
fermentation
fermenter
glucose
guanine
insulin
lactic acid
microorganism
mRNA (messenger RNA)
organelle
plasmid
polypeptide
protein
respiration
ribosome
RNA
rRNA (ribosomal RNA)
strand
thymine
transcription
translation
tRNA (transfer RNA)
triplet code
ventilation

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Learning outcomes

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Students will be assessed on their ability to:

- describe a DNA molecule as two strands coiled to form a double helix, the strands linked by a series of paired bases (adenine with thymine and cytosine with guanine) B2 1.1
- explain that DNA controls the joining together of amino acids to make a specific protein in a cell and that the order of bases in a section of DNA decides the order of amino acids in the protein B2 1.2
- explain that sections of DNA coding for specific proteins can be transferred into microorganisms which are then cultivated in fermenters to produce useful substances, including human insulin B2 1.3
- explain that microorganisms use an external food source to obtain energy, changing some substances in the medium and recall that this process is fermentation B2 1.4
- **describe a fermenter as a vessel used to cultivate microorganisms and explain the need to supply suitable conditions in fermenters, including aseptic precautions, nutrients, optimum temperature and pH, oxygenation and agitation** B2 1.5
- explain the advantages of using microorganisms for food production B2 1.6
  - rapid population growth; ease of manipulation
  - production independent of climate
  - use of waste products from other industrial processes
- demonstrate an understanding of the emerging role of genetically modified bacteria in the production of useful substances B2 1.7
- **describe organelles in the cell that are involved with making protein** B2 1.8
- **describe the stages of protein synthesis** B2 1.9
  - **the coding by triplets of bases in the DNA to produce mRNA**
  - **the attachement of the ribosome to the mRNA**
  - **the linking of amino acids to form polypeptides**

continued...

• explain how ventilation provides oxygen for aerobic respiration which releases energy for work	B2 1.10
• explain how glucose and oxygen diffuse from capillaries into respiring cells, and how carbon dioxide diffuses from respiring cells into capillaries	B2 1.11
• explain why heart rate and breathing rate increase with exercise and interpret data on these measurements	B2 1.12
• **explain why respiration is increased in exercising muscles and why diffusion of oxygen and carbon dioxide at the lung surface and muscle cells is increased**	B2 1.13
• explain why during vigorous exercise, muscle cells may not receive sufficient oxygen for their energy requirements	B2 1.14
• demonstrate an understanding of how digital thermometers, and breathing rate and heart rate monitors, can provide more reliable data than traditional methods	B2 1.15
• describe that glucose is changed to lactic acid and energy is released, during anaerobic respiration	B2 1.16
• **explain why extra oxygen is needed to remove the lactic acid that causes cramp (oxygen debt)**	B2 1.17
• discuss why official advice on diet and exercise change over time and consider the scientific basis of current fashionable diets and advice.	B2 1.18

Topic 2 — Divide and Develop

Understanding how living things grow helps us to understand and treat medical problems arising at birth or later in life.

Cells replicate by mitosis and gametes are produced by meiosis. Cells are differentiated to specific functions. In animals this differentiation arises from stem cells, but this ability is lost at an early stage. Scientists are beginning to understand the medical potential of stem cells. This can be compared with plant growth, where regeneration and virtually continual growth is common. The more we can understand plant growth the more we will be able to produce the quantity of food the world requires. Consideration is given to the limiting factors affecting plant growth and distribution, which can be investigated practically.

There is ample opportunity to discuss ethical issues associated with growth and development and genetic modification, as well as giving consideration to the potential of gene therapy.

Guidance for students

Have you ever wondered?

Why don't I keep on growing forever?

Why do scientists want to modify cows?

What is a stem cell and why do scientists think it is so valuable?

Why do plants need hormones?

Why have the International Olympics Committee (IOC) banned certain chemicals?

How does scientific knowledge contribute to decisions regarding the termination of pregnancies?

How can gene therapy help treat cancer sufferers?

Why do 'weeds' always grow in the most awkward places?

Learning objectives

- Organisms grow by cell division, elongation and differentiation of cells.
- Plants and animals are different and this results in different patterns of growth and development.
- There is a variety of environmental factors that will influence the growth and distribution of plants.
- Human intervention can manipulate the outcome of reproduction.

Glossary

You will be expected to be able to recall, explain, describe and use appropriately the following words and phrases:

auxins	embryo	meiosis	selective breeding
cancer cell	fetus	mitosis	species
cell division	gametes	nuclear transfer	sperm
chromosomes	genes	nucleus	stem cell
continuous variation	genetic modification	nutrient	steroids
differentiation	growth	ovum	termination
diploid	haploid	pedigree analysis	
discontinuous variation	hormones	phototropism	
elongation	inheritance	regeneration	

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Students will be assessed on their ability to:

- describe mitosis as the division of a cell to produce two nuclei with identical sets of chromosomes, for growth or replacement — B2 2.1
- **describe meiosis as the division of a cell to produce four haploid gametes with sets of chromosomes that are not genetically identical to produce gametes** — B2 2.2
- **explain the differences between mitosis and meiosis** — B2 2.3
- discuss the meaning of growth, in terms of increase in size; length; wet mass; dry mass — B2 2.4
- demonstrate understanding of how cell division, elongation and differentiation contribute to the growth and development of an organism — B2 2.5
- explore the scientific evidence for the potential of stem cell research — B2 2.6
- **demonstrate understanding that cells have a limit to the number of divisions they undergo, the Hayflick limit; stem cells and cancer cells have no Hayflick limit** — B2 2.7
- demonstrate understanding that stem cells in the embryo can differentiate into all other types of cells, but that cells lose this ability as the animal matures — B2 2.8
- explore the scientific evidence that contributes to the decision regarding the legality and age of termination of a fetus — B2 2.9
- explore the phenomenon that organisms have a size range for that particular species: height in humans is a continuous variable, influenced by a number of genes, hormones and nutrition — B2 2.10
- discuss the factors affecting the growth and distribution of plants, including: — B2 2.11
  - nutrients
  - light
  - temperature
  - carbon dioxide
  - oxygen
  - plant ‘hormones’

continued...

- interpret data on how environmental factors affect the distribution of plants B2 2.12
- **discuss fruit initiation in plants and how it can be manipulated with artificial hormones** B2 2.13
- discuss regeneration in animals (including spiders, worms and reptiles) and why it is relatively rare B2 2.14
- explore the evidence that selective breeding (artificial selection) can be used to: B2 2.15
  - improve the quality of milk from cattle
  - increase the number of offspring in sheep
  - increase the yield from dwarf wheat and other cereal crops
- discuss the ethics and health concerns of using growth factors to enhance performance in sport B2 2.16
- **demonstrate an understanding of the stages in the production of cloned mammals, including Dolly the sheep:** B2 2.17
  - **the replacement of the nucleus in an egg cell with a diploid nucleus from a mature cell (nuclear transfer)**
  - **stimulation of the diploid nucleus to divide**
- discuss the potential benefits and ethical dilemmas posed by advances in genetic modification in plants and animals B2 2.18

Topic 3 — Energy Flow

Understanding energy flow is the key to sustainable food production in both developed and developing nations. This topic offers students opportunities to prepare and observe animal and plant tissue under the microscope and to design and evaluate experiments on production factors. Consideration of the carbon and nitrogen cycle leads to investigations on the use of fertilisers and farming methods to maximise energy transfer in food production methods.

Students will discuss maximising food production and understand that the world already produces sufficient amounts of food to feed the whole population. How human activities affect the environment will also be explored, including global warming, deforestation and the use of fertilisers.

Guidance for students

Have you ever wondered?

We can feed the world's population, but how exactly?

What happens if we remove all of one kind of animal — will we ever be able to put them back again?

Should I travel on buses rather than take the car?

Why do some hospitals not allow plants in the hospital wards?

Why do some people put lights in greenhouses?

Why is there a global ban on whaling?

How do fertilisers harm the environment?

Can we set up a biosphere on Mars?

Learning objectives

- Plants provide energy for all other organisms.
- Plants and animals are interdependent due to their use and production of oxygen and carbon dioxide.
- Energy flows through the biosphere and elements are recycled within it.
- Human activities are often unsustainable and there are many associated ethical considerations.

Glossary

You will be expected to be able to recall, explain, describe and use appropriately the following words and phrases:

active transport	denitrifying bacteria	membrane	photosynthesis
animal cell	decomposer	microorganism	plant cell
biosphere	deforestation	mineral salt	predator
carbon cycle	disease	nitrifying bacteria	respiration
cellulose cell wall	eutrophication	nitrogen cycle	root
chlorophyll	fertiliser	nitrogen fixing bacteria	sustainability
chloroplast	food production	nucleus	transpiration
combustion	global warming	osmosis	vacuole
cytoplasm	glucose	phloem	xylem

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Learning outcomes

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Students will be assessed on their ability to:

- recall that plant and animal cells are similar because they contain nuclei, cytoplasm and membranes and that plant cells also have cellulose cell walls, chloroplasts containing chlorophyll and vacuoles — B2 3.1
- recall the reactants (carbon dioxide, water) for and products (glucose, oxygen) of photosynthesis — B2 3.2
- explore human exploitation of plants, including their use as a food source — B2 3.3
- analyse data on the effects of limiting factors on the rate of photosynthesis and draw conclusions — B2 3.4
- **appreciate the role of mineral salts, such as magnesium, nitrogen, phosphorus and potassium, in the growth of plants** — B2 3.5
- **demonstrate an understanding of now the mineral salts are taken up in the roots by active transport using energy from respiration** — B2 3.6
- demonstrate an understanding of and interpret data on the carbon cycle as representing the flow of carbon in nature, including the roles of:
  - microorganisms
  - photosynthesis
  - respiration
  - combustion — B2 3.7
- describe the importance of nitrogen in the environment, including the roles of:
  - nitrogen fixing bacteria
  - decomposers
  - nitrifying bacteria
  - denitrifying bacteria

  as shown and interpreted in nitrogen cycle diagrams (NB: specific names of bacteria are not required) — B2 3.8
- explore the evidence that a biosphere could be used to colonise Mars — B2 3.9

- describe how the indiscriminate use of nitrogenous fertilisers leads to environmental damage by eutrophication — B2 3.10
- **appreciate that human populations are increasing and are using resources unsustainably which can lead to massive environmental change, eg deforestation** — B2 3.11
- discuss the social and ethical considerations of the unequal distribution of food — B2 3.12
- explain that energy transfer can be maximised in food production by the use of:
  - optimum feeding/growing conditions
  - disease and predator control

  using the examples of fish farms and greenhouses — B2 3.13

Topic 4 — Interdependence

Understanding the principles of interdependence is the key to managing the Earth's resources successfully and sustainably. Television and newspapers often have stories about damage to the environment, but how can we put right the damage?

This topic explores how competition and predation affect the distribution and numbers of organisms in selected environments. The impact of human activity is then considered with the opportunity for students to interpret data on living and non-living indicators. This leads to the need for responsible recycling and conservation and consideration of the effects on biodiversity.

Guidance for students

Have you ever wondered?

Why are rabbits such a pest in Australia?

Why is territory so important for animals?

If animals fight over land and mating partners, what do plants fight over?

Why is there a variety of birds in the park and not just one species?

Why did dinosaurs become extinct?

Why do deep-sea fish have cylindrical eyes and not eyeballs?

Why are all conservation initiatives not equally successful?

Why is recycling of materials encouraged?

Learning objectives

- Organisms compete with each other for resources.
- Organisms are interdependent which affects their distribution and population size.
- Organisms have evolved to survive in extreme environments.
- Human impacts on the environment and conservation measures need management.

Glossary

You will be expected to be able to recall, explain, describe and use appropriately the following words and phrases:

adaptation	environment	organism	replacement planting
aquatic	extreme environment	ozone	resource
biodegradable	global temperature	phosphates	sewage
biodiversity	greenhouse gases	pollution	skin cancer
chloroflurocarbons CFCs	hydrothermal vents	population	terrestrial
competition	indicators	predation	waste disposal
conservation	interdependence	recycling	
coppicing	nitrate	reforestation	

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Learning outcomes

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Students will be assessed on their ability to:

- explore the principles of interdependence, adaptation, competition and predation and explain how these factors influence the distribution and population sizes of organisms in a given terrestrial or aquatic environment — B2 4.1
- **use primary and secondary data to consider how human activity, including differing economical and industrial conditions, can affect the environment and cause changes in sizes of population** — B2 4.2
- investigate, using primary and secondary data, the impact of human activity on the environment, including the pollution of air and of water; and the effects of air pollutants (including carbon dioxide, sulphur dioxide, carbon monoxide) and of water pollutants (including sewage, nitrates and phosphates) — B2 4.3
- interpret data on environmental change — B2 4.4
- explain the importance of protecting natural populations — B2 4.5
- describe the special nature of some extreme environments, notably deep sea volcanic vents, the Antarctic and high altitudes — B2 4.6
- interpret data to show the impact of human activity on the environment to include: — B2 4.7
  - living indicators, eg lichen distribution; incidence of skin cancer
  - non-living indicators, eg global temperature and ozone depletion
- explore whether recycling reduces the demand for resources and the problem of waste disposal, including paper, plastics and metals — B2 4.8
- consider conservation management techniques, including reforestation, coppicing, replacement planting and discuss how conservation can lead to greater biodiversity. — B2 4.9

Unit C2

Topic 5 — Synthesis

This topic gives students the opportunity to gain a fundamental appreciation of organic chemistry. Students should understand that organic chemistry is the chemistry of compounds containing carbon and hydrogen, often with other elements. A study of the simple but relatively unreactive alkanes can be used to introduce the more reactive alkenes and the useful polymers that can be made from them.

They should come to appreciate that chemists need to know what masses of reactants to use to produce the required amount of product. Students should also realise that chemical reactions do not produce the theoretical amount of product, but only a percentage of that maximum amount. This can lead to the idea of purity of products and appropriate tests for purity.

It is important for students to realise that yields are an important factor when manufacturing chemical products. The aim of manufacturers is to produce a pure product safely with a high yield. This will enable manufacturers to keep costs down and to use profit to further research and development.

Students need to appreciate that products must be pure and therefore the separation of the product from the impurities is an important feature of chemical production. Students need to appreciate the implications of not having a pure product.

Students will need to be aware that there is a number of analytical tests that can be carried out to check the purity of products. In some instances, such as wine, it would be smell and taste.

Practical activities can be carried out to prepare polymers and investigate the properties of polymers. The implications of non-biodegradable plastics can be discussed. Students can identify applications of plastics and how additives can alter their properties or use in specific applications, eg UPVC. Students can also investigate the importance of the products obtained from crude oil.

Guidance for students

Have you ever wondered?

Only a small part of crude oil is petrol, so how do we make enough for all the cars in the world?

Food labels give ‘total fat’ and ‘saturated fat’ — but what’s the difference?

How is plastic made from oil?

How do those plastic creatures, that grow when put in water, actually work?

How do you make slime/super-balls?

Why would you want a biodegradable plastic bag?

Is sucking plastic toys dangerous for a baby?

How do chemists discover new drugs?

Learning objectives

- Organic compounds contain the elements carbon and hydrogen and many originate from living things.
- Many new substances are made from oil.
- Polymers are large molecules which can be formed by the repeated joining of monomer molecules.
- Disposal of some polymers is an environmental problem.
- Raw materials are converted into new and useful substances by chemical reactions.
- The amount of reactant needed to form a desired quantity of product can be calculated, but the actual yield is lower than the theoretical yield and this has financial implications.

Glossary

You will be expected to be able to recall, explain, describe and use appropriately the following words and phrases:

addition	empirical	percentage yield	theoretical yield
alkane	fats	polymer	thermoplastic
alkene	formulae	polyunsaturated	thermosetting
covalent bond	hydrogenate	saturated hydrocarbon	toxicity
cracking	monomer	sustainable development	unsaturated hydrocarbon
double bond	monounsaturated	synthesis	unsaturated monomer

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Learning outcomes

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Students will be expected to:

- recall the formulae of elements and simple compounds in the topic
- represent chemical reactions by word equations and simple balanced equations and use state symbols (s), (l), (g) and (aq)
- write balanced equations to describe and explain a wide range of reactions in this topic.

Students will be assessed on their ability to:

• investigate cracking within the laboratory, eg of liquid paraffin	C2 5.1
• explain that cracking involves the breaking down of larger hydrocarbon molecules into smaller, more useful ones	C2 5.2
• recall that when alkanes are cracked, mixtures of alkanes and alkenes are formed	C2 5.3
• explain that alkanes are saturated hydrocarbons, containing only single covalent bonds between carbon atoms, and that alkenes are unsaturated hydrocarbons containing one or more double covalent bonds between carbon atoms	C2 5.4
• recall the formulae of methane, ethane, propane, butane and draw the structures of their molecules	C2 5.5
• recall the formulae of ethene and propene and draw the structures of their molecules	C2 5.6
• describe how bromine water is used to distinguish between alkanes and alkenes	C2 5.7
• demonstrate understanding that the ability of a carbon atom to form four stable covalent bonds results in a large number of carbon compounds	C2 5.8
• discuss how modern society depends on oil and predict the possible consequences when supplies are depleted	C2 5.9

continued...

- explain why some vegetable oils are referred to as 'polyunsaturated' or 'monounsaturated' C2 5.10
- explain why polyunsaturated oils are far less viscous than saturated ones C2 5.11
- describe how vegetable oil can be hydrogenated to form hydrogenated vegetable oil and what this is used for in the food industry C2 5.12
- **explain how ethene can be reacted with water to make ethanol in industry, and the uses of ethanol** C2 5.13
- recall that polymers are large molecules which are formed by a combination of many smaller molecules C2 5.14
- draw repeating units of addition polymers given the monomer and vice versa C2 5.15
- explain how addition polymers are formed from unsaturated monomers (equations required but not conditions and mechanisms) C2 5.16
- predict uses of polymers given appropriate information about their properties (NB: no recall expected) C2 5.17
- explain the similarities and differences in properties between thermosetting and thermoplastic polymers in terms of their structure C2 5.18
- explain how the properties of a polymer can be altered, depending on the starting materials, conditions of reaction, and additives (limited to plasticisers, preservatives and cross linking), and relate properties of polymers to their structure and bonding C2 5.19
- discuss the problems of disposing of some polymers, including non-biodegradability and breakdown to toxic products C2 5.20
- discuss the issue of toxicity to humans in how chemists synthesise new substances C2 5.21
- demonstrate understanding that chemists use information about known reactions to make new compounds and predict the products of a reaction given the reactants and products of similar reactions C2 5.22
- **use the formula:** C2 5.23

  $$\frac{\text{mass of useful product}}{\text{total mass of product}} \times 100\%$$

  to calculate the 'atom economy' of a reaction
- demonstrate understanding that reactions with high atom economy are important for sustainable development as they prevent waste C2 5.24
- calculate relative formula mass from relative atomic masses C2 5.25
- calculate the formulae of simple compounds from reacting masses and understand that these are empirical. C2 5.26
- **use chemical equations to calculate masses of reactants and products** C2 5.27
- **calculate theoretical and percentage yields of reactions** C2 5.28
- describe how staged methods of synthesis are used in drug development to speed up discovery of effective substances C2 5.29
- **calculate the number of possible products from a staged synthesis experiment, involving no more than four stages, given appropriate data.** C2 5.30

Topic 6 — In Your Element

In this topic students are able to extend their knowledge of naming substances and develop their ideas of atomic structure to understand the existence of isotopes and justify the existence of relative atomic masses which are not whole numbers.

Studying this topic, students will begin to understand the usefulness of the periodic table. First of all, students should realise how the periodic table enables them to recall the electronic configurations of elements. Data from the periodic table should then be used to study changes in chemical reactivity of the elements with increasing atomic number in groups 1 and 7 of the table. Study of the chemical reactions should be used to show how a knowledge of electronic configurations can lead to an understanding of how the atoms combine to form ionic bonds. Knowledge of the structure of compounds can then be used to rationalise some general physical properties of solids formed from ionic bonds.

Students can appreciate that the bonding in ionic substances largely determines their properties. Students can carry out investigations to obtain primary data for the physical properties of ionic compounds.

Guidance for students

Have you ever wondered?

What is the difference between 9 and 18 carat gold jewellery?

What makes platinum, diamond and zirconium look so different, when they're all made from the same basic ingredients?

How is gold-plated jewellery made?

Did you know the atoms in your body were born in a star?

Why do some scientists think life began in space and came to Earth on a comet?

How do scientists detect new elements (such as element-115) if they only last milliseconds before disintegrating?

Did you know scientists can make 'heavy water', so that an ice cube sinks?

Can the periodic table help you learn chemistry in a lot less time?

Learning objectives

- The number of outer electrons in an element determines its position in the periodic table and its reactivity.
- The process of electrolysis.
- The existence of isotopes and their relationship to relative atomic mass.
- The importance of electrons in ionic and metallic bonding.

Glossary

You will be expected to be able to recall, explain, describe and use appropriately the following words and phrases:

alloy	electrolysis	ionic bonding	nucleus
atomic number	electronic configuration	isotope	periodic table
binary salt	electron	malleability	proton
conductivity	formulae	mass number	relative atomic mass
electrode	ion	neutron	

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Learning outcomes

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Students will be expected to:

- recall the formulae of elements and simple compounds in the topic
- represent chemical reactions by word equations and simple balanced equations and use state symbols (s), (l), (g) and (aq)
- write balanced equations to describe and explain a wide range of reactions in this topic.

Students will be assessed on their ability to:

- describe and explain the physical properties of metals, including conductivity, malleability, hardness and high melting/boiling points — C2 6.1
- describe and explain how alloying can change the properties of metals, eg iron, aluminium and their alloys — C2 6.2
- recall the relative charges and relative masses of protons, neutrons and electrons — C2 6.3
- explain the terms atomic number, mass number and relative atomic mass — C2 6.4
- describe the structure of an atom as a nucleus containing protons and neutrons, surrounded by orbiting electrons arranged in shells — C2 6.5
- recall that an ion is an atom or group of atoms with a positive or negative charge — C2 6.6
- explain that ionic bonds are formed by the transfer of electrons to form positively charged ions (cations) and negatively charged ions (anions) — C2 6.7
- describe the formation of sodium ions (Na^+) and chloride ions (Cl^-) from their atoms and hence predict the formation of ions in other ionic compounds, from their atoms — C2 6.8

continued...

• describe and explain the physical properties of giant ionic structures (eg sodium chloride (NaCl)) including their regularly shaped crystals, high melting and boiling points and ability to conduct an electric current when molten and in solution	C2 6.9
• write the formulae of ionic compounds, given the charges on the ions	C2 6.10
• **predict the products of electrolysis of a given molten binary salt, and write balanced half equations for the electrode reactions**	C2 6.11
• demonstrate understanding that in electrolysis ions move towards electrodes of opposite charge	C2 6.12
• explain the existence of isotopes	C2 6.13
• **calculate the relative atomic mass of an element from the relative masses and abundance of its isotopes**	C2 6.14
• explain that reactions of an element depends upon the arrangement of electrons in the outer shell of its atoms	C2 6.15
• describe the connection between the number of outer electrons and the position of an element in the periodic table	C2 6.16
• explain the lack of reactivity of the noble gases in terms of the electron configuration of their atoms	C2 6.17
• write down the electronic configurations of the first 20 elements in the periodic table, given the atomic numbers, either as electron shell diagrams or in the form, eg 2.8.1	C2 6.18
• explain the trends in the reactivity of the alkali metals and of the halogens in terms of their electronic configurations	C2 6.19
• appreciate how creative insight influenced the discovery of the elements of the periodic table, eg appreciate Mendeleev's vision and understanding in predicting the properties of silicon before it was discovered.	C2 6.20

Topic 7 — Chemical Structures

Study of this topic enables students to begin to understand how very useful the periodic table is. First of all, students should realise how the table enables them to recall the electronic configurations of elements. Data from the periodic table should then be used to study changes in physical properties and chemical reactivity of the elements with increasing atomic number in groups 1 and 7 of the table. Study of the chemical reactions should be used to show how a knowledge of electronic configurations can lead to an understanding of how the atoms combine to form covalent bonds. The knowledge of the structure of compounds can then be used to rationalise some general physical properties of simple molecular and giant molecular covalent compounds.

Students can appreciate that the type of bonding in chemical substances can determine their properties. Students can carry out investigations to obtain primary data to compare the physical properties of compounds which have different types of structures.

Guidance for students

Have you ever wondered?

Did you know there is a molecule that has atoms arranged in the shape of a soccer ball?

Do the essential oils that supermarkets spray into the air put you in a positive mood?

Why do people think crystals have mysterious healing qualities?

If homeopathy works, why don't scientists believe it?

If particles in a solid are closer than in a liquid, why doesn't ice sink?

Why are diamonds so expensive when scientists can create them in a few hours?

Why is life on Earth based on the carbon atom?

Learning objectives

- Bonds result from the forces between the electrons and the nuclei of atoms.
- Atoms bond in different ways to form compounds.
- The structure and properties of substances are dependent on the nature of the bonding.

Glossary

You will be expected to be able to recall, explain, describe and use appropriately the following words and phrases:

Buckminsterfullerene	covalent bond	graphite	inter-molecular force
carbon nanotube	diamond	halogen	simple molecular covalent structure
conductivity	giant molecular covalent structure	homeopathic	

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Learning outcomes

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Students will be expected to:

- recall the formulae of elements and simple compounds in the topic
- represent chemical reactions by word equations and simple balanced equations and use state symbols (s), (l), (g) and (aq)
- write balanced equations to describe and explain a wide range of reactions in this topic.

Students will be assessed on their ability to:

• recognise the importance of chance in scientific discoveries such as that of Buckminsterfullerene	C2 7.1
• recall that Buckminsterfullerene and carbon nanotubes are forms of carbon	C2.7.2
• suggest uses for fullerenes and nanotubes, given data about their properties	C2 7.3
• describe and explain the physical properties of simple molecular covalent substances including their low melting/boiling points and their inability to conduct an electric current	C2 7.4
• **use appropriate information to draw conclusions about whether a chemical-based therapy is effective**	C2 7.5
• describe why ideas, such as the effectiveness of homeopathic medicine, are difficult for scientists to accept when they conflict with established theories	C2 7.6
• recall that metals conduct electricity because there are relatively free electrons in the giant structure of atoms	C2 7.7
• **relate the physical properties of the halogens to their inter-molecular forces of attraction**	C2 7.8

continued...

• describe how covalent bonds are formed by electron sharing and can result in the formation of simple molecules or giant molecules such as those of like diamond and graphite	C2 7.9
• **draw dot and cross diagrams of simple molecules including hydrogen (H_2), hydrogen chloride (HCl), water (H_2O) and carbon dioxide (CO_2)**	C2 7.10
• describe and explain the similarities and differences in physical properties between the giant molecular covalent structures of diamond and graphite, including high melting/boiling points, hardness and conductivity	C2 7.11
• **demonstrate an understanding of the limitations of representing models of atoms and molecules in two dimensions and how three dimensional representations can clarify understanding.**	C2 7.12

Topic 8 — How Fast? How Furious?

In this topic, studies of the way substances react are developed further. Practical evidence is obtained to show how different factors affect rates of reaction and to show the nature of heat changes when reactions occur. Students can carry out investigations where primary data can be collected, processed, interpreted and presented, and the results explained at an atomic level.

Students need a knowledge of the different factors that need to be taken into account when developing the effectiveness and efficiency of a chemical reaction, and understand that organisations need to consider these factors when developing a new chemical product safely.

Students are introduced to the idea that all reactions are reversible and that this results in a dynamic equilibria being established rather than a complete conversion of reactants into products.

Guidance for students

Have you ever wondered?

Why do some chemicals explode when you mix them?

How do you make rocket fuel?

Why do chips cook much faster than bigger roast potatoes?

How do the hot and cold packs that athletes use to treat injury work?

Can chemical reactions be undone?

How did the production of ammonia allow twice the world's population to be fed?

Learning objectives

- Different chemical reactions occur at different rates and these rates can be changed.
- Some reactions give out energy while others take in energy.
- Chemical reactions involve breaking bonds and forming bonds.
- Reactions are reversible.

Glossary

You will be expected to be able to recall, explain, describe and use appropriately the following words and phrases:

catalyst	endothermic reaction	fertiliser	rate of reaction
collision theory	enzyme	Haber process	reversible
concentration	equilibrium	organic	surface area
dynamic equilibrium	exothermic reaction	pressure	temperature

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Learning outcomes

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Students will be expected to:

- recall the formulae of elements and simple compounds in the topic
- represent chemical reactions by word equations and simple balanced equations and use state symbols (s), (l), (g) and (aq)
- write balanced equations to describe and explain a wide range of reactions
- **write balanced ionic equations to describe and explain a wide range of reactions**.

Students will be assessed on their ability to:

• recall that exothermic reactions are accompanied by an increase in temperature and endothermic reactions by a decrease in temperature	C2 8.1
• define an exothermic reaction as one in which heat energy is given out and an endothermic reaction as one which heat energy is taken in and give examples of such reactions	C2 8.2
• recall that the breaking of bonds is endothermic and that the making of bonds is exothermic	C2 8.3
• describe and explain the effect of changes in temperature, concentration and surface area of a solid on a given rate of reaction	C2 8.4
• describe experiments to investigate the effect of temperature, concentration and surface area of a solid on the rate of a reaction (data-logging equipment may be used here)	C2 8.5
• describe the effect of a catalyst on the rate of reaction, **and interpret the results**	C2 8.6
• **explain that reactions can occur when particles collide and that increasing the frequency and energy of collisions increases the rate of the reaction**	C2 8.7

continued...

• recall that enzymes are biological catalysts and appreciate the importance of controlling the speed of chemical reactions for the maintenance of life	C2 8.8
• describe the conditions under which ammonia is produced from nitrogen and hydrogen in the Haber process	C2 8.9
• demonstrate understanding that this reaction is reversible and can reach a dynamic equilibrium	C2 8.10
• **demonstrate understanding of how the position of a dynamic equilibrium can be affected by changes of temperature and pressure, to include the Haber process as an example**	C2 8.11
• **demonstrate understanding of the consequential effect of these changes on the rate of attainment of equilibrium and the possible need to use a catalyst**	C2 8.12
• explain that ammonia produced in the Haber process can be neutralised with nitric acid to produce artificial nitrogenous fertilisers	C2 8.13
• discuss the arguments for and against using natural and artificial fertilisers in farming.	C2.8.14

Unit P2

Topic 9 — As Fast as You Can!

Forces between interacting bodies act in pairs. An understanding of motion and the ability to measure it enables us to send astronauts to the Moon and design exciting rides at theme parks. A resultant force can change the motion of an object. If the motion of a vehicle changes abruptly, passengers may be protected from serious injury by crumple zones or other safety measures, for example airbags. The resultant force on a falling object in a liquid or gas may gradually decrease to zero, at this point the falling object travels at terminal velocity.

While studying this topic there are opportunities for students to collect, analyse and present data using ICT equipment by working with others in a safe manner.

Guidance for students

Have you ever wondered?

Do the experiences of bungee jumping, parachuting and free-fall all feel the same?

Could you manage the acceleration to be a good Formula 1 driver?

Did you realise how much you know of the laws of physics if you skate, snowboard or play flight simulators?

How does a Jetski work?

What is the chance of you being injured in a high-speed outdoor activity?

People have survived a fall from 20,000 feet — how?

How closely can you drive behind another moving car?

Which make of car is the safest?

Learning objectives

The motion of moving objects can be measured.

Forces can affect the motion of an object.

The speed of falling objects usually change as they fall.

Vehicles and theme park rides have safety features to protect passengers from injury.

Glossary

You will be expected to be able to recall, explain, describe and use appropriately the following words and phrases:

acceleration	gradient	resistance	terminal velocity
action	magnitude	resultant force	vector
collision	momentum	speed	velocity
displacement	reaction	stopping distance	weight

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Learning outcomes

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Students will be assessed on their ability to:

- explain that velocity is speed in a given direction and is a vector quantity — P2 9.1
- define acceleration in terms of a change in velocity (this can mean change in magnitude and/or direction) and the time taken for the change — P2 9.2
- draw and interpret velocity-time graphs and determine acceleration from the gradient of the graph — P2 9.3
- use the equation: — P2 9.4

  average velocity = displacement/time

  $v = s/t$
- use the equation: — P2 9.5

  acceleration = change in velocity/time

  $a = (v - u)/t$
- explain that if the resultant force acting on a body is zero, it will remain at rest or continue to move at the same speed in the same direction — P2 9.6
- explain that if the resultant force acting on a body is not zero, it will accelerate in the direction of the resultant force — P2 9.7
- calculate a resultant force using a range of forces (limited to the resultant of forces acting along a line) including resistive forces — P2 9.8
- use the equation: — P2 9.9

  force = mass $\times$ acceleration

  $F = ma$
- explain that when two bodies interact, the forces they exert on each other are equal in size and opposite in direction and that these are known as action and reaction forces — P2 9.10
- draw and interpret a free-body force diagram — P2 9.11

continued...

- describe how data about forces can be collected and incorporated into spreadsheet software for use in modelling 'what if' situations — P2 9.12
- explain that falling objects are acted on by a downward force (weight) and an upward force (air resistance) and that at the start of the fall the forces are unbalanced and the object accelerates — P2 9.13
- **describe the increase in resistance with an increase in speed for a falling object and explain how this can lead to terminal velocity** — P2 9.14
- explain that the stopping distance of a vehicle depends on the speed of travel — P2 9.15
- describe the effect of factors such as driver's reaction time and the condition of the vehicle and road, on stopping distance — P2 9.16
- **calculate the momentum of an object using the equation:** — P2 9.17

  momentum = mass × velocity
- **describe and explain measures designed to reduce the rate of change of momentum of fragile objects, eg passengers in theme park rides and eggs in cardboard packaging** — P2 9.18
- evaluate the effectiveness of safety technology when travelling, when provided with appropriate data, for example, safety belts/harnesses, crumple zones and airbags to reduce injury — P2 9.19
- demonstrate understanding of the different ways of expressing the size of a risk — P2 9.20
- demonstrate understanding of the factors that influence people's willingness to accept risks, for example, the degree of familiarity, whether it is imposed or voluntary, effects of adrenaline rush. — P2 9.21

Topic 10 — Roller Coasters and Relativity

This topic builds on the concepts presented in Topic 9. A resultant force can make an object move in a circular path. Work, energy and power are fundamental concepts that have applications in many branches of science and everyday life. When energy is converted (eg in electrical, potential or kinetic) the conversion process will not be 100% efficient; however the total amount of energy in the system is conserved.

This topic will explore the social benefits that science can bring when energy is used to do useful work, although it can also raise environmental issues arising from processes that involve energy transformation. The economic issues of converting energy from one form to another will also be raised within this topic.

Guidance for students

Have you ever wondered?

If you could design a roller coaster ride, what would it look like?

Where does the power come from to make a theme park ride accelerate faster than a space shuttle?

How do you make the biggest water splash?

Can you say why theme park rides are addictive?

Which parts of the ride make you feel sick?

Can spaceships fly across galaxies at warp speed (faster than light)?

How did Einstein come up with the most famous idea in physics — the theory of relativity?

Learning objectives

- How theme park rides work.
- For an object to move in a circular path a force must act on it.
- Energy can be converted from one form into another but it cannot be made or destroyed.
- New scientific theories are not always derived through experimental methods.

Glossary

You will be expected to be able to recall, explain, describe and use appropriately the following words and phrases:

acceleration	electrical energy	mass	speed
conservation of energy	energy transfer	potential energy	velocity
constant speed	force	power	voltage
current	gravitational potential energy	theory of relativity	work done
distance	kinetic energy	resultant force	

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Learning outcomes

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Students will be assessed on their ability to:

- use the relationship: P2 10.1

  change in potential energy = mass × gravitational field strength × change in height

  $PE = m \times g \times h$

- use the relationship: P2 10.2

  kinetic energy = ½ × mass × (velocity)^2

  $KE = \frac{1}{2} mv^2$

- use the equation: P2 10.3

  electrical energy = voltage × current × time

  $E = V \times I \times t$

- explain that work done is equal to energy transferred P2 10.4

- use the equation: P2 10.5

  power = work done/time taken

  $P = W/t$

- use the equation: P2 10.6

  work done = force × distance moved in the direction of the force

  $W = F \times s$

- demonstrate understanding of and apply the principle of conservation of energy, for example, gravitational potential energy, kinetic energy and other forms of energy P2 10.7

- describe a roller coaster or other ride, in terms of speed, acceleration, force and energy P2 10.8

continued...

• **explain that an object moving in a circle at constant speed is accelerating**	P2 10.9
• **explain the resultant force acting on an object which is moving in a circle causes this acceleration**	P2 10.10
• **recall that this force is directed to the centre of the circle**	P2 10.11
• recognise that some theories do not emerge from experimental data, but require creative imagination such as thought experiments, eg Einstein's theory of relativity	P2 10.12
• discuss the fact that some scientists are often reluctant to accept new theories, such as Einstein's relativity, when they overturn long-established explanations	P2 10.13
• **explain that Einstein's theory of relativity is believed because it led to predictions which were tested successfully in different situations, for example, atomic clocks and cosmic rays.**	P2 10.14

Topic 11 — Putting Radiation to Use

Radioactivity has many important applications in the modern world including treating malignant tumours, domestic smoke alarms, sterilisation of medical equipment, preserving food and dating materials. This topic provides an introduction to radioactivity. It enables students to find out about different types of radiation and their origins, examine their properties and explore their applications. The topic also provides an opportunity to discuss how scientific ideas change over time by considering the risks associated with radioactive sources. The benefits and environmental effects of using radiation can be debated.

Guidance for students

Have you ever wondered?

Irradiating food makes it last longer, so why won't the supermarkets sell it?

Radioactivity destroys cancers, but does it leave a patient radioactive afterwards?

How do we know things like 'Woolly mammoths died out 10,000 years ago', which is before humans learned to write?

Why do some people wear radioactive watches that shine in the dark?

What makes the 'Northern Lights' the most colourful sight on Earth?

Could a low dose of radiation actually be good for you?

Do you get a dangerous dose of cosmic rays if you fly often?

Learning objectives

- Atoms are made from particles that can be combined in different ways to produce isotopes, some of which are unstable.
- There are different types of ionising radiations that have different properties.
- The activity of a radioactive source can be measured and used in practical situations.
- Radioactivity has useful applications in everyday life and medicine.

Glossary

You will be expected to be able to recall, explain, describe and use appropriately the following words and phrases:

alpha particle	electron	mutation	radioactivity
atom	gamma ray	neutron	radon gas
atomic mass	half-life	nucleus	sterilisation
atomic proton number	ionising radiation	mass nucleon number	X-rays
background radiation	isotope	proton	
beta particle	magnetic field	radioactive dating	

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Learning outcomes

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Students will be assessed on their ability to:

- describe uses of radioactivity, for example, in household fire (smoke) alarms, in treating food so it keeps longer — P2 11.1
- compare the properties of X-rays and gamma rays including their ionising abilities, production and detection — P2 11.2
- describe uses of radioactivity in medical applications for both diagnosis and treatment for patients and also for sterilisation of equipment — P2 11.3
- describe the nature of alpha, beta and gamma radiation and compare their abilities to penetrate and to ionise — P2 11.4
- describe the structure of an atom in terms of protons, neutrons and electrons and describe particular nuclei using symbols in the format: — P2 11.5

  ${}^{m}_{p}X$

- **use the terms atomic (proton) number and mass (nucleon) number to explain the structure of isotopes** — P2 11.6
- **recall that alpha and beta particles and gamma rays are ionising radiations emitted from unstable nuclei in a random process** — P2 11.7
- describe how the activity of a radioactive source decreases over a period of time — P2 11.8
- use the concept of half-life to carry out simple calculations including graphical representations — P2 11.9
- explain how graphical representations of half-life can be made using suitable software, and compare this to traditional methods of creating graphical representation — P2 11.10
- demonstrate understanding that scientific conclusion, such as those from radioactive dating, often carry significant uncertainties — P2 11.11
- describe how scientific ideas change over time, eg the risks associated with radioactive sources — P2 11.12

continued...

- **recall the origin of background radiation from Earth and space** P2 11.13
- **explain what is meant by background radiation and explain how regional variations within the UK are caused in particular by radon gas** P2 11.14
- describe the dangers of ionising radiation in terms of tissue damage and possible mutations and relate this to the precautions taken while carrying out demonstrations at school P2 11.15
- **explain how the Earth's atmosphere and magnetic field protects it from radiation from space.** P2 11.16

Topic 12 — Power of the Atom

Nuclear energy provides an important economic basis for the production of electricity in the modern world, although the waste products from the process are extremely dangerous. Nuclear reactions provide the energy for stars, some submarines and nuclear weapons. Applications of nuclear energy raise ethical, social, economic and environmental issues that can be debated during the study of this topic. Students could use secondary data sources for this debate to help them draw conclusions. Students will have the opportunity to understand the chain reaction and how this may be controlled in a nuclear reactor to produce electricity.

Electricity, or more precisely electric current, is the movement of charged particles. Students will study the two different types of charges and how the movement of electrons can cause strange phenomena, including shocks and lightning. Although static charge can cause hazards, for example when fuelling aircraft, it can also be used in technological applications such as photocopiers and laser printers.

Guidance for students

Have you ever wondered?

What does E = mc2 really mean?

How easy is it to build an atom bomb?

Should we switch to nuclear power to stop global warming, as it doesn't produce greenhouse gases?

Is it safe to bury nuclear waste underground in the UK?

Two scientists claimed they could make a nuclear power station in a test tube. Are they crazy?

Your teacher can create lightning bolts and make objects levitate — is this magic or physics?

What should you do if you're in the countryside when lightning strikes?

Learning objectives

- Nuclear power stations use chain reactions to produce electricity.
- The Sun produces its energy using nuclear fusion.
- The movement of charged particles forms an electric current.
- Static charges have useful applications but they can also create hazards.

Glossary

You will be expected to be able to recall, explain, describe and use appropriately the following words and phrases:

attraction	electrical energy	insulation	radioactive
chain reaction	electrostatic	nucleus	repulsion
decay series	fission	neutron	thermal energy
daughter nucleus	fusion	nuclear reactor	

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Learning outcomes

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Students will be assessed on their ability to:

• demonstrate understanding of how scientific theories are used to make predictions	P2 12.1
• explain the principle of a nuclear chain reaction	P2 12.2
• describe the fission of U-235 to produce two daughter nuclei and two or more neutrons	P2 12.3
• **describe a simple decay series starting from the daughter products of U-235**	P2 12.4
• explain how a chain reaction can be used for both peaceful and destructive purposes	P2 12.5
• explain how the chain reaction is controlled in a nuclear reactor	P2 12.6
• evaluate the benefits and drawbacks of nuclear power for generating electricity, for example, carbon dioxide emissions, risks, public perception, waste disposal and safety issues	P2 12.7
• describe the environmental and social impact of a nuclear power station on a locality	P2 12.8
• describe how thermal energy from the chain reaction is transferred to electrical energy in a nuclear power station	P2 12.9
• explain that the products of nuclear fission are radioactive and discuss the long-term possibilities for storage/disposal of nuclear waste	P2 12.10
• **demonstrate understanding that nuclear fusion requires extremely high temperatures and densities, and relate this to the difficulty of making a practical and economic form of power**	P2 12.11
• **describe how fusion differs from fission and recognise it as the energy source for stars**	P2 12.12

continued...

- demonstrate understanding that new scientific theories, such as 'cold fusion', are not accepted until they have been validated by the scientific community — P2 12.13
- explain common electrostatic phenomena in terms of the movement of electrons, for example, shocks from car doors, charges on synthetic fibres, dust on television screens and lightning — P2 12.14
- demonstrate understanding that like charges repel and unlike charges attract — P2 12.15
- explain how insulating and insulated materials can be charged by contact by the transfer of electrons — P2 12.16
- describe some of the potential dangers of electrostatic charges, such as fuelling aircraft, and describe some of the uses of electrostatic charges, such as fingerprinting and laser printing. — P2 12.17

GCSE Biology, GCSE Chemistry and GCSE Physics — extension units

B3

Topic 1: Biotechnology

Topic 2: Behaviour in Humans and Other Animals

C3

Topic 3: Chemical Detection

Topic 4: Chemistry Working for Us

P3

Topic 5: Particles in Action

Topic 6: Medical Physics

Information for teachers

The format of the extension units is similar to GCSE Science and GCSE Additional Science with modifications to respond to the assessment requirements.

Students will be assessed on their ability to:

These are the assessment evidence requirements. Students are required to provide evidence that they have achieved them either through compiling a portfolio or through external assessment.

At the end of this unit students will be able to describe and explain the following statements and carry out the tasks indicated:

These are the referenced statements giving the context in which students will either compile their portfolio in order to demonstrate that they have met the learning outcomes, or answer questions in an external assessment.

In the following units students will have opportunities to explore the topics in a practical way.

Unit B3

Topic 1 — Biotechnology

Biotechnology is one of the fastest growing new industries in the developed world. The biotechnology industry will need highly-skilled people to work in it. This unit gives students the opportunity to study the contribution of biotechnology in the production of food and drink, and how this could impact on world food shortages, the treatment of disease and development of new medicines.

As with all new developments, advances in biotechnology raises new ethical questions which will be considered in this topic.

Guidance for students

Have you ever wondered?

Will scientists be able to make me a personalised medicine?

Who owns the medicine if the original plants come from a different country?

Are we able to cure genetic diseases?

Should you be allowed to choose the sex of your baby?

Is genetically modified food safe to eat?

Do genetically modified organisms harm the environment?

Can't we already feed the world?

Should we be making developing countries buy new seeds every year?

Learning objectives

- The food industry has traditionally made much use of biotechnology in the production of many food items, for example cheese, yoghurt, alcohol, chocolate, soy sauce and, more recently, mycoproteins and prebiotics.
- Plants can be modified to be resistant to herbicides and/or pests and this has environmental implications.
- The pharmaceutical industry generates a lot of money annually and consideration of the contributors to this profit and its distribution is needed.
- Stem cell research must consider many ethical questions, including the definition of 'life'.
- Organisms can be genetically modified to produce substances, including medicines that are of direct use to human health.

Glossary

You will be expected to be able to recall, explain, describe and use appropriately the following words and phrases:

amino acid	ethics	herbicide	pasteurisation
artemisinin	fermentation	insulin	prebiotics
bacteria	filtration	invertase	quinine
biotechnology	gelling agent	lactic acid	resistance
breeding	gene	lactose	salicin
cholesterol	genetic engineering	malaria	stem cells
chymosin	genetic modification	microorganism	taxol
citric acid	genome	obesity	toxin
enzyme	genomics	oligosaccharide	vector
ester	glutamic acid	Parkinson's disease	yeast

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Learning outcomes

Students will be assessed on their ability to:

- distinguish between and use primary and/or secondary data
- discuss and evaluate evidence and data
- consider ethical, contemporary and social issues.

At the end of this unit students will be able to describe and explain the following statements and carry out the tasks indicated:

Food and drink

- bacteria are used in the production of yoghurt from milk by the conversion of lactose to lactic acid — B3 1.1
- the commercial production of soy sauce includes fermentation of a mixture of cooked soya beans and roasted wheat using *Aspergillus*, further fermentation using yeasts and then *Lactobacillus*, filtration, pasteurisation, sterile bottling — B3 1.2
- functional foods are not necessarily produced by fermentation, including prebiotics such as oligosaccharides found as a food ingredient on the supermarket shelf, and 'spreads' that contain plant stanol esters that lower cholesterol — B3 1.3
- prebiotics are functional foods that are marketed as providing health benefits — B3 1.4
- microbial products are used in food, including: — B3 1.5
  - vitamin C produced by *Acetobacter* spp. (bacterium)
  - carrageen, a gelling agent from seaweed
  - enzymes such as invertase (sucrase) produced by *Saccharomyces cerevisiae* (yeast) used in the manufacture of sweets
  - citric acid produced by *Aspergillus niger* (fungus) used in fizzy drinks
  - amino acids such as glutamic acid produced by *Corynebacterium glutamicum* (bacterium) and the flavour enhancer, monosodium glutamate (MSG), a sodium salt of glutamic acid
- the production of the enzyme chymosin, produced by genetically altered microorganisms, which is used in the manufacture of vegetarian cheese — B3 1.6

continued...

- the importance of having a well-balanced diet, in terms of a healthy lifestyle B3 1.7
- the possible consequences of being severely overweight or underweight for your height B3 1.8
- the potential of biotechnology and evaluate in relation to world food shortage, eg kwashiorkor. B3 1.9

Plant modification

- weed control to reduce loss of food supplies by genetically modifying crops to ensure they are resistant to herbicides B3 1.10
- the use of *Agrobacterium tumefaciens* as a vector to transfer genes coding for herbicide resistance to the genome of a plant cell B3 1.11
- breeding insect-resistant plants including the insertion of the toxin gene from *Bacillus thuringiensis* and inserting it into plants B3 1.12
- the ethics of genetic modification and its use, for example, plants and animals in developing countries. B3 1.13

Reproduction

- stem cell research and therapies as possible treatments for diseases such as Parkinson's disease B3 1.14
- allowing people to choose the sex of their baby may skew the sex balance of the population and may lead to other choices being permitted — including colour of eyes B3 1.15
- ethical implications of reproductive biology research. B3 1.16

Pharmaceuticals

- the importance and medicinal value of drugs produced by plants, including: B3 1.17
  - aspirin — compound called salicin found in the bark and leaves of willow plants used for pain-relief
  - taxol — derived from the bark of the Pacific yew tree and used as an anti-cancer agent
  - quinine which comes from the bark of the cinchona tree: until the 1930s it was the only real treatment for malaria
  - artemisinin and its derivatives — extracted from the Chinese plant *Artemisia annua* used for treating malaria and reducing its transmission
- consider the advantages and disadvantages of drugs derived from plant sources compared to synthetic drugs B3 1.18
- an awareness of the potential for discovering sources of new drugs, including rainforests B3 1.19
- the production of insulin using genetic engineering: an understanding of the role of recombinant DNA technology including restriction enzyme, ligase and sticky ends B3 1.20
- the role of biotechnology in developing new substances, for example, the use of genomics in medical research to develop personalised medicines. B3 1.21

Topic 2 — Behaviour in Humans and Other Animals

Behaviour is an essential part of any animal's strategy for survival. This unit gives students an insight into instinctive and learned behaviour and how humans may make use of conditioning when training animals. Understanding why people behave as they do helps us to make rules and laws that work. The topic compares feeding behaviour in herbivores and carnivores and considers parental care as part of reproductive behaviour. It also explores the ethical issues surrounding the use of animals by humans.

Guidance for students

Have you ever wondered?

Why do dogs greet each other by sniffing?

Why do fish shoal?

What instincts are you born with and what do you learn?

How can people 'read' your face?

Why do cows spend all day eating?

Why are dogs so different from cats?

How does sexual attraction work in humans?

Do animals have rights?

Learning objectives

- Animals have evolved instinctive behaviours, through natural selection, which increase their chances of survival.
- Animals learn throughout their lives to increase their chances of survival and reproduction.
- Feeding behaviours maximise animals' chances of finding sufficient food.
- Reproductive behaviours maximise animals' chances of successfully passing on their genes.
- Social behaviours and communication skills enable animals to respond in particular ways to members of their own species and to members of other species.
- Humans have made use of other animals in different ways, and there is an increasing awareness of animal welfare issues that need to take account of animal behaviour.

Glossary

You will be expected to be able to recall, explain, describe and use appropriately the following words and phrases:

anthropomorphism	emotion	inherit	protection
behaviour	evolution	instinctive	selection
bird	experience	learning	sexual reproduction
carnivore	facial expression	mammal	signal
communicate	gesture	pack	sound
conditioning	great ape	pheromones	vertebrate
conscious	habituation	posture	
courting	herbivore	predation	

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Learning outcomes

Students will be assessed on their ability to:

- distinguish between and use primary and/or secondary data
- discuss and evaluate evidence and data
- consider the ethical, contemporary and social issues.

At the end of this unit students will be able to describe and explain the following statements and carry out the tasks indicated:

Instinctive and learned behaviour

- animals inherit certain patterns of behaviour from their parents known as instinctive behaviour — B3 2.1
- an animal's early experiences in life have a big impact on the way in which it behaves as an adult — B3 2.2
- habituation is an important part of the learning process in young animals — B3 2.3
- animals can learn through conditioning — B3 2.4
- humans can make use of conditioning when training captive animals for specific purposes. — B3 2.5

Social behaviour and communication

- much behaviour requires animals to communicate — B3 2.6
- communication can happen in many different ways — sounds, signals, and chemicals (pheromones) — B3 2.7
- most mammals are able to communicate their intentions through body posture and facial expression — B3 2.8
- facial expressions are species-specific; a gesture or expression may appear as a threat to one species, but may mean something totally different to another — B3 2.9

continued...

- humans have developed highly-complex ways of communicating — transmitting knowledge of past events, emotions, and complex ideas to other humans B3 2.10
- humans are conscious of the outcomes of their actions, and as a result are more self-aware than other animals. B3 2.11

Feeding behaviours

- feeding behaviours are different depending on the type of food being consumed B3 2.12
- herbivores have to eat more food in order to get the nutrients (particularly amino acids) they require so that more time is spent eating B3 2.13
- vertebrate herbivores may feed in large groups or herds, and they may do so for protection in numbers. This is a successful evolutionary strategy, even though some members of the herd may be killed B3 2.14
- vertebrate herbivores who feed in large groups usually need to be continually on the move to find new feeding areas B3 2.15
- herbivores have to be good at avoiding, fleeing from, or resisting predation B3 2.16
- carnivores eat protein-rich food and have to spend less time actually eating B3 2.17
- carnivores have to be good at detecting and catching their food B3 2.18
- some carnivores hunt efficiently in packs B3 2.19
- some carnivores hunt efficiently as individuals B3 2.20
- mammals and birds have special feeding behaviours in relation to their young, since they show parental care B3 2.21
- some animals have developed the use of tools in their search for food. B3 2.22

Reproductive behaviours

- sexual reproduction requires the finding and selection of a suitable mate, and can involve courting behaviour B3 2.23
- some animals mate for life, others select several different mates during the mating season B3 2.24
- some animals, in particular birds and mammals, have developed special behaviours for the rearing of young, since they display parental care B3 2.25
- parental care is a successful evolutionary strategy; although it involves risk to the parents, it can increase the chances of survival of the parental genes. B3 2.26

continued...

Human behaviour in relation to other animals

- humans are one of the great apes, and have developed from small family groups of hunter-gatherers, closely related to bonobos (pygmy chimpanzees), to complex societies capable of gross modification of their own environment — B3 2.27
- humans have exploited other animals; originally hunters, they domesticated animals that helped them hunt; as humans developed agriculture, humans exploited herd animals to provide a constant and dependable source of food — B3 2.28
- humans have exploited animals in other ways, as a source of clothing and domestic materials and, more recently, for medical purposes — B3 2.29
- humans also use animals as a source of entertainment (hunting, racing, circuses, wildlife parks) and companionship (pets) — B3 2.30
- humans now debate the ethics of the use of animals in these different ways; some consider that animals have rights comparable or identical to humans, others consider that such beliefs are not tenable — B3 2.31
- it is a mistake to interpret behaviour observed in other animals as showing human characteristics (anthropomorphism) — B3 2.32
- it is also a mistake to assume that human and animal behaviours have nothing in common. — B3 2.33

Unit C3

Topic 3 — Chemical Detection

In this topic analytical chemistry is used to enable students to widen and deepen their experience of reaction chemistry and related calculations.

Students should come to understand that the first step, when an unidentified substance is found, is to discover what the substance contains. The reactions of ions in solution provide extensive opportunity for practical work and consolidation of the idea that given ions have characteristic reactions and that these reactions can be used to identify them. The final challenge in this area, to identify an unknown ionic compound, can give students satisfaction and proof of their new-found abilities! Students can be introduced to ionic equations as an extension of their practical work and should come to appreciate that these equations show only the ions which react to give, or are produced from, non-ionic products and precipitates.

Calculations will help students to understand that amounts of substances can be measured in moles of particles as well as in grams or as a number of particles. The idea that one mole of molecules of any gas occupies the same volume under the same conditions of temperature and pressure enables students to do calculations involving the production of gases from solid and liquid reactants. An understanding of Avogadro's law enables them to do calculations for reactions involving solely gaseous reactants and products.

Students can investigate applications of qualitative and quantitative analysis in fields such as forensic science, quality control and research. The topic will also help students to appreciate the need for accuracy and reliability of data.

Guidance for students

Have you ever wondered?

How does a forensic scientist works?

Why do we need to analyse substances?

Why is it important to know that the label of contents on the packet is correct?

How do we find out how much of a substance is present in a given sample?

How pure is our water and how pure does it need to be?

Learning objectives

- Cations and anions are present in many samples and can be identified.
- Amounts of substances present can be calculated in moles.
- How to calculate the amount of raw materials to use in a chemical reaction in order to produce the mass of product required
- The importance of knowing the purity of substances and that different users require different levels of purity.

Glossary

You will be expected to be able to recall, explain, describe and use appropriately the following words and phrases:

acid	flame test	mole	reactant
anion	indicator	precipitation	titration
Avogadro's law	ion	purity	
base	ionic substance	qualitative	
cation	molar volume	quantitative	

Information for teachers

ICT is an integral part of the way science works, and students should be given opportunities to experience and explore its use. It is expected that ICT will be used where it enhances the learning and teaching of science and helps to make scientific concepts easier to understand.

Some of the learning outcomes have been written deliberately in order to promote discussion and expression of opinion. Where contentious, unresolved or other scientific issues are discussed, it is expected that students will be exposed to the facts, evidence and opinions from all sides of the argument.

Learning outcomes

Students will be assessed on their ability to:

- distinguish between and use primary and/or secondary data
- discuss and evaluate evidence and data
- consider the ethical, contemporary and social issues.

Students will be expected to:

- recall the formulae of elements and simple compounds in the topic
- represent chemical reactions by word equations and simple balanced equations and use state symbols (s), (l), (g) and (aq)
- write balanced equations to describe and explain a wide range of reactions in this topic
- write balanced ionic equations to describe and explain a wide range of reactions in this topic.

At the end of this unit students will be able to describe and explain the following statements and carry out the tasks indicated:

What is present?

- why substances need to be identified and their purity determined C3 3.1
- analysis may be qualitative or quantitative C3 3.2
- ionic substances are identified by identifying each type of ion they contain C3 3.3
- why the test for each ion must be unique C3 3.4
- precipitation reactions form the basis of some tests for ions C3 3.5

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