Answers

9A Genetics and evolution

9Aa Environmental variation

Student Book

1: 9Aa Monsters and myth

1 **a** no longer living

b any one sensible suggestion, such as change in environmental conditions, disease or the introduction of a predator/humans

2 **a** any two sensible suggestions, such as size, length of neck, shape of head, shape of teeth

b by the environment or by inheritance/heredity

3 a group of organisms that can reproduce with one another to produce offspring that can also reproduce

4 *Megalosaurus*

5 nucleus (it is also found in mitochondria but students may not know this)

2: 9Aa Environmental variation

1 sensible suggestions, such as being given the right amount of water, warmth, light, carbon dioxide, nutrients/minerals/mineral salts

2 **a** two from: amount of light, temperature, humidity, wind/air currents/draught

b other humans and possibly other plants and/or animals

3 **a** B – the tree is bent/curved; C – the apples have scabs/damaged skin; D – the person has a scar

b B – wind; C – a parasite/insect/disease; D – fire (knife or other sharp object or disease are also sensible suggestions)

4 **a** one of: hair length, clothing

b continuous because they can have any intermediate value between two points

5 B – continuous (there are degrees of curvature); C – discontinuous (the fruit either has the disease or does not) but some students may justify continuous as being the amount of the fruit affected and this should be considered as correct; D – discontinuous (the person either has a scar or not) but again some students may justify this as continuous by taking into account the amount of scarring and this should be considered correct

6 **a** They are probably the same species.

b Plants that look very different from each other may not look as if they are the same species and so may be classified as two different species.

Activity Pack

9Aa-1 Environmental variation

1 water, light, mineral salts, warmth

2

- characteristic – a feature of an organism
- environment – the conditions in a habitat
- environmental factor – anything that can change the conditions in a habitat or the organisms that live there
- environmental variation – differences between organisms caused by environmental factors
- physical environmental factor – something non-living in an organism's surroundings that can change it

3 **a** hair colour

b chin shape (or hair colour)

c moles

4 produce offspring

5 **a** diet (lack of algae or shrimps)

b They may have thought that they were a new species of flamingo.

9Aa-4 In the garden

1 small plants – shaded by apple tree; apple tree missing branches – person sawing; bigger tomato plants – extra fertiliser added; apples with holes in – bird feeding on them; short grass – lawnmower; plants missing flowers – person picking them; lettuce leaves with holes – rabbit

2 continuous variation examples: smaller/bigger plants

discontinuous variation: number of holes in apple/lettuce leaf, or whether a plant has been attacked by something or not

9Aa-5 More environmental variation

1 (possible answers)

person with a suntan – Sun

plant with holes in leaves – snails

wilted plant – lack of water

tree with hole in it – woodpecker

person with big muscles – exercise

tree growing at an angle – wind

2 A living thing is called an *organism*. Different types of organism are called *species*. There is a lot of *variation* between different species. Some variation is caused by *factors* in an organism's surroundings. These are called *environmental*

factors and they cause *environmental variation*. Some of these factors are other organisms but others are non-living factors, and these are called *physical environmental factors*.

3 **a** discontinuous

b continuous

9Aa-6 Environmental variation in plants

1 Five of the following, presented in a table.

Environmental factor	Environmental variation
soil acidity	height of plant
soil drainage	fungal diseases/crown rot
sunlight	brown leaves
wind	brown leaves
slugs/snails	damaged to/eaten/holes in leaves

2 **a** light

b scatter graph accurately plotted

c The greater the light level, the longer the leaf.

d The more light, the more food the grass can make and so the faster it can grow.

e continuous

3 **a** A group of organisms that can breed with one another to produce offspring that will also be able to reproduce.

b The lower the temperature the redder the lettuces were.

c Lettuces that have grown at higher temperatures may be thought to be a different species from those grown at lower temperatures (because they will be different colours).

9Aa-7 Do starlings learn?

1 **a** It is caused by a factor in the environment (other people) rather than something you are born with.

b learned behaviour

2 A more reliable conclusion can be drawn if more animals are used.

3 **a**

What the trained starling did	What the observer starling did	
	pushed	pulled
pushed	15	1
pulled	7	7

b Yes. If pushing is more innate then the fact that half of the birds pulled after watching the demonstrator pulling suggests that they had learned something.

c A table allows you to compare figures at a glance and puts everything in the same format.

4 **a** Pushing, because almost all of the observer starlings in the 'pushing trial' pushed. In fact the researchers suggested that this was because starlings' usual way of feeding is to push their beaks down into a lawn and open them to create a tunnel through which to look for their prey.

b Not very valid because the experiment was designed to look for social learning and not to identify innate behaviours.

c Put hungry starlings that have been hand-reared (and so have not learned things from the parents) into the apparatus and see what they do to the lid in the box.

5 They can learn the best methods for obtaining food and so be more able to survive.

6 **a** any two human innate behaviours (e.g. blinking, sneezing, knee jerk)

b any two learned behaviours in animals (e.g. animal learning where food is, avoiding unpleasant things, birds singing); students may relate their answers to the behaviour of pets.

c suitable suggestions as to why learning and innate behaviours are useful for animals

9Ab Inherited variation

Student Book

1: 9Ab Inherited variation

1 three of: skin colour, 'leaf' colour, flesh colour, size, shape

2 **a** her father

b hair colour

3 Environmental variation is caused by factors in your surroundings but you get inherited variation from your parents.

4 T and Y are brothers; U, W, X and Z are brothers (the actors Alec, Stephen, Daniel and Billy Baldwin); V is not related to anyone else in the photo.

5 nucleus (students may not know that mitochondria also contain genetic information)

6 student's own response, e.g. hair colour, eye colour, handedness, blood group, etc.

7 Foot length can be any value (some people have very short feet and some people have very long feet and any value between those two extremes is possible. Shoes are only available in certain sizes and so are an example of discontinuous variation.

8 inherited variation and diet

9 suggestion, such as height of plant, size of tomatoes; as well as genes, these are also affected by e.g. water, feeding, light

10 a

	inherited	environmental	continuous	discontinuous
natural eye colour	✓		✓	
skin colour	✓	✓	✓	
having a scar		✓		✓
hair length		✓	✓	
naturally curly hair	✓			✓
blood group	✓			✓
speaking Welsh		✓		✓
dimpled chin	✓			✓
wearing a watch		✓		✓
height	✓	✓	✓	

b height

2: 9Ab Probability

1 pie chart

2 a fraction out of 100

3 the chance of something happening

4 94 cm sleeves

5 student's own results

6 0.5

7 2/6 which is 1/3, 0.33, 33%

Activity Pack

9Ab-1 Inherited variation

1 a

	David	Marta
hair colour	✓	
hair curliness	✓	
nose shape	✓	

b Environmental variation is differences in characteristics caused by things around you whereas inherited variation is differences in characteristics that you get from your parents.

2 a in the nuclei of all cells

b controls inherited characteristics

3 a 325–329 cm

b a normal distribution

c They are the most numerous (regardless of whether you choose mean, mode or median).

9Ab-4 Eye colour probabilities

6 a It suggests a normal distribution.

b It is continuous variation.

c The pattern is shifted towards dark brown in Wales.

9Ab-5 Probability

1 The ordering of the cards (and probabilities to one decimal place) are:

nearly 0	0.1	0.2	0.3	0.4	0.5
Likelihood that a living dinosaur will be found tomorrow.	The likelihood that a person you meet at random is left-handed: 11%.	Probability of snow falling on 25 December in Lancashire: 1/5.	Probability that a person you meet at random has A+ type blood is 311 in every 1000.	Probability that a middle-aged person will die if they catch Ebola: 2/5.	The likelihood of a couple with 4 children having 2 girls and 2 boys.
0.6	**0.7**	**0.8**	**0.9**	**nearly 1**	
Based on past performance, the likelihood of Newcastle beating Sheffield is 0.6.	Experts say there is a 70% chance of a powerful earthquake in Tokyo in the next 4 years.	Likelihood that a randomly picked molecule of air is nitrogen.	Likelihood that if I roll two dice the score will not be 12.	Probability that the Sun will rise tomorrow.	

2 The following should be in the correct order and position on the scale:

a 0.125

b 0.27

c 0.33

d 0.003

e 0.8

f 0.14

9Ab-6 Characteristics

1

Characteristic	Inherited	Environmental	Both
colour of eyes	✓		(✓ coloured contact lenses)
colour of skin			✓
colour of hair			✓
length of hair		✓	
scars		✓	
height			✓
weight			✓
shape of fingernails		✓	
need to wear glasses	✓		
shape of nose	✓		(✓ broken nose)

2 **a** genetic information

b within the nuclei of cells (or genes, chromosomes but this has not yet been met)

9Ab-7 Inheritance

1 **a** From top left, clockwise:

The *male* gamete is called the *sperm cell*.

fertilisation

The *zygote* contains the same amount of *genetic information* as a normal body cell.

The *nucleus* contains half the *genetic information* of a normal body cell.

The *female gamete* is called the *egg cell*.

b It contains the instructions for characteristics and controlling the cell.

2 **a** chin shape, ear shape

b chin shape, ear shape

c They have each inherited a slightly different mixture of their parents' genes.

d Two of: They have had different diets, or have inherited slightly different genetic information for height, or are different ages.

9Ab-8 Wild tomatoes

1 **a** yellow patches on leaves, younger leaves are twisted, plant does not grow very tall, resistance to the virus

b one of: yellow patches – virus, younger leaves twisted – virus, plant height – amount of mineral salts/light/virus.

c Resistance to the virus is dependent upon the genetic information in the plant, and this was inherited from the plant's parents.

2 **a** those in section A because they are the least badly affected by the virus

b a normal distribution

c Inherited variation that is continuous usually shows this pattern.

d The mosaic virus kills more of the plants, which are the food for blister beetles. So there is less energy from the plants to support a large population of blister beetles. Robber flies eat blister beetles and so with fewer blister beetles there is less energy from them to support a large population of robber flies.

e any two from: genes, lack of sunlight (less photosynthesis means slower growth), lack of mineral salts, cold weather

3 Each gamete contains a slightly different mix of chromosomes/genes/genetic information from the parent, so during fertilisation many different genetic variations can occur.

9Ab-9 Mendel

1 **a** suggestions include amount of light, mineral salts, water and temperature

b grow all the plants in exactly the same conditions

c graph sketch showing a normal distribution curve

2 **a** round seeds, tall plant, purple flower

b within the nucleus of a cell/on chromosomes/on genes

3 **a** wrinkled to round: 0.75; tall to short: 0.74; purple flower to white flower: 0.76

b They are all about the same probability, around 0.75.

4 **a** round seeds

b 0.25 (25% or ¼)

9Ac DNA

Student Book

1: 9Ac DNA

1 suggestions could include scientific papers/journals, conferences, private letters, meetings

2

Scientist	Contribution
Rosalind Franklin	took photos of DNA using X-rays
James Watson	helped build a double helix model of DNA in 1953
Maurice Wilkins	spent years testing the double helix model of DNA
Francis Crick	recognised the shape spiral molecules make on X-ray photos

3 any two inherited characteristics (e.g. blood group, eye colour, natural hair colour, handedness)

4 male – there is one X sex chromosome and one Y

5 **a** 23 **b** 46 **c** 46 **d** 46

6 **a** 2

b because each cell has two copies of the same chromosome (which contain the same genes), one from the mother and one from the father

7 Student's own diagram to show how DNA, chromosomes, genetic information and genes are linked. This could be a concept-map type diagram.

2: 9Ac Genetic counselling

1 46

2 Sequences X and Y. They both have ATGC sequences that have a difference to the normal gene. Sequence X (which was given to students in the caption) has an A instead of a T at the 5th position from right (highlighted). Sequence Y has a T instead of a C at the 6th position from right. (Sequence Z is identical to sequence W.)

3 One or more of:

- testing for genetic disorders means that they can be spotted and treated early before they cause too much damage
- developments in technology mean that it is faster/cheaper/easier to do
- developments in technology and science mean that we know about more genes that should be checked
- more and more people want them, as education about genetics improves

4 To see whether either parent is a carrier of a genetic disorder, which a baby may then have. (There may then be options, such as embryo selection and IVF, to ensure a healthy child.)

5 The answer should deal with both sentences. For the first sentence, one or both of these points:

- everyone has two copies of every gene, which may be slightly different
- some of these differences can cause genetic disorders/problems (such as Alzheimer's disease) For the second sentence, one or more of these points:
- having this version of the APOE gene increases the chance that you will get Alzheimer's disease
- the chance that you will get Alzheimer's disease for the age of 85 is 1 in 5
- in the general population, 13 out of every 100 people will get Alzheimer's disease.

If you have one copy of this 'variant', then 20 people out of 100 will get Alzheimer's disease.

Activity

1 There is only one chromosome 21. And one chromosome 14 has an extra bit. (This is actually the other copy of chromosome 21.)

2 **a** Students need to show some evidence that they have researched the effects of Down's syndrome (such as flat facial features, an upward slant to the eyes, small ears, protruding tongue, slower physical and mental development).

b Two or more of:

- the person is a man (because photo D shows an X and Y chromosome)
- so he will not cause an increase in the risk of having a baby with Down's syndrome
- his partner/wife could also be tested, to make sure that her chromosomes are normal
- he may pass on his chromosomes to his child, and if that child is female she would be at greater risk of having a baby with Down's syndrome.

Activity Pack

9Ac-1 DNA

1 **a** cell nuclei

b DNA (deoxyribonucleic acid, although students have not been introduced to this term)

2 in genes, in chromosomes, in DNA, in animal cells, in plant cells, in gametes (all of them)

3 in a gene

4 chromosome 1

5 liver cell – 46, sperm cell – 23, zygote – 46

6 Rosalind Franklin: Took photos of DNA using X-rays.

James Watson: Helped build a double helix model of DNA in 1953.

Maurice Wilkins: Spent years testing the double helix model of DNA.

Francis Crick: Recognised the shape spiral molecules make on X-ray photos.

7 on chromosomes

9Ac-5 Chromosomes, genes and DNA

1 **a** DNA

b nucleus

2 **a** 38

b horse

c bar drawn to 46 chromosomes

d because the cells have two copies of each type of chromosome so will always have an even number

e and f No. Shrimps are very much smaller than cats, horses and humans but have many more chromosomes.

3 **a** chromosomes

b inherited characteristics

4 **a and b**

5 *Watson* helped build a correct double helix model of DNA.

4 *Crick* recognised the pattern on an X-ray photo.

3 *Wilkins* showed an X-ray photo to Francis Crick.

1 *Franklin* told Watson and Crick their model was wrong.

2 *Franklin* took a very good X-ray photo of DNA.

9Ac-6 Models for genetics

The wallet signifies the cell; the credit card pocket is the nucleus; the credit card is a chromosome containing DNA; chip on the card models the genes that contain genetic information.

9Ac-7 Chromosomes

1 **a** DNA

b Two chromosomes drawn in above '3', both looking the same and of intermediate height between those numbered '2' and those numbered '4'. Also an identical chromosome '10' should be drawn in.

c more (because it is larger)

d the same number

e inherited characteristics

2 muscle cell – 46, red blood cell – 0 (they do not contain nuclei), egg cell – 23, zygote – 46

3 They built a model of DNA that explained the evidence of its structure.

4 factory building – cell, computers – chromosomes, software – genes/genetic information, central office – nucleus

9Ac-8 DNA structure

1 **a** Watson and Crick

b The expected answers are either Franklin, who took X-ray pictures of DNA, or Wilkins, who tested the Watson and Crick model.

2 Levene's model had equal amounts of A, T, G and C.

3 **a**

Ratio	i	ii	iii	iv	v	vi
	A/C	A/G	A/T	C/G	C/T	G/T
human	1.47:1	1.42:1	1.03:1	0.97:1	0.70:1	0.73:1
octopus	1.89:1	1.89:1	1.05:1	1.00:1	0.56:1	0.56:1

b A paired with T and C paired with G. Those are the ratios that come out at or very close to 1:1 (i.e. one of each base).

4 Levene thought this as there is much more variety possible in a sequence of 21 different proteins, or it could be that Levene's model showed no variation in the sequence of the bases.

9Ad Genes and extinction

Student Book

1: 9Ad Genes and extinction

1 **a** 'Light' is the expected answer.

b The lack of light meant that the plants could not photosynthesise properly and died, which meant that animals had less to eat and so also died.

2 **a** claws **b** tail

3 **a** through lack of food

b They can store more fat in their bodies because they are bigger.

c The adaptations that squirrels have are caused by their genes.

4 The grey squirrels are better adapted. Grey squirrels carry squirrel pox, which kills red squirrels.

5 Red squirrels are smaller and so more able to get out onto the thin branches.

6 Ideas include: putting out extra food in winter, making sure that grey squirrels don't enter the area or killing those that do.

7 Ideas include: native Hawaiian animals depend on it for food/shelter; it is an attractive plant; it may contain substances that will be useful to humans in the future; they help hold the fragile volcanic soil together.

8 The population will decrease. Ideas could include: the lack of snow means that they will not be so well camouflaged and so their prey will see them coming and they will not get enough to eat; the lack of sea ice means that there is less space for them to live and breed, putting them into competition with one another and/or meaning that supplies of food in the areas around land will become depleted more quickly by larger numbers of bears; higher temperatures will mean that the bears overheat.

9 The seeds from an extinct species can be taken out of the gene bank and planted. Or tissues from extinct species of plants could be used to regrow them, in a similar way as taking a cutting works.

Activity Pack

9Ad-1 Genes and extinction

1 Dinosaurs died out completely (became *extinct*) about 65 *million* years ago. Many scientists think this was because a giant *meteorite* hit the Earth and threw massive amounts of *dust* into the *atmosphere.* This blocked out the sunlight and so plants could not *photosynthesise*. The plants died and animals could not get enough to eat.

2 **a** red

b A long bushy tail for balancing, or sharp claws for climbing trees, or sharp teeth to eat nuts and seeds.

c They can digest unripe acorns.

d The greys will eat the acorns before the reds, and so there will not be enough food for the reds to survive.

e sensible suggestion, such as provide food, stop grey squirrels entering certain areas, kill grey squirrels

3 seeds, gametes, pollen

4 one of: to protect other organisms because all organisms are interdependent, we may have new uses of some organisms in the future

9Ad-4 Tiger and deer adaptations

Adaptations, clockwise from top left:

Fur pattern to provide camouflage.

Forward-facing eyes to spot prey and judge how far away it is.

Large ears to hear danger.

Male can use antlers for protection.

Powerful legs to help it run fast.

Fur colour to match the surroundings for camouflage.

Eyes on the side of its head so it can see behind.

Large, sharp teeth to rip flesh.

Sharp claws to grab prey.

Powerful legs to help it run fast.

9Ad-6 A well-adapted animal

1 Student's own responses.

2 **a** Student's own responses.

b Student's own responses.

3 **a** Ideas could include: killing predators or organisms that would out-compete their organism; setting up breeding programmes; gene banks; or nature reserves.

b one of: to protect other organisms because all organisms are interdependent; we may have new uses of some organisms in the future.

9Ad-7 Adaptation problems

1 Ermine:

a White fur means that it is camouflaged against the snow, allowing it creep up on prey unseen, and/or hide from predators.

b Desert – the ermine's fur will make it overheat; Lake – cannot breathe underwater/cannot swim well.

c If the temperature stays above freezing then there will be no snow and so the animal will stick out, white against the green and brown vegetation.

d gametes (sperm cells and egg cells)

Cactus:

a It doesn't rain very often in the desert and so when it does rain the cactus can absorb a lot of water quickly and store it for later use.

b Arctic – it would freeze and this would damage its cells, or it would soak up too much water during the spring/summer/autumn months. Lake – cannot take oxygen or carbon dioxide out of water.

c It will soak up too much water, which may make it burst.

d seeds

Fairy shrimp:

a It can digest its food even at high pHs.

b It would freeze in the Arctic and there is too little water in a desert.

c Less acidic conditions mean that the shrimp's enzymes may not digest food as efficiently and so it may not get enough nutrition.

d gametes (sperm cells, egg cells)

9Ad-8 Dodo evidence

1 habitat destruction (chopping down the trees), introduction of new animals, getting fed by humans

2 **a** 23 400 – 20 000 = 3400 cm^3 but the model was at one fifth the size, so volume of life-size bird = 3400 × 5 = 17 000 cm^3

mass = density × volume; = 0.73 × 17 000 = 12 410 g = 12.41 kg

and mass = density × volume; = 0.84 × 17 000 = 14 280 g = 14.28 kg

so the spread of masses is 12.41–14.28 kg

b mass = density × volume; = 0.73 × (5940 × 5); = 21 681 g; = 21.68 kg

and mass = density × volume; = 0.84 × (5940 × 5); = 24 948 g; = 24.95 kg

so the spread of masses is 21.7–25.0 kg

c Yes

d Not fully, the experiment provides supporting evidence for the potential mass of fat and thin dodos. It does not provide support for captivity causing obesity, or obesity causing extinction.

3 **a** 12 kg

b Yes it does. This is the mass predicted for the thin bird so it is likely that the bird was thin.

c use more data from many more different birds to plot more points on the graph

d 1.6 kg

4 **a** This would make the skeleton heavier than it should be, making the predicted mass of the bird heavier.

b This would make the skeleton lighter than it should be, making the mass of the bird lighter.

c Match up all the bones that are the same and only take the best ones of each type.

5 They could store fat by eating a lot when there was plenty to eat in the wet season. They could then use their fat reserves in the dry season.

6 If the birds were adapted to store fat quickly when food was plentiful, but there was no period of time when they had to use their fat stores, the birds would get fatter and fatter.

9Ae Natural selection

Student Book

1: 9Ae Natural selection

1 genes

2 **a** They were less easy to spot on the blackened buildings and trees by birds that eat them.

b More of the pale moths were eaten, so a greater proportion of the moths that reproduced were black and their genes were carried into the next generation. Because more moths in the next generation carried the genes for 'blackness' there were more black moths.

3 **a** It has decreased because the buildings have been cleaned/factories do not produce all the smoke that they used to.

b The black moths are more easily seen against the paler trees and buildings and so are more likely to be eaten by the birds. So more pale moths survive and reproduce and so the next generation contains a greater proportion of pale moths.

4 **a** tolerance to salty water

b The water in the sea has been evaporating, leaving the salt behind and so making the water get more and more salty. The fish that could by chance cope with the saltier conditions were more likely to survive and reproduce, meaning that the next generation had a greater proportion of fish that could cope with the saltier conditions.

5 **a** an idea about how or why something occurs that can be tested

b when there is a lot of evidence from experiments to support the hypothesis

6 a change in characteristics over time

7 In any area, the local conditions mean that organisms with certain variations in characteristics will be more likely to survive and reproduce than other members of the species. As time goes on this natural selection means that characteristics will change. Differences in local conditions for the two populations mean that different variations may be 'naturally selected'. After a long period of time, the characteristics may have changed so much that two organisms from what were the same species are no longer able to breed successfully.

2: 9Ae Recreating animals

1 spear marks

2 two of: ear size, amount of hair, body size

3 **a** DNA

b 29

c genes

4 **a** long hair to help stop energy being transferred to the surroundings by heating (helping them to stay warm); large size meaning that energy was transferred to the surroundings less quickly; large feet to stop them sinking into the snow; large tusks to push snow out of the way

b They may have overheated in hotter parts of the world.

5 As they moved north, the animals that by chance had slightly more hair would keep a bit warmer and so would be more likely to survive and reproduce. This meant that the next generation had proportionally more animals with a bit more hair. This process happened over and over again, until there were animals with a lot of hair.

Activity Pack

9Ae-1 Natural selection

1 **a** genes/genetic information

b Pale moths would become rarer than black ones.

c Birds are more likely to eat the paler ones because they are less well camouflaged against surfaces polluted with soot.

2 **a** Some birds like bird *X* arrived on the island. They had a range of beak *lengths*, some slightly *shorter* than average and some slightly *longer* than average (*shorter and longer can be reversed in this sentence*). There were many flowers and the *population* of birds grew. However, in some years there was very little rain and so fewer flowers. All the birds could get nectar from the *shorter* flowers. However, the birds with the *longer* beaks were also able to get nectar from *longer* flowers. The birds with slightly *shorter* beaks could not feed from these flowers. The birds with *longer* beaks got more food and so were *more* likely to survive and reproduce. The next generation of birds then included more birds with slightly *longer* beaks. This process repeated over thousands of years until all the birds had much *longer* beaks and looked similar to bird *Y*. They had *evolved*.

b natural selection

c Charles Darwin and Alfred Russel Wallace

9Ae-3 Resistance to poison

1 and 2 will depend on the die rolls.

3 Students should state that the resistance levels of the population gradually increase and should then explain how this happens through natural selection, with the pesticide doing the 'selecting' of the variation in the level of resistance.

4 This is genetic variation happening in the next generation. In each generation, a characteristic will, by chance, have some slight variation amongst members of a population.

9Ae-4 Genetic variation and selection

1 natural selection – a process in which an organism is more likely to survive and reproduce than other members of the species because it possesses a certain inherited variation

evolution – a change in one or more characteristics of a population over a long period of time.

inherited variation – differences between organisms that are passed on to offspring by their parents in reproduction

2 **a** There will be fewer white mice and more grey ones.

b The grey ones are more difficult to spot by predators (more camouflaged) and so are more likely to survive and reproduce (passing on this characteristic to the next generation).

3 **a** inherited

b continuous

c far right of the graph (those with longer legs)

d The birds most likely to get enough to eat are those that can get food from more different areas/depths. They are more likely to survive and reproduce.

9Ae-5 Natural selection in birds

1 leg length

2 **a** Legs in the bird population have become longer (but there is still variation).

b As the water level rises, birds with shorter legs may not get enough to eat. The birds most likely to get enough to eat are those that can get food from more different areas/depths (i.e. those with longer legs). They are more likely to survive and reproduce and pass the longer legs characteristic to their offspring. The next generation will have a greater proportion of birds with longer legs. This process then repeats itself.

9Ae-6 Fossils and evolution

1 **a** A

b D

c they got bigger/longer; bigger eye sockets; flatter noses; bigger jaw bones

2 As the vegetation changes from soft leaves to tough ones, the animals that by chance had variations in their teeth (hard ridges) that allowed them to better chew the grass and were more likely to survive, especially in times when food was scarce. They would be more likely to survive and so more likely to reproduce. The next generation would therefore have more animals with this variation.

Award additional credit for students spotting that modern horse teeth have ridges on them to aid with grinding tougher plant material.

3 **a** W, Z, Y, V, X

b As the land dried out, the animals that by chance had variations in their feet that allowed them to have feet that were better at fast running on the ground were more likely to escape predators. They would be more likely to survive and so more likely to reproduce. The next generation would therefore have more animals with this variation.

9B Plant growth

9Ba Reactions in plants

Student Book

1: 9Ba On a farm

1 **a** photosynthesis

b starch (or glucose)

c Less sunlight for photosynthesis means that the plants will grow less well and there will be a reduction in useful crop produced.

2 2010/11, 2012/13 or 2018/19 because more wheat was used than was produced. (Note that usage above the level of production is possible due to stores of wheat from previous years when the reverse was true.)

3 to help plants grow; to add mineral salts, which plants need to grow well

4 He can't use chemical pesticides against wireworm and so needs other, more 'natural' methods.

2: 9Ba Reactions in plants

1 The tree gains much more mass than the soil loses.

2 yes, because this is the only thing that has obviously been added to the soil

3 carbon dioxide, water

4 chloroplast

5 They cannot photosynthesise if there is no light (e.g. when it is night).

6 A flow chart such as the one below.

7 three of: amount of light because photosynthesis needs energy transferred by light; water because photosynthesis needs water as a raw material; carbon dioxide concentration because photosynthesis needs carbon dioxide as a raw material; temperature because enzymes for photosynthesis work more slowly if it is colder; amount of chlorophyll/number of chloroplasts – more chlorophyll/chloroplasts = more photosynthesis.

8 It turns limewater milky.

9 **a** D

b Y

c When it starts getting darker photosynthesis gets slower and so less carbon dioxide is taken out of the water, but respiration is still occurring and releasing carbon dioxide into the water. So, the amount of carbon dioxide increases at this time.

10 for aerobic respiration

11 The crops' roots cannot get oxygen for respiration out of flooded/waterlogged soil because there are no air spaces.

Activity Pack

9Ba-1 Plant reactions

1 The raw materials for photosynthesis are *water*/*carbon dioxide* and *water*/*carbon dioxide*. The sugar made by photosynthesis is *glucose*. *Oxygen* gas is also produced. Photosynthesis needs *energy* transferred by *light* to make it happen. This is trapped by a substance called *chlorophyll*.

2 **a** C

b A

c aerobic respiration

d glucose

3 **a** word equation (accept symbol equation)

b X and Y

c glucose + oxygen → carbon dioxide + water

4 **a** It has not changed.

b too little carbon dioxide

9Ba-4 Discovering photosynthesis 1

The correct order is:

Artistotle, van Helmont, Bonnet, Priestly, Ingenhousz, Senebier, de Sassure, von Sachs, Godlewski

9Ba-5 Photosynthesis

1 **a** respiration , aerobic respiration

b glucose + oxygen → carbon dioxide + water

c carbon dioxide

2 **a** from top left down: energy, carbon dioxide, water

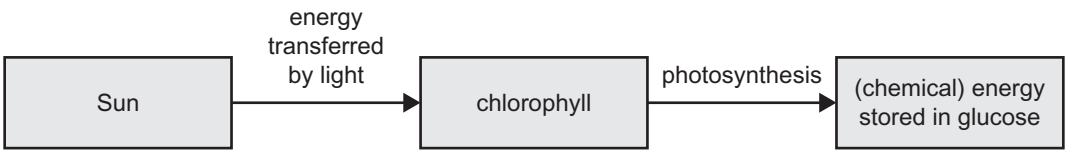
from top right down: oxygen, glucose

b carbon dioxide + water → oxygen + glucose

3 **a** oxygen

b i Fewer bubbles because the less light, less photosynthesis occurs.

b ii More bubbles because there is more raw material for photosynthesis.



c Her results do not show that all underwater plants act in the same way, only the particular type of pond weed that she was using.

9Ba-6 Discovering photosynthesis 2

1 **a** carbon dioxide

b It turns limewater milky.

c respiration, aerobic respiration

d glucose + oxygen → carbon dioxide + water

2 **a** carbon dioxide + water → oxygen + glucose

b carbon dioxide and water

c Ingenhousz

d Bubbles only appeared on underwater leaves when it was light.

e It can prevent a further increase in the rate of photosynthesis.

f Increase the amount of light and measure the bubbles produced. Keep increasing the amount of light, and you come to a point where there is no further increase in the number of bubbles.

g two from: temperature, water, carbon dioxide

3 **a** oxygen

b Any sensible suggestion as long as light can get to the leaves. It might include submersing the leaves and placing an inverted piece of glassware, filled with water, over them.

c A candle would burn in 'dephlogisticated air'. Accept details of the reaction with limewater or testing for acidity.

4 **a** Yes. If the earth was not being used up it could not be a major 'element' in the plant.

b Carbon dioxide is needed as well as water to make the plant's new material.

c Some students may suggest that some of the material has been used in respiration. Others might spot that the plant will have lost its leaves each year.

5 **a** Julius von Sachs discovered that light and chloroplasts are needed for photosynthesis.

b Emil Godlewski showed that the carbon in starch must come from carbon dioxide in the air.

9Ba-7 Limiting factors

1 Line graph. Check that students have chosen sensible scales; have added tick marks on both axes to show the scale; have plotted the points neatly and accurately; have labelled the axes; have linked the points by straight lines and have added a title.

2 The amount of carbon dioxide has become a limiting factor. There is not enough carbon dioxide for the reaction to go any faster.

3 **a** Increase the percentage of carbon dioxide in the water to be above 0.06 %. (Or, increase the temperature of the water.)

b The more raw material available the faster the process can occur.

4 **a** 37 mm (depending on graph drawn)

b 61 mm (depending on graph drawn)

5 **a** 1500 – 1600 lux (depending on graph drawn)

b 850 – 950 lux (depending on graph drawn).

6 The line should be approximately mid-way between the other two lines and the same shape.

7 **a** carbon dioxide + water → oxygen + glucose

b Temperature (not water for an experiment involving pondweed!). (Students at this level should appreciate that this is a chemical reaction and can thus, in general terms, be speeded up by an increase in temperature.)

8 **a** Yes, because the data show a consistent pattern.

b Either the bubbles are difficult to count, produced too fast to count accurately, or the bubbles may be of different sizes.

9Ba-8 Biological symbol equations

1 **a** H_2O

b 1

2 **a** CO_2

d 2

3 **a** carbon dioxide + water → oxygen + glucose

b $6CO_2 + 6H_2O \rightarrow 6O_2 + C_6H_{12}O_6$

4 **a** glucose

b $nC_6H_{12}O_6 \rightarrow (C_6H_{12}O_6)_n$

5 **a** aerobic respiration

b glucose + oxygen → water + carbon dioxide

c $C_6H_{12}O_6 + 6O_2 \rightarrow 6H_2O + 6CO_2$

9Bb Plant adaptations

Student Book

1: 9Bb Plant adaptations

1 **a** so that rain drops and other non-living things don't trigger the traps

b insects

c cannot absorb water properly, so it would not be able to photosynthesise (and make its own food)

2 absorbed by root hair cells, travels through other cells to xylem vessels, flows up xylem vessels in the stem and into a leaf

3 **a** They are hollow (so can form tubes).

b They have a large surface area (and so can absorb water quickly).

4 The cells in the epidermis (they don't contain chloroplasts).

5 to prevent loss of water

6 guard cells

7 two of: It is broad (to allow a large surface area to collect energy), it is flat (so that gases do not have far to travel to reach photosynthesising cells), veins/xylem vessels carry water (for photosynthesis); for adaptation, for correct explanation

Activity Pack

9Bb-1 Plant adaptations

1 Plants need water from the soil for … photosynthesis.

The roots of a plant are spread out to … absorb lots of water.

Leaves have a large surface area to … absorb lots of light.

If a plant does not get enough water … it wilts.

Photosynthesis happens in … chloroplasts.

Carbon dioxide gets into leaves … through open stomata.

Roots, stems and leaves are all … plant organs.

2 **a** root hair cell – absorbs water quickly

b palisade cell – (main cell used for) photosynthesis

c xylem tissue – carry water (and dissolved mineral salts)

d guard cells – open and close stomata

9Bb-4 Adaptations for photosynthesis

1 Water is needed to fill up the cells of plants/to help the plants stand up straight/Water also carries dissolved mineral salts.

2 This also gives them a large surface area to take in water from a large volume of soil quickly.

3 **a** the swapping of gases

b carbon dioxide

c leaf

d one of: It is thin (so that gases do not have far to travel to get into or out of the leaf). It has stomata (to allow the gases to get in and out).

4 **a** There are many chloroplasts in each cell.

b Adaptations include: they have large surface areas to trap a lot of energy from the Sun; they are thin so that carbon dioxide for photosynthesis does not have very far to travel into the leaf before reaching a cell where it can be used.

5 root, stem, leaf Into the root via root hair cells, and then into the xylem vessels in the centre of the root, and then up the stem in the xylem vessels, and into a leaf. It evaporates inside the leaf and moves out through the stomata (by diffusion).

9Bb-5 Water loss

1 by diffusion through open stomata

2 **a** independent: type of plant; dependent: mass

b size of plant – plants that are more closely matched in size will give a fairer test); total leaf surface area of plant – matching this between the plants would allow you to be more sure that the difference is caused by the type of plant and not the differences in surface area; moisture content of the soil – plants should ideally all be in the same type of soil with the same moisture content to make this a fairer test

3 **a**

Mass of type A plants at start (g)	Mass of type A plants at end (g)	Mass lost (g)	Mass of type B plants at start (g)	Mass of type B plants at end (g)	Mass lost (g)
750	749	1	777	772	5
680	679	1	656	655	1
721	680	41	706	703	3
735	733	2	711	709	2
	Mean loss	11.25		Mean loss	2.75

b The mean mass of the plants will not mean anything because all the plants started off with quite different masses.

4 It is assumed that the loss in mass is due to loss of water.

5 **a** He has calculated a mean from all the results. (Students should show how the means for plants A and plants B are calculated, showing their working.)

b Tara has calculated all the results also; however, she has ignored one value from the plant A results because it is so different from all the others that she suspects it may contain an error. (Students should calculate the means for plants A (ignoring one result) and for plants B, showing their working.)

c Tara's conclusion. The third reading (721–680) for plant A is obviously wrong and was probably due to incorrect measurement of the mass at the start or at the end, and so should be ignored.

d By plotting the results on a scatter graph he would have spotted how far away the anomalous point is from all the other points and be better able to realise that this measurement is wrong.

9Bb-6 Leaves and roots

1 **a** root hair cell

b to absorb water

c It has a large surface area to absorb water quickly from the soil.

d to carry water up the plant

e They are hollow cells with no end walls.

2 **a** A – air space, B – guard cell, C – chloroplast, D – cuticle, E – spongy cell, F – stoma, G – palisade cell

b diffusion

c evaporation

d gas exchange

3 They are full of chloroplasts to trap as much of the light energy as possible.

4 **a** to trap as much energy/light as possible

b so that carbon dioxide does not have to travel far inside a leaf to get to a cell that needs it

c so that all the leaves can get light for photosynthesis

d to stop water loss at night when there is no need for the stomata to let carbon dioxide in

5 The cells do not have enough water to keep them firm.

9Bb-7 Gas exchange

1 **a** Gases diffuse into and out of the leaf through stomata when they are open.

b It is zero, so there is no gas exchange occurring.

c The stomata are shut and so gas exchange does not occur.

d It stops water loss at night when there is no need for the stomata to let carbon dioxide in for photosynthesis (because there is no light to power photosynthesis).

2 **a** There is an overall diffusion of carbon dioxide out of the leaf.

b aerobic respiration (builds up carbon dioxide inside the leaf when the stomata are shut at night, when no photosynthesis is occurring)

c (just before) 04:00. This is when gas exchange starts and so is when the stomata start to open. This only occurs when there is some light.

3 06:30

4 **a** It would be earlier in the day because more light allows photosynthesis to happen at a faster rate and so more carbon dioxide would be used up creating a bigger difference between the numbers of carbon dioxide particles inside and outside of the leaf.

b It would be later in the day because lower temperature slows down photosynthesis and so less carbon dioxide would be used up creating a smaller difference between the numbers of carbon dioxide particles inside and outside of the leaf.

c It would not be reached because the tree has no leaves!

5 Between 11:00 and 14:00. This is the time of maximum carbon dioxide diffusion, which will correspond with widest opening of the stomata.

6 **a** Lower, because the increase in the number of water vapour particles outside the leaf will slow diffusion.

b Higher, because the wind blows away the vapour particles that have diffused out of the leaf, maintaining a larger difference between the numbers of carbon dioxide particles inside and outside of the leaf.

9Bc Plant products

Student Book

1: 9Bc Plant products

1 during the night because the process only starts when photosynthesis stops

2 The iodine would turn a blue-black colour because chips are made out of potatoes, which contain a store of starch.

3 Only the green parts of the leaves turn a blue-black colour because starch is only made in places where photosynthesis is occurring and photosynthesis needs chlorophyll to occur.

4 It is a store of energy (for respiration).

5 glucose

6 The expected answer is either for food or to cook with.

7 two from each of the following: lipids – energy store (in seeds), making parts of cells (e.g. cell membranes), to attract animals for seed dispersal; proteins – storage (of amino acids), plant defences against being eaten, enzymes; carbohydrate – starch (as an energy store), cellulose (for cell walls)

8 They need nitrates to make proteins. All enzymes are proteins and so processes such as photosynthesis and respiration cannot occur properly without a good supply of nitrates.

9 proteins

10 three of: lipid (as an energy store), starch (as an energy store), enzymes (to break down starch), proteins (as a store of amino acids), cellulose (in cell walls of the embryo)

11 They contain glucose because the solution has turned orange.

Activity Pack

9Bc-1 Plant products

1 **a** clockwise from top left: respiration, starch, fat/lipid, cellulose, amino acids, proteins

b nitrates

c the soil

2 iodine solution

3 **a** aerobic respiration

b Enzymes work faster when it's warmer.

c It allows molecules to move more easily.

4 proteins

9Bc-4 What's in food?

1 **a** glucose

b potato

c storage of energy

d Add iodine solution, a blue-black colour indicates the presence of starch.

e two of the following substances with use for each: protein (to supply amino acids, as enzymes, to build cells), lipids/fats/oils (for cell membranes, leaf cuticle), cellulose (for cell walls)

2 **a** aerobic respiration

b to speed enzymes up

c water

9Bc-6 Glucose use

1 **a** starch

b The cross-shape will turn blue-black.

c drawing of starch as a chain of linked hexagons (starch is a polymer of glucose)

d To store glucose for energy. (Students working at a higher level may have answered in terms of removing the end product of photosynthesis (glucose) so that the reaction does not reach equilibrium and further glucose will be produced.)

2 **a** two from: water, oxygen, warmth

b two from: water to allow reactions to occur; oxygen for aerobic respiration; warmth to speed up the activity of enzymes

3 lipids (accept 'fats')

4 **a** nitrates (accept 'nitrogen')

b proteins

c Drawing of a chain of linked amino acids (protein is a polymer of amino acids) but give extra credit if the drawing shows that not all the amino acids are the same (e.g. different shapes).

d enzymes, proteins

9Bc-7 Black-eyed peas

1 **a** *Rhizobium* bacteria because the nodules do not form if they are not present.

b The plants without the bacteria do not get nitrates and so cannot make proteins, which are needed to build parts of plants/for enzymes. So, plants without the bacteria do not grow very well compared with the plants that are getting nitrates from the bacteria.

c There are proteins in the seeds, which can supply some amino acids needed to make proteins.

2 **a** Enzymes speed up the reactions, but are not used up by the reaction.

b proteins

c The results show that starch is made, and that this is only made when the enzyme is present.

d Drawing should show glucose molecules (hexagons) being linked together by lines to form a chain (starch).

e storage of energy

3 The reaction turning the glucose into starch removes the glucose product from photosynthesis and so prevents equilibrium being reached. Photosynthesis therefore is not slowed by the build-up of the product.

9Bd Growing crops

Student Book

1: 9Bd Growing crops

1 The plants do not grow very tall.

2 **a and b** from the left-hand page of Topic 9Bb, Growing crops, in the Student Book, two of: potassium (needed to absorb water properly), nitrogen/nitrates (needed to make proteins), magnesium (needed to make chlorophyll)

3 **a** decreases the amount of food per person/food supply – because there are more mouths to feed but the same amount of food

b decreases food supply – because there is less yield due to the pests

4 **a** It is an easy way to kill weeds without harming the crop.

b It is too expensive.

5 **a** It tastes bitter.

b cross-breed with apples that taste nice (and this is exactly what is being done)

6 The old variety does not produce as many grains as the new one and so is a less useful crop that would make less money. The old variety is not as resistant to rust and so will be more likely to be harmed by the disease and produce less yield. Other answers are possible, such as the older variety has a thinner stem (and so more likely to be wind damaged) and the ear is held more upright (so more likely to trap water and so provide good conditions for fungal growth).

7 The thin carrots were bred and only the fatter ones chosen to be bred from, over and over again. Or students may answer in terms of colour.

8 Farmers use better fertilisers, higher yielding varieties, more efficient machinery and more pesticides than they did in 1973.

Activity Pack

9Bd-1 Growing crops

1 Farmers want to get as much *yield* (useful crop) as cheaply as possible. To do this, they use *machinery* to get things done quickly. Farmers around the world try to kill *pests* because these organisms reduce the supply of food to humans. Such organisms include plants, animals and fungi. *Herbicides* kill weeds. *Insecticides* kill insect pests.

Farmers often plant the *varieties* of crops that give the most yield. They also add *mineral* salts to their crops in the form of *fertilisers* or manure. Important salts contain potassium, phosphate and *nitrates.*

2 **a** to produce varieties with specific combinations of characteristics

b B and D

c To produce a plant that is less likely to be blown over by the wind.

d • The shortest plants of variety A are selected for breeding.

- The shortest offspring are selected for breeding.
- This process is repeated and repeated.

9Bd-3 IR36

1 Drawings in the correct order according to the text (IR8, Tadukan, TKM6, TN1, IR1561, CR94-13, IR36)

2 X: small, ripened quickly, high-quality grain, resistant to 'bacterial blight' and 'stem borer'.

IR36: small, ripened quickly, high-quality grain, resistant to 'bacterial blight', 'stem borer', 'tungro', 'green leafhopper', 'grassy stunt' and 'fungal blast'.

TKM6: small.

3 It gave them high-quality grain, plants that did not fall over in the wind, plants that were resistant to a lot of pests and diseases, plants that ripened quickly to allow more than one crop in a year, plants that were resistant to pests and diseases so that less money needed to be spent on pesticides.

9Bd-4 Wild mustard

1 Diagram showing: cabbages were selected for the top leaf bud on the stem; Brussels sprouts for the side buds on the stem; kohlrabi for the roots; kale for the leaves; cauliflower for top leaf bud on stem; broccoli for flower buds.

2 Students explain how offspring are selected depending on the desired characteristics and only those offspring are used to breed. This process is repeated again and again.

3 Suggestions include disease resistance (so that the farmer gets a better yield), need for less mineral salts, growing bigger.

9Bd-5 Growing and breeding plants

1 to produce varieties with useful new combinations of characteristics

2 **a** Drawing showing some characteristics from each plant. (Of course, in real life none of the characteristics from one plant may be inherited.)

b and c Description of features that student has drawn.

3 Students explain how: tall/big offspring are selected; only those offspring are used to breed; this process is repeated again and again.

4 **a** Suggestions include increasing population size, war, damming rivers.

b Suggestions include pests, diseases, drought.

c Suggestions should be matched to the answer in part **b** (e.g. pesticides being used to kill pests).

5 nitrates, potassium, phosphorus

9Bd-6 Breeding plants

1 **a** any three from: they produce big tomatoes, tomatoes are bright red, tomatoes stay fresh for 6 days, tomatoes are juicy, tomatoes are very tasty, with suitable explanations

b any three from: they produce big tomatoes, plants produce lots of tomatoes, tomatoes stay fresh for 6 days, plants are resistant to disease, with suitable explanations

c any three sensible suggestions with reasons

2 **a** pollination

b Without pollination the fruit/seeds do not form or do not form so well (reducing yield).

c male

d fertilisation

3 **a** to stop any more pollen reaching the flower (preventing unintentional cross-breeds)

b to stop the flower pollinating itself

9Bd-7 Farming plants

1 X and Y. X is a good variety apart from the dull colour, which could be introduced by crossing with Y, which has bright red fruits. Other answers are possible.

2 **a** • The shortest plants of variety A are selected for breeding.

- The shortest offspring are selected for breeding.
- This process is repeated and repeated.

Award additional credit if students have also spotted that breeding out the side-shoots of the plant may also be useful.

b Suggestions include: increased yield/more grains/increased size of grain, growth in lower light levels. Disease resistance is not important in space!

3 **a** Fertilisers provide the elements/mineral salts/nutrients needed by the plants to make a variety of

new substances, some of which are stored in the useful part of the crop.

b Insecticides kill insect pests that may eat the useful part of the crop.

c Herbicides kill weeds that may compete with the crop, reducing its supply of water/light/space/elements/mineral salts/nutrients and therefore making it grow less well and produce less useful product.

4 It releases heat to keep the plants warm and help them photosynthesise faster (because enzymes work faster at warm temperatures); it produces carbon dioxide, which should also increase the rate of photosynthesis because it is a raw material needed for photosynthesis.

9Bd-8 Greenhouse growing

1 **a** Advantages: growing conditions can be more easily controlled, better protection from pests (e.g. rabbits). Disadvantages: cost, may get too hot.

b If you measured the mass of plants containing water it would not be fair because they may have absorbed different amounts.

c Suggestions include: starch, glucose, protein, lipids (fats, oils), cellulose. Other answers are possible.

2 **a** C – The lettuces in C had a greater dry/biomass than the others.

b Explanation should consider the reactants needed in photosynthesis and knowledge of the fact that increasing the concentration of carbon dioxide increases the rate of photosynthesis because it is often a limiting factor.

3 The amount of light, temperature (the plants were grown in different parts of the UK).

4 The plants received different amounts of light and were grown at different temperatures because they were grown in different parts of the country. Answer should also indicate that both light and temperature (up to a point) will increase the rate of photosynthesis and thus the production of biomass.

5 **a** ammonium nitrate

b Phosphates provide the plant with phosphorus, which is needed to make DNA and which is needed in all cells to control them. Without it, new cells cannot be formed/be controlled properly.

c Yellow patches on the leaves – because chlorophyll, which gives the leaves their green colour, cannot be formed.

d Potassium is needed to help plants absorb water.

e Major elements – nitrogen, phosphorus and potassium. Trace elements – copper, iron, magnesium, manganese, zinc (sulfur). Reason is based on the relative amounts in the packet.

9B Protecting wild plants (STEM)

1 Farming can change the environment and reduce the space available for wild plants to grow in. (Other possible answers include that adding chemicals to the land could kill wild plants.)

2 A species that is only found in a particular part of the world.

3 If the only place they grow in is damaged, they may become extinct.

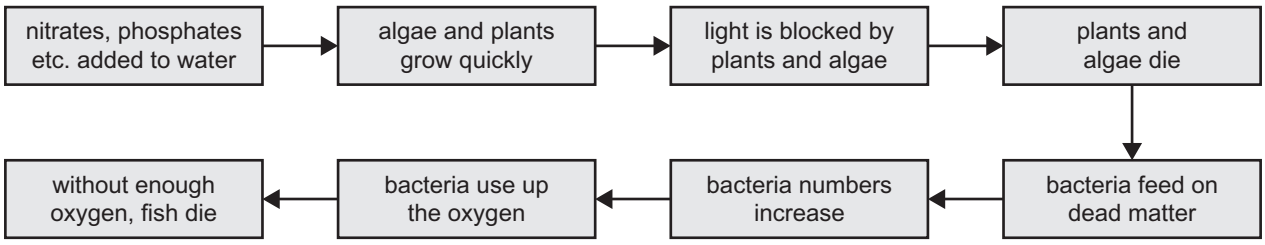
4 Using a plant identification guide/database.

5 Any suitable explanations that indicate different purpose of communication (e.g. persuading governments to spend money on conservation or persuading farmers of benefits of conservation) and differing background knowledge of audience (using appropriate terms and language that will be understood).

Activity

1 A suitable answer would include: visit the area to record all the plants that live there; identify how abundant different species are locally; identify how abundant different species are globally using the IUCN Red List; identify current and possible future risks to the plants from human activities and other sources.

2 The template should be well structured to provide information about the results from the audit, e.g. with different sections for each of the elements indicated in answer to Question 1, criteria for decision on KBA status should be made clear.



9Be Farming problems

Student Book

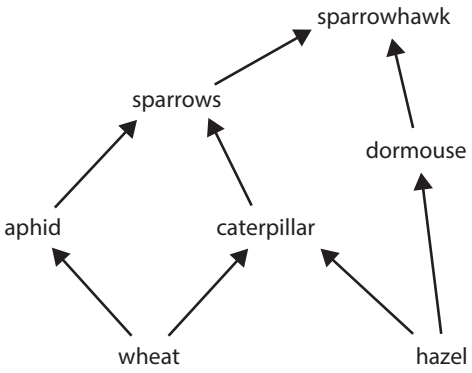
1: 9Be Farming problems

1 The bacteria use up all the oxygen and so there is not enough oxygen for the fish and they die.

2 They allow algae and plants to make proteins quickly.

3 Flow charts need not be divided into such small points but the best attempts will include all of these points: eutrophication, leading to dead algae, bacteria using up oxygen as they break down the algae; fertilisers.

4 a



b i The wheat may grow better because there would be fewer aphids and caterpillars feeding on it. There may be fewer sparrows because they have less to eat. Accept other answers that are correctly based on the premise that the aphids and caterpillars are killed.

b ii There would be fewer dormice because the hazel trees would be killed. The wheat plants would not be harmed because they have narrow leaves. Accept other answers that are correctly based on the premise that the hazel trees are killed but not the wheat.

5 Wheat has wind-pollinated flowers and so an insecticide in the pollen will not harm bees.

6 A disease (potato blight) infected all the potatoes because they were all the same variety.

7 (for part of answer, for complete answer). The planting of wheat will result in fewer pollinators, such as bees, in the area, because wheat plants are not insect-pollinated and so there is no food for pollinators in these plants. There will then not be enough pollinators around to pollinate the flowers of the rapeseed.

8 Two of: Using less fuel/more efficient machinery (which would reduce carbon dioxide emissions), plant trees and hedgerows (to increase biodiversity, to take up carbon dioxide from the atmosphere), use less fertiliser (to avoid eutrophication and killing aquatic organisms), using less pesticide (to avoid killing non-target organisms).

9

Farming process	Advantages	Disadvantages
Clearing land	more room to plant crops or graze animals; easier to operate large machinery	destroys the habitats of other plants and animals, reducing their numbers; makes land more prone to erosion
Insecticide use	increases the yield of crops by reducing losses caused by insects	can kill useful insects that are needed to pollinate flowers or that usually eat other pests
Herbicide use	increases the yield of crops by reducing competition from other plants	kills plants that other animals in the habitat rely on for food
Fertiliser use	increases the yield of crops by providing mineral salts	can pollute rivers and lakes, killing fish and other organisms

2: 9Be Bias and validity

1 a that increasing use of HT soybean has led to increasing numbers of monarch butterflies

b Only some of the available data have been chosen.

c Examples might include a farmer who had decided to grow HT soybean or a seller of HT soybean seeds.

2 There are a variety of options, but the best will involve data that have been selected at the same time intervals, because this makes it look more like they have been systematically collected. So the data could be in 5-year periods: 1996, 2001, 2006 and 2011.

3 He is only telling one side of the story/What he is saying is not balanced/He is only referring to the disadvantages of growing HT soybean.

4 Student's own work making use of the phrases in the Advantages column in table D. Some students may include adjectives and adverbs or use powerful verbs to add weight.

5 because there may be many fewer or more butterflies higher up and/or butterflies may not just be on trees and/or butterflies may not just be on the trunks of trees

6 The percentage only gives information about the proportion of HT soybean compared with soybean. There is no information about the actual amount of soybean planted, which could have gone up or down. If for example the total amount of soybean planted had gone drastically down, this would not be reflected in the percentage; but if a graph were plotted with total soybean planted, it would give the opposite impression to that given in graph B. As it happens, the total amount of soybean plants has remained fairly constant.

3: 9Be Organic farming

1 **a** any simple description of the plant using sunlight to help make food; a description of how carbon dioxide and water are used to produce glucose and oxygen using energy transferred by light (or a word equation showing this)

b It reduces the amount of photosynthesis by blocking sunlight. It reduces the surface area of the leaf for trapping energy transferred by light.

c It would reduce the yield because all organic compounds made in the plant depend on glucose as the starting material.

2 **a** a green pigment used to trap energy transferred by light in order to power photosynthesis

b key points: salts are dissolved in water; absorbed into the root; carried in xylem vessels in stems to the leaves

c Roots have a large surface area to ensure fast absorption of water/mineral salts. Stems have xylem vessels, which are hollow and so can transport water and dissolved mineral salts.

3 Bees are important pollinators and so help fruits/seeds to form (increasing yields); or students may answer in terms of a helpful organism controlling the numbers of pest organisms.

Activity Pack

9Be-1 Farming problems

1 using fertilisers – can cause fish to die

using herbicides – can kill plants that animals need for food

using insecticides – can kill useful animals

clearing land – removes animal and plant habitats

2 **a** pondweed

b The number of pond snails will go down because there is no pondweed to eat/pond snails are consumers of pondweed.

c The amount of carbon dioxide would go up because there are fewer plants to photosynthesise.

d algae

e pondweed

f There is no light for photosynthesis (which uses up carbon dioxide) but other organisms are still respiring (which produces carbon dioxide).

3 **a** It reduces the number of different organisms.

b One disease may kill all the organisms. Or a general statement about the importance of biodiversity (in terms of preserving as many species as possible because useful products may be obtained from them, keeping food webs large, enriching our lives, more biodiverse areas being better at recovery from disaster).

9Be-3 Farming for wildlife

What happens	Problems this causes	Possible solutions	Drawing
Insecticides get sprayed onto hedges.	This kills insects that are not harmful to the crops and are useful food for other animals.	The farmer leaves a strip around the edge of the field that is not sprayed with chemicals.	D
Hedges and trees are removed to make it easier for machinery to move around.	Animals need to run across large areas of open country in order to move from wood to wood to find food and mates. This makes them easy targets for predators.	The farmer is encouraged or paid to plant hedges to re-connect areas of woodland back together.	C
Fertilisers wash into rivers and lakes and pollute them.	This causes water animals, such as fish, to die.	The farmer makes sure that only the right amounts of fertiliser are applied, and fertiliser is not applied if it is about to rain.	B
Farmers run over the nests of birds that make nests in fields in some areas of the country.	This kills the chicks.	Encourage the farmer to leave an area in the middle of the field where machinery doesn't go.	A

9Be-4 Lakes and fertilisers

The correct order is:

B – Fertilisers containing phosphates and nitrates are washed into the lake by rain.

F – The algae in the lake use the phosphates and nitrates in the fertiliser.

C – The algae grow quickly.

D – The algae become overcrowded and cannot get enough light for photosynthesis, so they die.

E – Bacteria feed on the dead algae.

A – As the numbers of bacteria grow, they use up all the oxygen in the water. The fish die.

9Be-5 Farm food web

1 **a** insecticide (accept pesticide)

b one of: it can kill useful insects, it can kill insects that useful animals rely on for food, it could harm other animals higher up the food chain

c Ladybirds eat aphids and so would reduce their numbers.

d It would reduce the numbers of hedgehogs because there is less food for them.

e one of: to preserve biodiversity, to make sure that if one crop fails there are still other crops that could be sold, different crops grow better in different parts of the farm due to different environmental conditions

2 **a** one of: more room for planting crops/easier access for farm machinery/rid the surrounding fields of a pest problem (e.g. rabbits)

b one of: destroys habitats of animals and plants, reduces the numbers of natural predators of some pests, reduces biodiversity

3 **a** clockwise from top right: combustion, respiration, photosynthesis, respiration

b They would go down.

9Be-6 Sugar cane farming

1 **a** Diagrams showing two simple carbon cycles, only one of which includes combustion. Diagram of the carbon cycle from the burnt field should include combustion, photosynthesis, respiration of the animals. Diagram of the carbon cycle from the 'green' harvested field should not include combustion but should include photosynthesis, respiration of the animals and respiration of the microorganisms involved in decay.

b There is no respiration from the animals in the burnt field, because they have been killed or driven away, plus there is additional respiration from the decomposers in the 'green' harvested field.

c The drought will reduce the amount of photosynthesis by the plants (and so less carbon dioxide is removed from the atmosphere). However, there will also be reduced respiration from animals (which may not survive (the toads) or have less to eat). The cycling of carbon will be slowed.

2 Explanation should include:

- the pesticide does not break down
- a list of the animals in the food chain leading to the peregrine falcon
- an explanation that the total amount of pesticide in all the prey animals enters the top predator birds
- this causes the bird to lay eggs that break easily and so do not hatch

3 one of: one disease may wipe out the entire crop, a drought may wipe out the entire crop, this reduces biodiversity in the area (the total number of species that an area can support)

9Be-8 Natural cycles

3 **a** Fertilisers containing nitrates are washed into the lake by rain. The algae /plants in the lake use the nitrates in the fertiliser. The algae/plants grow quickly. The algae/plants become overcrowded and cannot get enough light for photosynthesis and die. Decay bacteria feed on the dead algae. As the numbers of bacteria grow, they use up all the oxygen in the water. The fish die.

b ammonia from human waste/intensive farming of animals has also increased the amounts of nitrates, car engines pumping out nitrogen oxides

9C Transition to further study – Biology

9Ca Diseases

Student Book

1: 9Ca Threat from disease

1 A deficiency disease is harm to the body caused by not absorbing enough of an essential nutrient, e.g. scurvy caused by lack of vitamin C, rickets caused by lack of vitamin D, anaemia caused by a lack of iron or folate, kwashiorkor caused by a lack of protein.

2 any two groups of microorganisms such as bacteria/prokaryotes, unicellular fungi, protoctists/protists; accept viruses, though remind students that most people consider these not to be living organisms

3 Nerves from the central nervous system (brain and spinal cord) carry electrical impulses to muscles that control when and how strongly the muscles contract. If the nerves are damaged, then the impulses won't reach the muscles and so the muscles will not contract.

4 Not every case of polio was counted. Samples were taken from different parts of the world, and the

value multiplied by the total area or population size to get the estimate for the whole world.

5 Diffusion is the movement of small particles from an area where there are more of them to an area where there are fewer. This can happen across a partially permeable membrane such as a cell membrane.

2: 9Ca Diseases

1 **a** any one non-infectious disease such as rickets, sickle cell disease, cancer or diabetes

b The example cannot be passed from person to person and is caused by (as appropriate) a poor diet or a change in the immune system, is inherited from parents, may be linked to factors in the way we live.

2 The pathogen that causes cholera is found in human waste from a person infected with the disease. Touching waste that contains the pathogen, or touching anything that has been in contact with the waste, such as drinking water from a nearby pool, can lead to infection.

3 (fluid-filled) red spots and a high temperature

4 **a** make microorganisms easier to ingest, clump them together, make them burst

b When a new microorganism gets into the body, lymphocytes take time to make new antibodies to attach to that microorganism. So, while that is happening, you get ill. Once the antibodies are made, they help destroy the microorganisms and so you get better.

5 They only attach to a certain type of microorganism. / Different antibodies are needed to attach to each different microorganism.

6 You cannot get the disease.

7 Viruses cannot carry out all the life processes.

8 Vaccinations make people immune to diseases, so that they cannot get them. If fewer people in a community are likely to get a disease, then it is more difficult for the disease to spread.

3: 9Ca Veterinary science (STEM)

1 The birds and the people both had the same symptoms/swollen brains; All the blood samples contained the same virus/West Nile virus.

2 One of: a mosquito carrying the virus was carried to the USA on an aeroplane / an infected animal or person entered the USA.

3 To stop them catching diseases, which might kill the animals or pass to humans in meat or dairy products.

4 **a** West Nile is a viral disease and so antibiotics will not work on it.

b One of: Vaccinate other animals, kill mosquitoes, separate/quarantine animals that have the disease.

5 **a** 160 mg (8 x 20 = 160; ensure that the unit is included)

b Because the antibiotic is broken down more quickly in squirrel monkeys than in cats.

Activity

1 5 days. 64 hours is approximately 2.5 days. After 2.5 days, half of the antibiotic will have been broken down, leaving 5 mg/kg (half of the original dose). After another 2.5 days, this will be halved again, leaving 2.5 mg/kg. Below this value, the antibiotic ceases to be effective.

2 Students should have developed some sort of model that can be used to demonstrate the idea that after a certain amount of time, half of the antibiotic will have been broken down. Students could, for example, use a set of blocks and instruct a presenter to take away half the blocks after a set period of time. Better models will include the idea that the process is continuous and so recommend that the presenter starts with (say) 20 blocks and removes one from a pile every 2 seconds. After 20 seconds, 10 blocks (half the original sample) are left and so 20 seconds is the half-life. It is recommended that you randomly select various student's/group's presentation ideas and then carry them out in front of the class, to show whether their model works or not. Ask students for feedback on how a model could be improved.

Activity Pack

9Ca-1 Types of diseases

1 infectious: cholera, malaria, influenza, Ebola, norovirus; liver disease
genetic: haemophilia, type 1 diabetes
deficiency: anaemia, scurvy, rickets
lifestyle: lung cancer, heart disease, liver disease
autoimmune: type 1 diabetes, multiple sclerosis

2 cholera, bacteria; malaria, protoctist; influenza, virus; Ebola, virus; norovirus, virus; liver disease, hepatitis C virus

9Ca-2 Immunity

1 From top: 3, 1, 7, 5, 8, 6, 2, 4, 9

2 Two from: make it easier for pathogens to be ingested, make pathogen cell burst open, stick pathogen cells together

3 **a** phagocyte

b Drawing showing one cell (labelled as the phagocyte) spreading itself around another cell/virus particle (labelled as the pathogen or equivalent). Drawing should be similar to photo D in the Student Book. Labelling should mention and explain the term 'ingest' (meaning 'surround and digest').

4 Person X's immune response is far quicker and far stronger. Neither person has had contact with

the virus before, which means that this increased response is due to a vaccine. A vaccine contains parts of the surface coating of a microorganism. In the body, these parts cause memory cells to form. The memory cells then produce a lot of the correct antibodies very quickly when the real pathogen gets inside the body.

9Ca-3 Disease questions

1 **a** …can make the person feel very tired or weak.

b …their gums started to bleed and their teeth fell out.

2 Type 1 diabetes is an autoimmune disease; scurvy is a deficiency disease.

3 **a** a disease that can be passed from one person to another

b any suitable example with correct pathogen, e.g. flu/virus, cholera/bacterium, malaria/protoctist

4 **a i** protein coat **ii** protects what is inside the virus

b i genetic material **ii** genes carrying instructions for making a virus

5 any one suitable difference, such as bacterium is surrounded by cell surface membrane but virus is not; bacterium contains cytoplasm but virus does not

9Ca-4 Viruses and bacteria

1

	Structure	Name	Function
Virus	A	protein coat	protects genetic material
	B	genetic material/ string of genes	instructions for building new viruses
Bacterium	C	genetic material/ chromosome	instructions for controlling all processes in cell including producing new bacteria
	D	cell surface membrane	controls what enters and leaves the cell
	E	cytoplasm	where the reactions of life processes take place

2 **a** As the cell grows, it gets to a point where the genetic material is copied and the cell splits in two.

b Genetic material of a virus is inserted into a living cell, where it takes over the way the cell works and instructs the cell to make new viruses.

3 Some bacteria have a flagellum, which moves the cell forward. Others depend on movement of the environment, such as being in water. Viruses cannot move independently of the environment.

4 Viruses cannot carry out any life processes on their own, and so are not considered to be true organisms. This means there is no virus kingdom.

9Ca-5 Viral diseases

1 communicable/infectious diseases

2 pathogens

3 symptoms

4 through the air, by breathing in droplets released from an infected person when they sneeze or cough; they sneeze and cough because the virus irritates the linings of the nose and throat

5 **a** The pathogen that causes cholera is water-borne and is released into the environment in faeces. If the man in the latrine has cholera, the pathogen is released into the stream where the children are playing. So the children will easily be infected.

b any suitable answer that describes the disposal of human waste in a way that keeps it separate from water that is used for drinking and washing

6 **a** Similarities: Both the virus and *Amoeba* contain genetic material, which is used for reproduction, though it is found inside a nucleus in *Amoeba*.

Differences: The virus is not surrounded by a cell surface membrane, as other cells are, including *Amoeba*. Instead it has a protein coat. *Amoeba* also has other cell structures that the virus does not have, including pseudopods that are used for movement, and mitochondria where respiration is carried out.

b *Amoeba* (like other protoctists) is considered to be a living organism as it can carry out all the life processes at some time in its life. So protoctists are classified within a kingdom. Viruses can only reproduce within a living cell, and carry out no other life process, so are not considered to be living organisms by many scientists. So they are not classified in a kingdom.

9Ca-6 Virus replication

1 yes, because it can be passed from an infected plant to other plants

2 Infected plants have mottled or discoloured leaves, and possibly stunted growth.

3 The genetic material forms a single helix inside the virus. Coat proteins surround the genetic material, forming a long thin rod shape. The genetic material provides the instructions for making a virus. The protein coat protects the genetic material.

4 The genetic material instructs the cell to stop producing the substances it usually does and instead produce viral proteins and genetic material.

5 The damage to leaf cells is caused by the leaf cells no longer making the substances they need for survival and growth and by the damage caused when the viruses are released from an infected cell.

6 any two suitable answers that prevent the virus being transferred from an infected plant to other plants: for example, clear an infected plants from the field and destroy them, wash hands and equipment before working in a field of uninfected plants, prevent aphids from feeding on uninfected plants

9Cb Control systems

Student Book

1: 9Cb Control systems

1 Organs: brain, spinal cord (do not accept spine), nerve, receptor organs (such as eye, ear, skin). Tissues: nerve tissue, receptor tissue (such as retina at back of eye). Cells: nerve cells, receptor cells such as light-sensitive cells in eye and temperature or pain receptor cells in skin.

2 Answers should use examples identified in Q1. Brain controls responses of the nervous system. Spinal cord carries electrical impulses to and from brain. Nerves carry electrical impulses to and from the spinal cord. Nerve tissue/cells carry electrical impulses. Receptor tissue/cells respond to changes in the surroundings or in the body.

3 Receptor cells in skin respond to touch of pen by sending electrical impulses to brain → brain sends impulses to spinal cord → impulses travel from spinal cord into nerves → impulses travel along nerves to muscles that control hand movements → muscles respond by moving muscles to lift hand.

4 A hormone is a chemical messenger released by a gland into the blood. Target organs and cells respond to the hormone by changing what they are doing.

5 any suitable suggestion, such as heart, lungs

6 any suitable suggestions related to changes in boys during puberty: for example, cells that produce hairs around mouth and chin; cells that cause more rapid growth in bones; cells that cause growth of larynx (producing deeper voice)

7 thyroid gland and pituitary gland, because both produce hormones that affect growth rate; Chandra Dangi probably has glands that release less of the hormones related to growth than normal, while Sultan Kosen probably has glands that release more hormone than normal

8 nervous system, because a rapid response is needed to avoid harm

9 **a** Receptor cells in eye send electrical impulses through nerves to brain → brain sends electrical impulses via spinal cord and nerves to adrenal glands → adrenal glands release adrenaline into blood.

b Adrenaline increases both heart rate and breathing rate, which causes more blood containing more oxygen to be circulated around the body. This means muscle cells can respond quickly (for fighting or running) when the brain tells them how to respond to the danger.

Activity Pack

9Cb-1 Processing drawing

1 Receptors in eyes collect visual information, receptors in skin respond to touch. (There are receptors in muscle and other tissues, called proprioceptors, that respond to pressure and help us know the positions of limbs without having to look at them, but it is unlikely students will know about these.)

2 the muscles of the lower arm and hand, to move the pencil correctly

3 the brain

4 receptors (eyes and skin) → electrical impulses in nerves → brain → electrical impulses in nerves → muscles

9Cb-4 Response cartoon

1 correct order: pictures C, A, D, B; labels 1, 2, 3, 4

2 Captions may vary, but must include *stimulus*, *electrical impulses*, *receptor cells, muscle cells, nerves, eyes* and *brain* used appropriately; for example:

C/1: Paul enters a room where there are other students.

A/2: As Paul *sees* the other students, *receptor cells* in his eyes receive a *stimulus* from the environment. This creates an image of the students, which travels as *electrical impulses* along *nerves* to Paul's brain. His *brain* coordinates the information and recognises Jo in the group.

D/3: Paul's brain sends *electrical impulses* along *nerves* to the muscles in his legs. This causes the *muscle cells* to contract and move his legs so that he walks towards Jo.

B/4: Impulses from *receptor cells* in Paul's *eyes* pass to his brain showing that he has reached Jo. His *brain* then sends *electrical impulses* to his leg muscles to stop moving. His *brain* also coordinates movement of the mouth so that he asks the question.

9Cb-5 Type 1 diabetes and insulin

1 The pancreas produces insulin. (1)

2 Insulin is a chemical substance that is produced by a gland and affects other parts of the body by changing the way that they work. (1)

3 The target cells of insulin are muscle cells, some liver cells and fat cells. (1)

4 Insulin is released from cells in the pancreas. (1) The hormone reaches target cells as it is carried round the body in the blood. (1)

5 As blood sugar concentration increases, the pancreas releases insulin. (1) The insulin stimulates muscle, liver and fat cells to take sugar out of the blood, so reducing the blood sugar concentration. (1)

6 Cells of the pancreas that produce insulin are destroyed (1); therefore insulin is no longer produced. (1)

7 **a** any two from: feeling hungry all the time, feeling tired all the time, being thirstier than normal (1 mark per example, up to max. of 2 marks)

b Blood tests after a sugary drink would show if there is insulin released into the blood when blood glucose concentration is high. (1) If there was no insulin, then the patient is more likely to have Type 1 diabetes. (1)

Alternative answer: measuring blood glucose over a period of time will show if it remains high or reduces as normal. (1) If it remains high, it indicates Type 1 diabetes. (1)

9Cb-6 Control systems questions

1 The brain coordinates responses to changes in the body and surroundings.

The spinal cord contains nerve cells that link the brain to the main nerves.

Nerves contain nerve cells that carry electrical impulses from receptor cells to the spinal cord and from the spinal cord to effectors (muscles and glands).

2 The eyes receive light signals and transmit these to the brain via the nervous system as electrical impulses. The brain receives this information and sends electrical impulses through the spinal cord and nerve cells in the arm to the muscles that control the fingers. The muscles contract to pick up the pen.

3 **a** hormones

b muscle and liver (and fat) cells

c Insulin is released into the blood from cells in the pancreas, and travels around the body in the blood until it reaches the target cells.

9Cb-7 Control system diseases

1 Breathing movements are caused by muscles. If those muscles do not receive impulses from the nervous system, then they do not work and the person cannot breathe.

2 The brain sends electrical impulses through nerve cells to muscles that need to contract to produce a particular movement.

3 **a** The stimulus is detected by touch receptors in the skin. These cause electrical impulses to travel along nerve cells through nerves and the spinal cord to the brain. The brain becomes aware of the touch.

b The poliovirus mainly damages nerve cells that connect the brain to the muscles, not those that connect receptor cells to the brain. So movement may be affected but not touch.

5 oestrogen because it controls the menstrual cycle

6 Oestrogen is produced in the ovaries. One of its target organs is the uterus/womb, which changes during the menstrual cycle.

7 an organ that is affected by a hormone

8 The pills are digested in the gut, and the hormone is absorbed into the blood. The hormone travels around the body in the blood until it reaches the uterus/womb.

9Cb-8 Control of heart rate

1 The vagus nerve delivers impulses more rapidly than the accelerans nerve, because the resting heart rate is slower than the natural rate of contraction of cardiac muscle cells set by the heart's pacemaker.

2 Sketch should show: pacemaker controlling contraction of cardiac muscle cells, and accelerans and vagus nerves connecting the heart's pacemaker to the control centre in the brain.

3 During exercise more impulses reach the control centre in the brain, which sends more impulses through the accelerans nerve to the pacemaker to make the heart beat rise. When the heart beats faster, blood is pumped round the body faster. This delivers food and oxygen to cells so they can work faster, including the cells in muscles for being more active and cells in the brain.

4 Adrenaline is released into the blood from the adrenal glands and is carried to the heart in the blood.

5 Releasing adrenaline before activity or stress increases heart and breathing rate, which increases the amount of oxygen and dissolved food molecules carried around the body. Thought processes in brain cells can take place more rapidly, to respond to changes in the environment more quickly. Muscle cells will also be ready to respond rapidly if needed.

6 As exercise decreases, so muscles are stretched less and the amount of carbon dioxide in the blood falls, so the accelerans nerve will produce fewer impulses, so the heart rate will slow down. Adrenaline is broken down after exercise or stress, so the hormone will have less and less of an effect on the heart and lungs, so breathing and heart rate will slow down.

7 The nervous control system means the heart rate can change rapidly in response to different situations. The hormonal control system helps sustain a higher heart rate over a longer period of exercise or stress as well as affecting other parts of the body.

9Cc Treating diseases

Student Book

1: 9Cc Treating diseases

1 They affect the way the body works.

2 To kill bacteria, which are causing the infection.

3 Giving the person vitamin C.

4 **a** insulin – pancreas; growth hormone – pituitary gland

b • there is a lack of insulin and so glucose is not removed from the blood • this results in high levels of glucose in the blood • high levels of glucose can cause organ damage

5 DNA

6 The DNA of the gene is changed (genetic modification) but no DNA from another species is introduced (transgenic).

7 using high-pressure steam (to clean the fermenter)

8 **a** to provide oxygen for aerobic respiration

b • so that other microorganisms are not introduced into the fermenter • these may be harmful/produce harmful substances/produce unwanted substances/reduce hormone production/ compete with the genetically modified bacteria.

2: 9Cc Median and quartiles

1 **a** (1) Arrange all the values in the dataset in order. (2) Find the middle value in the set, which is the median.

b (1) Find the median as in 1a. (2) Find the middle value between the lowest value in the set and the median. That is the lower quartile. (3) Find the middle value between the highest value in the set and the median. That is the upper quartile.

2 **a** median = 17, lower quartile = 11, upper quartile = 25

b 25 – 11 = 14

3 Tree B would have leaves that vary the most because the normal distribution for that tree shows the greatest interquartile range.

4 **a** This made it possible to see whether people with different abilities to absorb cholesterol in the test responded in the same way or differently to taking statins.

b 148 – 107 = 41

c The people in the lowest, lower middle and upper middle quartiles for cholesterol absorption showed a decreased risk of heart attack as a result of using statins. The people in the top quartile for cholesterol absorption showed an increased risk of heart attack as a result of using statins.

Activity Pack

9Cc-1 Killing bacteria

2 and **3** The disc that had the biggest clear circle around it was the one that killed bacteria most effectively.

4 to prevent the spread of any bacteria that may have got on to your hands

5 Placing the forceps in ethanol helps to kill bacteria, and holding the Petri dish lid over the dish while placing a disc on to the agar helps to prevent bacteria or other microorganisms in the air falling on to the agar. Other microorganisms in the dish might interfere with the bacteria and antibodies used in the investigation and spoil the results.

9Cc-3 Diseases and medicines

1 drugs, antibiotics, symptoms, vaccinations, infections

2 infectious disease – measles – antiviral; deficiency disease – scurvy – vitamin C; genetic disorder – growth hormone deficiency – growth hormone; autoimmune disease – type 1 diabetes – insulin; lifestyle disease – cardiovascular disease – low-fat diet

3 **a** glucose

b respiration

4 Two sensible suggestions, such as: more exercise, more balanced diet/eating less fatty/ sugary foods, eating less

9Cc-4 Making medicines

1 **a** bacteria

b Streptomyces (technically this should be in italics or underlined)

c pH 6 because this was the pH that produced the most tetracycline

d Repeat the experiment but using a narrower interval between the pHs (e.g. 0.5 or 0.1); test only pHs between 5 and 7 (we can see from the existing results that the optimum must lie within this range).

e The last temperature tested gave the highest mass of tetracycline and so we cannot be sure if a higher temperature will produce more or not.

f Enzymes produce the tetracycline; enzymes work best at certain temperatures. (Accept answers that talk in terms of reactions happening more quickly at higher temperatures and the kinetic theory.)

g One of: amount of oxygen, mass of food/ carbohydrate, concentrations of mineral salts, amount of stirring/agitation

h So that other microorganisms do not grow, which may produce harmful substances/reduce hormone production.

i One of: everything is sterilised, steam is used to clean the fermenter, the air is filtered

2 **a** (type 1) diabetes

b transgenic

c humans

9Cc-5 Fast-track testing

1 It was not correctly identified at the start. Also, once it reached the capital of Liberia, the chances of contact between infected and uninfected people increased greatly. Isolating people before they caused further infections would have been far more difficult in a city than in villages in the countryside.

2 It costs a lot of money to produce a new medicine, and the countries where it occurred first are very poor, so the people would not have been able to afford expensive medicines.

3 First, tested on cells or tissues containing Ebola virus to check that it affected the virus with minimal harm to cells. Then tested on animals with Ebola, to see how it affects whole-body systems. Then tested on a few healthy volunteers to make sure it has minimal side effects. Then tested in large clinical trials on many people with Ebola to see how it works in practice.

4 Different people may have different amounts of chemicals in their blood that kill the viruses, so the effect of giving plasma from different people to other patients will be difficult to compare. Also this has only been done on a few people, so differences in response may occur by chance.

5 The risks are that the vaccines have not been fully tested, so many people given the new vaccines may be harmed or even killed by them. The advantages are that there are no other vaccines that can be used to prevent infection by the virus, and the virus does kill a lot of people who are infected by it. So some people are likely to be saved by having the vaccine.

6 Responses to question may vary, but should be well supported by explanation. For example, no it is not right because it is using people who cannot afford to buy expensive medicines as guinea pigs for new treatments; yes it is right because in deadly situations like this the new drugs are likely to save some people, and may help to prevent the spread of the disease to other places.

9Cd Ecology

Student Book

1: 9Cd Ecology

1 An estimate is a guess at the real value based on good evidence.

2 **a** predation

b a decrease in the gazelle population

3 **a** pitfall trap because they would run along the ground and fall into the trap

b a sweep net that brushes them off the long grass and traps them in the net

4 **a** area of quadrat is $0.5 \times 0.5 = 0.25$ m^2, total area is $60 \times 10 = 600$ m^2

abundance = $(3/0.25) \times 600 = 7200$

b the crabs

5 **a** The birds show a regular distribution as there is similar spacing between the nests.

b A suitable answer would be: counting the number of birds in the photo and then working out how much more of the island was covered with nests and multiplying up.

6 **a** This is a clumped distribution.

b A clumped distribution makes it very difficult to get an accurate estimate because many samples will contain no crabs and only a few will contain some. If you miss any pools when sampling, the estimate will suggest no crabs live there, or if several quadrats cover pools the estimate will suggest there are many crabs. The quadrat in Q4 must have covered a rock pool, so the estimate of 7200 is probably a large exaggeration.

7 Quadrats would be placed randomly in the field to take samples. For each quadrat, either the number of plants of each species inside the quadrat would be counted, or the percentage cover of the quadrat by each species would be calculated. For the number of plants, the population size for each species would be calculated using the equation at the bottom of the left-hand page of the Student Book spread 9Cd Ecology. For percentage cover, the average value for a particular area (e.g. one quadrat or 1 m^2) would be calculated. The largest value of population size or average percentage cover indicates the most abundant species.

Activity Pack

9Cd-2 Abundance and distribution

1 **a** method: light trap; reason: because moths that fly at night will be attracted to the light

b method: quadrat; reason: because the seaweed is attached to the rocks and does not move

2 **a** population size = $(2/1) \times (30 \times 25) = 2 \times 750 = 1500$

b any suitable answer that indicates avoiding bias in results, such as not choosing all the interesting places

3 **a** the percentage of a quadrat that the species fills

b clumped distribution

c The buttercups are all grouped together in a few quadrats and not spread evenly or randomly through all the quadrats.

9Cd-3 Percentage cover

1 abundance = (4/1) × (100 × 60) = 4 × 6000 = 24 000

2 Grass would be difficult because there is a large number of individual plants within the quadrat.

3 There are 100 smaller squares in the quadrat, so the area of each small square is 1% of the total area.

4 all values should be within a few per cent of the following: dandelion 15%, plantain 10%, daisy 20%, grass 55%

5 grass: (65 + 24 + 20 + 35 + 93)/5 = 47.4% cover
daisies: (24 + 72 + 55 + 44 + 6)/5 = 40.2% cover

6 The abundance of grass in terms of percentage cover is a little larger than that of daisy plants.

7 Grass is likely to be much more abundant than daisy plants in terms of population size, because each grass plant takes up less space. So the number in a particular area must be much larger.

8 to avoid bias in the results from choosing particular areas

9Cd-4 Seaweed survey

1 Seaweeds do not move and grow on the surface of the rocks, which makes them easy to see.

2 Taking four samples helps to average out variation between samples and so gives more reliable results.

3 The rocks near to low tide are only out of the water for a short time, so there would not be enough time to take more than a few samples before the rocks were covered again by the incoming tide.

4 In each quadrat, the percentage of the area of the whole quadrat covered by each species was estimated by eye. Then the values for each quadrat at that point on the transect line were added together and the mean calculated.

5 Any suitable three that will change with being in and out of sea water, such as light availability as seaweeds under water will receive less light than those out of water, dryness as seaweeds out of water will be dried by the sun and wind, wave action because as waves break at the tide edge they could cause damage to the seaweeds.

6 **a** The top of the shore will spend more time in air than in water, and so will get more light and dry out more than lower on the shore. Wave action will more likely be greater lower on the shore than near the top because waves reach the top of the shore for a shorter time.

b Seaweeds living at the top of the shore need adaptations that protect them from drying out and from strong sunlight.

7 Serrated wrack and spiral wrack show clumped distribution, with serrated wrack mainly at low tide level and spiral wrack mainly at high tide level. The distribution of bladder wrack is more even, though there is some clumping towards the middle of the shore.

8 For one of the factors identified in Q5, students should describe a simple experiment that tests how well the three seaweed species tolerate changes in that condition. For example, they could take rocks with seaweeds attached into the lab, and measure how much fronds increase in length (or any other suitable measure of growth) under different conditions of light or dryness.

9Cd-5 Plantain survey

1 Plan should identify:

- use of quadrats for measuring % cover by different species because quadrats are a good sampling method for plants as they do not move
- use of a measured transect line for placing quadrats at different distances from the centre of the path out into the longer grass, to get different amounts of trampling
- sampling of several quadrats at each distance from the centre of the path, for example by using several transect lines, and taking the mean of the results to average out random variation.

It might also include measurement of other physical environmental factors at each distance along the transect line, to make sure that they do not vary enough to affect distribution.

2 Graph showing % cover on *y*-axis, and distance from centre of path along *x*-axis, with the two lines clearly marked and labelled on the same axes.

3 any three suitable factors such as light intensity, soil moisture, wind speed, humidity

4 Cover by greater plantain plants is highest in the centre of the path and decreases as you move into the long grass, and cover by ribwort plantain is highest in longer grass and decreases as you get nearer to the centre of the path.

5 The data suggest that greater plantain is better able to withstand trampling than ribwort plantain, and that ribwort plantain is better able to grow in longer grass than greater plantain. However, as other environmental factors were not measured, and a measure of trampling was not recorded, this conclusion needs testing further.

6 **a** The results show a broadly similar pattern in that greater plantain covers a greater area than ribwort plantain near the centre of the path and ribwort plantain covers a greater area than greater plantain as you get further from the path. However, the actual coverage of both species is much lower than in the data in Q2.

b Some of the difference may be due to different ways of estimating by the different groups. However, other environmental factors may vary at the two sites, such as light availability, and this may affect both species.

c Several transects should have been taken, so that the data for each distance from the centre of the path could be averaged to reduce the effect of random variation. Environmental factors should have been measured at each quadrat, such as light availability, soil moisture, wind speed, to assess whether they vary enough to affect plantain distribution. Ideally some measure of trampling should be recorded so that the assumption that there is more trampling in the centre of the path could be checked, though this could be difficult to do.

9Ce In and out

Student Book

1: 9Ce In and out

1 **a** Vitamin B12 is found in food. When food is digested, there are more molecules of vitamin B12 in the small intestine than in the blood. Small molecules can diffuse through the surface of the small intestine. So there is overall movement of vitamin B12 from the small intestine into the blood, which is diffusion.

b Tropical sprue reduces the surface area of the small intestine. This means there is less area for vitamin B12 to diffuse across and into the body. This could cause a lack of vitamin B12 inside the body, and so result in pernicious anaemia.

2 **a** During respiration, the number of oxygen molecules inside the organism falls because the oxygen is used to break down food molecules. This means there are more oxygen molecules outside the organism than inside, so there is diffusion of oxygen into the organism across its cell surface membrane.

b As the organism increases in size, its volume increases more rapidly than its surface area. This will make it more difficult for the organism to absorb all that its volume needs. Splitting in two reduces the volume in relation to surface area again.

3 **a** lungs

b The inside surface of the lung is formed from millions of small sacs called alveoli that greatly increase its surface area.

4 **a** surface area = $2(3 \times 2) + 2(3 \times 1) + 2(2 \times 1) = 12 + 6 + 4 = 22$ cm^2
volume = $3 \times 2 \times 1 = 6$ cm^3
surface area:volume ratio = $22/6 = 3.7$

b surface area = $2(6 \times 4) + 2(6 \times 2) + 2(4 \times 2) = 48 + 24 + 16 = 88$ cm^2
volume = $6 \times 4 \times 2 = 48$ cm^3
surface area:volume ratio = $88/48 = 1.8$
The larger cuboid has a smaller surface area:volume ratio than the smaller cuboid.

5 **a** silky anteater: 5000/400 = 12.5 ants/g, giant anteater 30 000/40 000 = 0.75 ants/g

b The large body size of the giant anteater gives it a small SA:V ratio, so it transfers energy more slowly to the environment than the silky anteater. It does not therefore need to eat as much to make up for that transfer as the smaller animal.

6 **a** Y

b from Y to X

c osmosis; random movement of particles means that there will be an overall movement from a higher concentration of them to a lower concentration (down the concentration gradient) but in osmosis there is only an overall movement of water molecules because they are the only ones small enough to fit through the partially permeable membrane

7 The cell on the left has been in a liquid that contains fewer water molecules than are inside the blood cell. So there has been overall movement of water molecules out of the cell into the surrounding liquid, making the cell spiky.

8 Tropical sprue reduces the height of the villi in the small intestine. This reduces the surface area of the small intestine without changing the volume, so SA:V ratio is reduced. A smaller amount of substances can be absorbed into the body over this smaller surface area, leaving more substances in the gut. More of these substances in the gut may mean that there are more water molecules inside the body than in the gut, and so water will move by osmosis out of the body into the gut and cause diarrhoea.

2: 9Ce Combatting pandemics

1 yes, because it occurred in many people across the world at the same time

2 People can travel quickly between countries, and may be infected even if they do not yet feel ill. This means that the disease could spread to other countries very quickly.

3 If you keep infected people away from uninfected people, then the disease cannot spread. Keeping people who may have come into contact with an infected person isolated until you are sure they don't have the disease will make sure the disease isn't spread before a person shows symptoms.

4 It costs money to set up treatment centres, for medicines and for people to look after those who are ill. For highly infectious diseases such as Ebola, money is also needed for special clothing and equipment. If a country doesn't have enough money for these things, then it is more likely that the disease will spread quickly to more people.

Other points that students might mention include: terrain (with some countries finding it more difficult to get supplies to certain parts of its territory), wars (supplies are often difficult to get into war zones), border controls/transport links (it's more difficult to control the flow of diseases in countries that have better links to others), population density (with diseases spreading more rapidly in densely populated areas), general health and nutrition (with diseases spreading faster through a population that is malnourished, for example).

Activity Pack

9Ce-3 Osmosis and diffusion

A/B: diffusion from B to A, because there are more solute particles in B than A; osmosis from A to B because there are more solvent particles in A than B

A/C: Diffusion from C to A, because there are more solute particles in C than A; no osmosis as there is the same number of solvent particles in both solutions

A/D: Diffusion from D to A, because there are more solute particles in D than A; osmosis from A to D because there are more solvent particles in A than D

B/C: No diffusion as there is the same number of solute particles in both solutions; osmosis from C to B because there are more solvent particles in C than B

B/D: Diffusion from D to B, because there are more solute particles in D than B; osmosis from D to B because there are more solvent particles in D than B

C/D: Diffusion from D to C, because there are more solute particles in D than C; osmosis from C to D because there are more solvent particles in C than D

9Ce-4 Diffusion in *Amoeba*

1 **a** glucose + oxygen → carbon dioxide + water

b **i** decrease **ii** increase

c A partially permeable membrane allows some substances to pass through it but not others.

d There are more carbon dioxide particles inside the cell than outside. So there will be an overall movement of carbon dioxide particles from inside the cell across the cell surface membrane into the water.

2 **a** osmosis

b Osmosis describes the movement of solvent molecules; diffusion describes the movement of solute molecules.

9Ce-5 SA:V ratio and osmosis

1 **a** The disease reduces the surface area of the small intestine.

b It reduces the surface area for absorption/diffusion of food molecules into the body and so reduces the rate at which they are absorbed.

c If absorption of important nutrients such as vitamins is reduced too much, the body may not get enough of them to work properly, and this will cause deficiency diseases.

2 **a** The most obvious difference in the diagrams is the size and shape of the ears, which are large and long in the jack rabbit and small in the Arctic hare. (There may be other differences.)

b Heat transfer is from the warmer object to the cooler, so usually from the hare's body to the environment.

c The larger the volume of a warm animal, the smaller its SA:V ratio, and the slower the rate of transfer of energy to the environment.

d Large ears will increase the surface area for heat transfer, which is an advantage in a warm environment. Small ears reduces surface area, which will reduce the rate of heat transfer and is an advantage in a cold environment.

3 Diagram A shows cells that were placed in the solution that was mostly water because the cytoplasm fills each cell. There were more water molecules in the solution surrounding the cells than in the cytoplasm. So there was overall movement/osmosis of water into the cells until they were full. Diagram B shows cells placed in the solution containing a lot of salt, because the cytoplasm of each cell has lost water. This is because the cytoplasm contained more water molecules than the solution, so water moved out of the cells by osmosis.

9Ce-6 Exchange in flatworms

1 The respiratory system exchanges gases between the body and the environment. The circulatory system carries substances around the body.

2 Multicellular organisms are usually too large to exchange substances with the environment just through their outer surface. So they have a respiratory system which is adapted to have as large a surface area as possible for rapid exchange of gases between the body and the environment. The circulatory system ensures that substances carried in the blood have only a short distance to diffuse into cells, or vice versa, so that cells are supplied quickly enough with what they need to work properly.

3 The thin shape of the planarian means that no cells are far from the environment, so that gases can easily diffuse fast enough into and out of cells for the cells to work properly.

4 A larger distance would mean that it could take too long for gases to diffuse into or out of the innermost cells for them to work properly.

5 The food particles need to be broken down into smaller substances so that they can be absorbed into the body.

6 The gut has a very complex shape that not only increases the surface area for absorption, but also penetrates every part of the body so that cells can get the nutrients they need without the presence of a circulatory system.

7 By osmosis, because there are more water molecules in the water surrounding the planarian than in its body. So by random movement, there is an overall movement of water into the animal's body.

8 Planarians living in freshwater will absorb water molecules continually by osmosis. If they did not get rid of the water, their cells might expand and burst. Sea water contains many dissolved salts and so the amount of water molecules in the body of the flatworm and the water surrounding it may be similar. So there may be little overall movement of water between them, and no need for the planarian to get rid of excess water.

9E Making materials

9Ea About ceramics

Student Book

1: 9Ea Materials of the future

1 New substance(s) is/are formed.

2 any four from: melting point, hardness, flexibility, electrical conductivity, heat conductivity, malleability

3 conductors, any two from: metal elements, alloys (like steel or brass), carbon (graphite); insulators, any two from: non-metal elements, wood, plastic (other answers possible)

4 **a** atoms

b the force that hold atoms together

5 any personal wearable electronic equipment, phone, mp3 player, TV, computer, exercise monitor, dieting monitor, etc.

2: 9Ea About ceramics

1 **a** It does not allow electricity to pass through it.

b It prevents electricity flowing from the cables into the pylon's metal structure.

c plastic, wood, glass, etc. (many other possible answers)

2 two of: strong, hard, very unreactive, can be shaped exactly

3 **a** two of: heat resistant, good insulator, high melting point, non-toxic, unreactive

b brittle

4 china for cups and plates, glass for bottles, porcelain for electrical pylon insulators (other answers possible)

5 **a** clay and sand

b Both are heated to very high temperatures. Glass is made from sand but china is made from clay.

6 **a** Smaller crystals (in X) are formed when the molten ceramic is cooled quickly.

b Larger crystals form on slow cooling as the atoms have more time to form the lattice structure.

7 **a** lattice

b They represent different elements (silicon, oxygen, aluminium).

8 There are lots of strong bonds that have to be broken to melt or break a ceramic.

Activity Pack

9Ea-1 About ceramics

1 **a** glass **b** china

2 brittle, insulators of heat, hard, non-conductors of electricity

3 **a** non-conductors of electricity

b transparent **c** hard

4 **a** clay **b** lattice **c** large

9Ea-3 Sorting ceramics

Teapot: China ... because it is strong and a good insulator of heat

Electrical connector blocks: Ceramic ... because it is strong and a good insulator of electricity.

Lab beakers and flasks: Glass ... because it is strong and transparent (see-through).

Silicon carbide (brake discs): Ceramic brake disc in high performance car ... because it is strong and resistant to heat.

9Ea-4 Structure and properties

1 Clockwise from top left:

silicon carbide; lattice; formula = SiC; m.pt/b.pt = 2730/3265 °C

silicon chloride; molecule; formula = $SiCl_4$; m.pt/b.pt = –69/58 °C

carbon dioxide; molecule; formula = CO_2; m.pt/b.pt = –78/–57 °C

silicon dioxide; lattice; formula = SiO_2; m.pt/b.pt = 1610/2230 °C

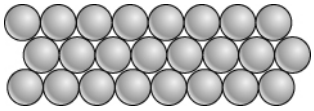
9Ea-5 Webquest on lattice structures

1 Any three from each set.

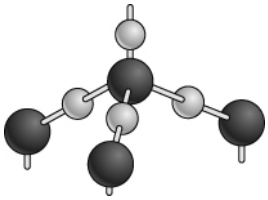
Ceramics: china for cups and saucers; glass for bottles and windows; and pottery for teapots and plant containers.

Metals: copper for water pipes; steel for sink tops and lead for roof flashings.

2 **a** billions of copper atoms bonded together in a regular pattern



b billions of silicon and oxygen atoms bonded together (alternatively) in a regular pattern



3 copper: strong; melting point 1085 °C (high); good malleability; high conductivity

silicon dioxide: strong; melting point 1600 °C (very high); poor malleability (brittle); low/nil conductivity

4 **a** Copper is malleable as the layers of atoms in the lattice structure can slide over each.

b The layers of atoms in ceramic structures are held in place by strong bonds and cannot slide over each other.

c Most ceramics do not contain charged particles that can move.

5 The bonds in ceramics are strong and hold the atoms in fixed positions in a regular pattern.

The bonds in metals are strong and hold the atoms in a regular pattern but allow layers of atoms to slide over each other.

6 The different atoms will have different sizes (and may form different types of bonds) and so they will change the structure of the ceramic lattice.

7 The different atoms will have different sizes and so will distort the metallic lattice, making it harder for the layers to slide over each other.

9Ea-6 Ceramics crossword

1 ceramic

2 insulators

3 conductors

4 temperatures

5 bricks

6 china

7 porcelain

8 glass

The missing word is *material*, and a suitable clue would be: *Another name for a substance*.

9Ea-7 Breaking glass

1 transparency

2 **a** Brittle describes a material that does not bend but breaks under a force.

b Glass is brittle because it has many atoms held together by many strong bonds that hold the atoms together in a rigid pattern.

3 sand, sodium carbonate and calcium oxide

4 **a** Thermal shock is damage caused by rapid cooling or heating.

b The glass breaks when heated or cooled rapidly as it is a poor conductor of heat and rapid expansion or contraction occurs at one point, causing cracks to form.

c It caused problems by shattering the signal lights causing them to fail.

d borosilicate glass is used as it can withstand rapid temperature changes.

5 **a** Borosilicate glass

b borosilicate glass is the best choice as it is resistant to chemicals, can withstand rapid temperature changes and does not tend to shatter into sharp pieces. Plastics will melt on heating and soda glass and china could shatter with thermal shock.

6 **a** slow cooling

b It allows the atoms time to form larger lattice structures forming larger crystals.

9Ea-8 Changing structures

1 A lattice structure contains billions of atoms held together by bonds in a regular pattern.

2 A substance made up of molecules contains groups of atoms of a set size, lattice structures have no set size.

3 Malleable substances can be beaten and bent into different shapes. Brittle substances break rather than bend and change shape.

4 They have a lattice structure containing billions of atoms held together by billions of strong bonds.

5 The atoms in quartz form a regular lattice. The arrangement of atoms in glass is more random.

6 The hot glass shatters when cooled rapidly as rapid contraction occurs at one point, causing it to shatter.

7 Boron oxide make the glass more resilient to temperature changes as it makes the structure more regular throughout and so it expands and contracts more evenly.

8 cookware and laboratory glassware

9 Metals are malleable as the layers of atoms in the lattice can slide over each other. In quartz and glass the structures are held in place by strong bonds that do not allow the atoms to slide over each other.

9Eb Polymers

Student Book

1: 9Eb Polymers

1 a long-chain molecule (made up of repeating groups of atoms)

2 **a** There are three different types of atoms.

b by (forces of attraction called) bonds

3

Object	Polymer name	Properties that make polymer suitable for use
gloves	rubber	flexible, waterproof
scouring pad	nylon	tough
bucket	PVC	chemically resistant
bottle	poly(propene)	tough, flexible, fairly high melting point
bottle	poly(ethene)	cheap, flexible

4 **a** Vulcanised rubber is elastic because when it is stretched out of shape it returns to the original shape. It is not plastic though because it cannot change shape when heated.

b It would become too rigid/brittle or it would not bend because the cross-links would hold the molecules tightly together.

5 **a** The monomers that are used to make synthetic polymers are produced from crude oil.

b The natural polymer is rubber.

6 **a** Ethene monomers join together to make the polymer, which is poly(ethene).

b A drawing of the monomer labelled repeating atoms in diagram A.

7 Poly(propene). It is strong, flexible and hardwearing.

8 Energy is transferred to the surroundings.

9 A molecule is a group of atoms joined together (usually of a set size). A lattice structure has billions of atoms joined in a regular structure (of no set size). A long-chain molecule is made up of repeating groups of atoms.

2: 9Eb Peer review

1 two from: speaking at meetings/conferences, posting papers on the Internet, publishing scientific papers in journals and magazines

2 hypothesis – an idea about how something works that can be tested using experiments; conclusion – an explanation of how or why something happened (which is backed up by evidence)

3 so the experiments can be repeated exactly (to check the results match those in the paper); to confirm that appropriate variables were controlled.

4 **a** the process by which scientific papers are checked by other scientists, by repeating the experiments and checking the conclusions drawn from the results

b It is important to check that a paper is original and correct so others can use the findings and ideas. This is best done by a 'peer' who understands the area of science that the paper is about.

5 because the scientists are well respected in their field and so believed without proper review, or because of a lack of suitable expert scientists to carry out the review

6 to fit their ideas, become famous, get grants for future work, please the companies they work for

7

Benefits	Drawbacks
tests data for mistakes checks scientific content gives recognition for new discoveries allows others to take research further	expensive takes up a lot of time slows down further research

Activity Pack

9Eb-1 Polymers

1 **a** flexible, heat insulators, plastic, strong

b water pipes

2 Polymers are often made from crude oil.

Polythene is an example of a synthetic polymer.

Rubber is an example of a natural polymer.

3 missing words: monomers; propene; cross-links; elastic

4 **a** exothermic

b plastic

9Eb-3 About polymers

Most polymers are made from raw materials from crude oil.

Rubber is an example of a natural polymer.

Polymers are often **elastic** which means they return to their original shape after stretching.

The long 'bendy' molecules of polymers mean that most of them are flexible.

Polymers are formed by joining lots of small molecules together.

Some examples of artificial polymers are poly(vinyl chloride) and poly(propylene).

Poly(ethene) is useful for plastic shopping bags because it is strong and flexible.

The small molecules used to make polymers are called **monomer** molecules.

The polymer structure is made up of long-chain molecules with repeating groups of atoms.

Poly(vinyl chloride) is useful for electrical cables because it is flexible and an insulator.

This diagram shows polymer chains that will melt when heated: right-hand diagram.

This diagram shows polymers with cross-links between the molecules: left-hand diagram.

9Eb-4 Polymerisation

2 a Word equation: propene → poly(propene)

Symbol equation: $nC_3H_6 \rightarrow (C_3H_6)_n$

Word equation: chloroethene → poly(chloroethene)

Symbol equation: $nC_2H_3Cl \rightarrow (C_2H_3Cl)_n$

b Word equation: tetrafluoroethene → poly(tetrafluoroethene)

Symbol equation: $nC_2F_4 \rightarrow (C_2F_4)_n$

9Eb-5 Polymer ideas

1 Most polymers are made from (crude) oil.

2 It is flexible and waterproof.

3 Most polymers are strong, flexible and durable.

4

5 A small molecule that joins together to form polymers.

6 Styrene would be used to make poly(styrene).

7 The monomers are joined together to make long-chain molecules.

9Eb-6 Peer review

1 by publishing on the Internet or by speaking at conferences or meetings

2 so others can use their findings

3 scientists working in the same field

4 **a** 2 **b** 5 **c** 3 **d** 1

5 A scientific paper is checked to see if it is correct and worthwhile. This could mean repeating experiments to check results and checking that the work is new and not copied.

6 so that they can be repeated for validation

7 the editor of the scientific journal

8 Advantage: it checks the quality of published research.

Disadvantage: it takes a long time to carry out and this delays publication of the research.

9Eb-7 Polymer structures

1 Natural materials are found naturally. Synthetic materials have to made (by chemical reactions).

2 They have similar properties; flexible, heat insulators.

3 Lots of small molecules (monomers) are joined together.

4 It melts easily.

5 The molecules are joined together (cross-linked) by sulfur atoms.

6 The vulcanised rubber is not plastic (it cannot be moulded) and is harder. The natural rubber is plastic and softer.

7 It is soft and flexible because its long molecules can move and stretch out and return to their original shape.

8 **a** natural rubber

b There are no cross-links.

c crude oil

d poly(butadiene)

9 **a** an endothermic reaction

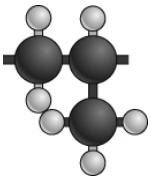
b exothermic reactions

9Eb-8 Making polymers

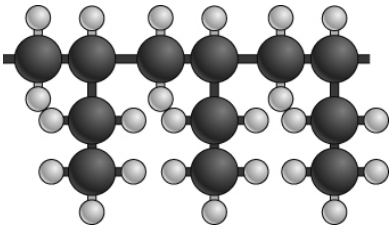
1 **a** polymerisation

b They join together (to form a long molecule).

c C_3H_6 and



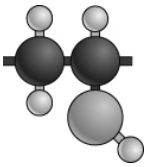
2 **a**



b poly(butene)

3 **a** vinyl alcohol

b



c C_2H_4O or CH_2CHOH (no double bond required)

9Ec Composite materials

Student Book

1: 9Ec Composite materials

1 a material made from a combination of two or more substances that has some of the properties of each material

2 GRP is a composite made from glass fibre and a polyester resin.

3 because it is strong to withstand knocks, is light to move easily, will flex without breaking under stress, can be moulded easily to produce complex shapes

4 It would need to be light, very strong, flexible and easily moulded.

5 Concrete combines two or more materials (cement, sand, water and aggregate).

6 Decomposition reactions involve breaking up compounds into simpler substances. In endothermic reactions, heat is absorbed from the surroundings or the temperature of the surroundings falls.

7 It is reinforced to increase its strength and prevent it cracking under pressure.

8 **a** an exothermic reaction

b Energy has been transferred to the surroundings as the reactants change into products.

2: 9Ec Materials for cars

1 **a** Transparent, and any other sensible property such as stiff, or strong enough not to break.

b Any two from: strong enough to withstand pressure, high friction to grip the road, slightly flexible (to adapt to different inflation pressures), do not wear away easily.

c Flexible, hard-wearing, comfortable to sit on.

2 **a** Glass, or transparent polymer. Glass is transparent and strong.

b Rubber, or a manufactured polymer with similar properties. Rubber is strong and provides good friction with the road surface.

c Fabric made from natural or manufactured polymers (e.g. cotton, poly(propene)). Fabrics can be made so that they are comfortable and hard-wearing.

3 It has to support the weight of the passengers, engine, fuel and the rest of the car, and it must withstand forces caused by the movement of the car. It also has to be strong enough to protect the passengers in a crash.

4 **a** Advantages of aluminium: lighter, so the car will be more efficient; does not rust.

Disadvantages of aluminium: more expensive; not as strong, so the car body will need a greater volume of metal than if the parts were made from steel (however, the greater volume of aluminium needed still produces a car with a lower mass than a steel car).

b It is lighter than steel, so the car will be more fuel efficient. It will not rust. (The much lower strength does not matter in car bumpers, which are designed to absorb some of the impact of a collision, although students are not expected to know this.)

c Ceramics are not as strong as steel, aluminium or carbon fibre composite; they are brittle, so would break rather than bend in a crash; they are much more expensive.

5 Its body is made of carbon fibre composite, which is a lot more expensive than steel. Students may also comment on its very high top speed, which would require a much more powerful engine than normal cars, which would also be expensive.

Activity Pack

9Ec-1 Composite materials

Across: **3** endothermic **4** exothermic **5** composite **7** strong **9** aggregate **10** light **11** plastic

Down: **1** reinforced **2** decomposition **6** matrix **8** glass **12** sand

9Ec-3 Composite poster

Glass-reinforced plastic is used to make boat hulls and car bodies.

Plywood is made by combining layers of wood and glue.

Safety glass combines layers of glass and a clear polymer.

Concrete is made from a mixture of sand, cement and aggregate.

Composite materials are made up of two or more different materials.

The properties of a composite material are a combination of the materials it is made from.

Plywood is strong, slightly flexible and a poor conductor of heat.

Safety glass is hard and rigid but does not break up into small pieces when impacted.

Concrete is hard, strong, and weather resistant.

Cement is a mixture of dried clay and **lime** (calcium oxide).

Lime is made by **decomposing** limestone (calcium carbonate).

The reaction that makes lime is an example of an **endothermic** reaction.

9Ec-4 Exothermic and endothermic

1 **i** exothermic **ii** endothermic
iii exothermic **iv** endothermic
v exothermic **vi** exothermic

2 **a** increases **b** endothermic **c** decreases
d exothermic **e** exothermic **f** endothermic

3 **i** exothermic as energy is being given out (surrounding are getting hotter)

ii endothermic as energy is being supplied

iii exothermic as energy is being given out (the explosion)

iv endothermic as the temperature of the surroundings is getting lower

v exothermic as the temperature of the surroundings is increasing

vi exothermic as energy is being given out (concrete gets hot)

9Ec-5 Using composites 1

1 **a** Concrete is made of more than one material (sand, cement and aggregate).

b any two sensible suggestions such as: glass-reinforced plastic, plywood, carbon fibre resins, laminated safety glass

c It is strong, hard and is not affected by weather.

d Limestone decomposing to lime when heated.

2 **a** mixture 1 = 40 g; mixture 2 = 360 g.

b Use mixture 2 as it is the strongest.

9Ec-6 Using composites 2

1 A material made by combining two or more materials.

2 because they have useful properties from all the materials used to make them

3 **a** glass-reinforced plastic and carbon fibre reinforced polymer

b glass-reinforced plastic as it is cheaper

4 any sensible suggestion, such as: could be used for covering roofs as it is waterproof

5 **a** They are easily eroded by wind and rain.

b concrete

c The materials are cheap and easy to source and would be most useful in hot, dry countries (non-industrial).

6 **a** an exothermic reaction

b The energy is transferred from the reacting substances (reactants) into the surroundings.

9Ec-7 Concrete mixes

1 sand, cement and aggregate (stones)

2 because bridges are under high compression forces (carry heavy loads)

3 to check they will be suitable for the job

4 The mix proportion 1/1/2 would be most suitable because it is the strongest.

5 The mix proportion 1/5/2 would not be suitable as it is too weak.

6 You could put cylinders of concrete in a machine that applied a measured, crushing force until the cylinder of concrete crumbled.

7 **a** The anomalous result was mix 1/1/4 and DCS test 2. This result was very different from the other two results for that mix.

b The anomalous result could have been caused by making the mix up wrongly or reading the scale on the apparatus wrongly.

8 **a** The mean values were: 1/1/2 = 41; 1/2/2 = 30; 1/3/2 = 25; 1/4/2 = 18 and 1/5/2 = 6.

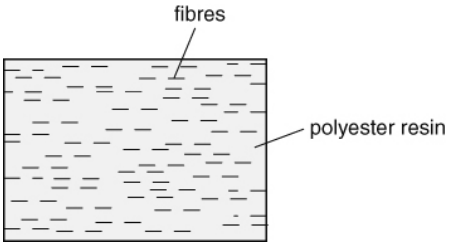
b Increasing the proportion of sand in these mixes decreases their strength.

9Ec-8 Structure of composites

1 Because the composite has properties of both materials. Students may state that the glass fibre reinforces and gives strength while the resin binds the fibres together and improves the appearance.

2 The four factors are: the type of fibre, the type of resin, the length of fibre used, whether the fibres are aligned or at random.

3



4 All are thermosetting polymers, so they do not melt on heating and so cannot be remoulded.

5 two of: hard, strong and light

6 They might have properties that make them more suitable for particular uses (because they are harder and stronger than other composites).

7 **a** Epoxy resins form the strongest materials. The glass fibre epoxy resin composite is used for the hulls of boats while the glass fibre polyester resin composite is used for garden ornaments.

b Aligned fibres make the most flexible composite as carbon epoxy composite with aligned fibres is used in springs, which need to be flexible.

9Ed Problems with materials

Student Book

1: 9Ed Problems with materials

1 **a** sulfur + oxygen → sulfur dioxide

b $S(s) + O_2(g) \rightarrow SO_2(g)$

2 Calcium nitrate

3 The stone is blackened by soot and attacked by acid rain.

4 Carbon capture reduces the amount of carbon dioxide released by power stations. Carbon capture does this by capturing and storing carbon dioxide underground (thus reducing the greenhouse effect).

5 **a** Pollutants are released into water (directly into the sea or through water courses that flow into the sea). The pollutants then get into the fish. Humans then eat the fish that contain the pollutants.

b The poisons taken in by the small animals do not break down, and the larger animal eats several of the smaller animals (and so receives a higher dose of the toxin).

6 Advantage: plastic is durable (doesn't break down when you are using it); disadvantage: can cause long-lasting pollution, harm organisms which eat them.

7 These plastics would decompose and disappear in a shorter time than other common plastics and they are formed from renewable sources (do not use up crude oil).

Activity Pack

9Ed-1 Problems with materials

Top left missing words: carbon; greenhouse; global. Solution: Burn less fossil fuels or use carbon capture technology.

Top right missing words: sulfur; acid. Solution: Remove sulfur from fuels before use.

Bottom left missing words: biodegradable; pollution. Solution: Use biodegradable polymers or use less non-biodegradable polymers.

Bottom right missing words: sea; fish; increase. Solution: Control factory waste.

9Ed-3 Material problems

1 **a** coal, oil and gas

b unburnt carbon

c greenhouse effect

d carbon dioxide

e rising average global temperatures

f sulfur

g become concentrated

2 **a** The rising global temperatures could be controlled by reducing carbon dioxide in the air either by burning less fossil fuels or by using carbon capture technology. (Reducing levels of other greenhouse gases, such as methane, would also help reduce global temperatures.)

b Long-term pollution by polymers could be reduced by using more biodegradable polymers or using fewer synthetic non-biodegradable polymers.

3 The conclusion that air pollution is causing problems is based on one person's cough. The polluter being identified as the local factory was based on the views of one person who did not seem to have any expertise or specialised knowledge.

4 **a** Farmers report beaver problem

b Farmers in Tayside have reported that beavers have caused problems by damming waterways, which caused flooding and the destruction of crops. A spokesperson for the Beaver Trial Trust admitted that this could be true; however they argued that beavers also brought benefits to an area.

c any three from: blamed, hundreds, mayhem, extensive, vast, beasts

9Ed-5 Plastic oceans

1 Biodegradable materials break down quickly in nature while non-biodegradable materials do not break down quickly in nature.

2 Marine animals can be choked by plastic parts or they can be poisoned by eating plastics that have absorbed toxins.

3 Student's own answers.

9Ed-6 Problems with fuels

1 **a** The general trend is that carbon dioxide emissions have been increasing since 1850 (and the rate of increase is rising also).

b Average global temperatures will rise as the increased levels of carbon dioxide trap the Sun's energy and increase the greenhouse effect.

c burning more carbon-based fossil fuels

2 **a** sulfur dioxide (or nitrogen oxides or carbon dioxide)

b Many fossil fuels contain sulfur that burns to form the acidic sulfur dioxide.

3 **a** A biodegradable substance will decompose/break down in the soil. A non-biodegradable substance does not decompose in nature, but lasts for a long time.

b The animals can swallow non-biodegradable plastic bags, causing either choking or poisoning.

9Ed-7 Poisoning ourselves

1 Either the soot damages lungs (causing breathing problems and respiratory diseases) or it dirties buildings.

2 These fuels produce sulfur dioxide when they burn. This is an acidic gas that then contributes to acid rain.

3 When fuels burn they produce carbon dioxide, and other gases such as water vapour and nitrogen (nitrous) oxide, which are greenhouse gases.

4 Burning fuels produces more carbon dioxide (and other gases like water vapour and nitrogen oxides) which traps the Sun's energy and increases the average global temperatures. This causes the polar ice caps to melt and make the sea levels rise.

5 by using less carbon fuels or increased use of carbon capture technology or growing more trees

6 The tiny sea creatures take in low levels of poison. These are eaten by small fish, which are eaten by bigger fish, which are eaten by humans.

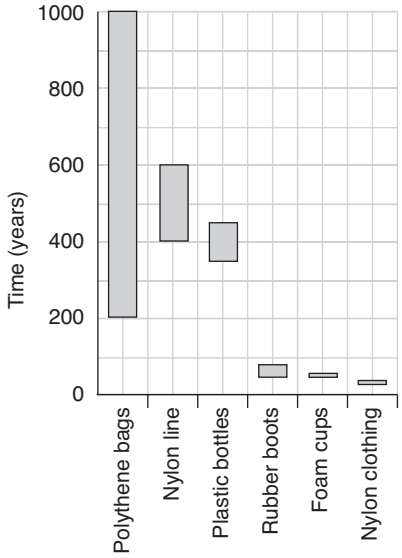
At each stage in the food chain the larger animal eats more of the smaller animal and the amount of poison the organism is taking in increases. Humans are at the top of the food chain and the levels can reach dangerous proportions.

7 **a** A substance that does not decompose quickly in nature.

b The animals can be trapped by or even be choked by polymer materials and they can be poisoned by plastics that have absorbed toxins.

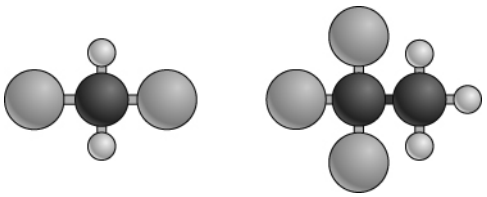
c Increase use of biodegradable polymer bags, or use fewer non-biodegradable plastic bags, or prevent plastic waste from entering the environment.

8

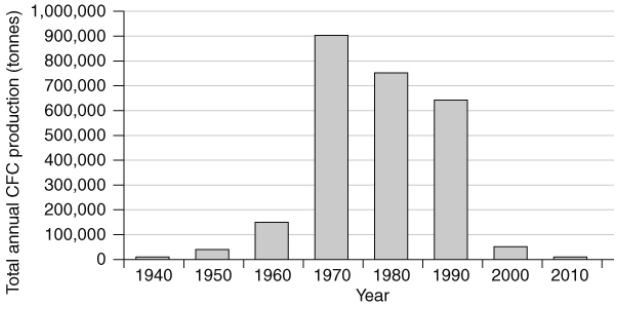


9Ed-8 Ozone problems

1



2 **a**



b Production increased rapidly as new uses for CFCs were found. In the 1970s it decreased rapidly after it was discovered that they were causing problems (by reducing the ozone concentrations in the upper atmosphere).

3 **a** Both trends change direction – CFC production trends is for a sharp rise, then sharp fall. The ozone concentration falls rapidly, but has now started to rise.

b This is because the CFCs remained in the atmosphere for many years continuing to destroy the ozone and decrease its concentration even when the production of CFCs fell. It took some time for the fall in CFCs to be enough to allow the ozone to recover.

4 somewhere near the year 3000

9Ee Recycling materials

Student Book

1: 9Ee Recycling materials

1 The metal ores will run out eventually. No more metal ores can be made.

2 oil 53 years; natural gas 56 years; coal 109 years

3 **a** We can reduce our use of landfill by recycling more materials.

b any two of: they can be unsightly, use up valuable land, cause environmental pollution

4 any two of: saves resources, saves energy, reduces use of landfill

5 to separate clear and coloured glass (as it is harder to recycle coloured glass)

6 **a** It is time consuming and expensive to separate different types of polymer.

b Advantage: it would be easier to separate the different polymers. Disadvantage: no choice in colours of household goods.

7 **a** It is broken up into aggregate.

b It is used in foundations of roads and buildings.

8 paper is used → waste paper collected → water added and ink removed → solids filtered out → heated and mixed to form pulp → pulp squeezed and dried to make paper

2: 9Ee Material failures?

1 Advantage: fireproof and/or good at heat insulating the cooker. Disadvantage: danger of asbestos dust.

2 **a** any four of: glass, metals, polymers, building waste, garden waste, paper, cardboard, fabric (other answers possible)

b one suggestion from: glass into coloured and clear; metals into different types (copper, steel, etc.); polymers into different types (polythene, pvc, etc.); building waste into concrete and bricks (other answers possible)

3 **a** Ceramics, like china and glass, are made from sand and clay (*or* are made up of strong lattice structures).

Polymers, like poly(ethene) and poly(chloroethene), are made up of very-long-chain molecules (which contain repeating groups of atoms).

Composite materials, like GPR and concrete, combine two or more different materials (and combine their properties).

b Glass is recycled by melting and remoulding it. It is important as it takes less energy compared with making new glass.

or Concrete is collected and crushed to make new aggregate. It is important as waste concrete can take up a lot of space in landfill.

or Polymers can be recycled by using identification labels. It is important as it saves precious resources of oil.

(Other answers are possible.)

c Making polymers uses up finite resources of fossil fuels.

or Using some polymers causes long-term pollution problems in the environment.

or Making some polymers can release toxic substances into the environment.

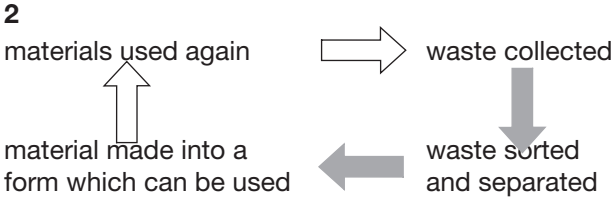
(Other answers are possible.)

Activity Pack

9Ee-1 Recycling problems

1 **a** landfill **b** land **c** finite **d** energy

2



3 Metals like iron are collected in scrap yards.

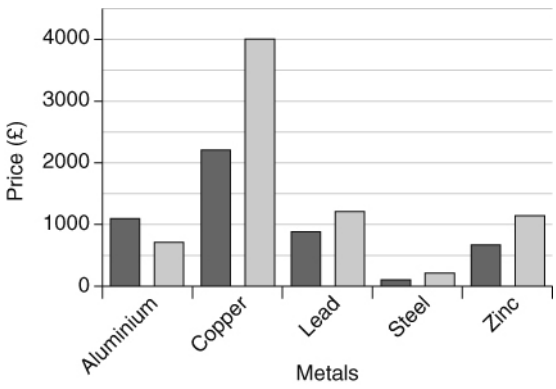
Glass is sorted into different colours for recycling.

Concrete is broken up into aggregate for using again.

Metals are easily melted and reshaped for re-use.

9Ee-3 Prices of metals

1 **a and b**

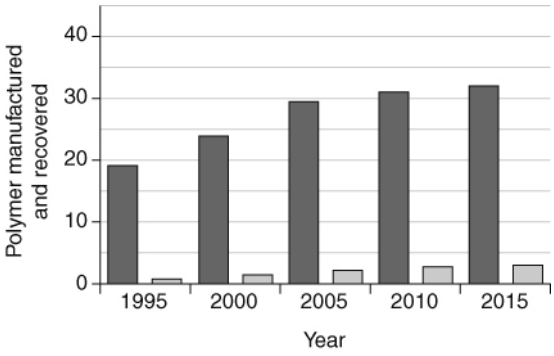


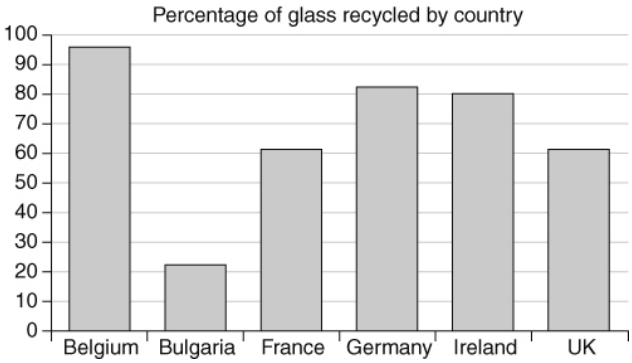
c lower

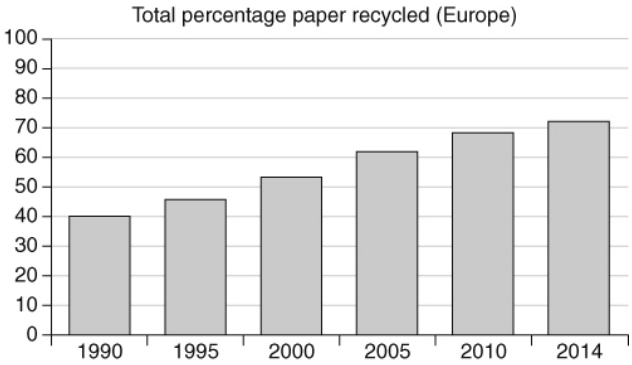
2 **a** land **b** ores **c** finite **d** separated, melt

9Ee-5 What to recycle?

1







2 Polymers: advantage – saves crude oil resources; disadvantage – difficult to separate.

Paper: advantage – saves trees; disadvantage – produces lower quality paper.

Glass: advantage – saves energy; disadvantage – need to separate colours.

The trends shown by the data are that as the amount of polymer manufacture increased (by about 50%) the amount of polymer recovered increased more (by about 200%).

3 **a** Main source for new materials: There are greater resources of the main source of glass, so it is unlikely to run out.

Recycling rate: The recycling rate for aluminium is higher as it is more efficient (easier to collect).

Energy saving: The energy saving in recycling aluminium is much higher so will make large savings on costs and fuels.

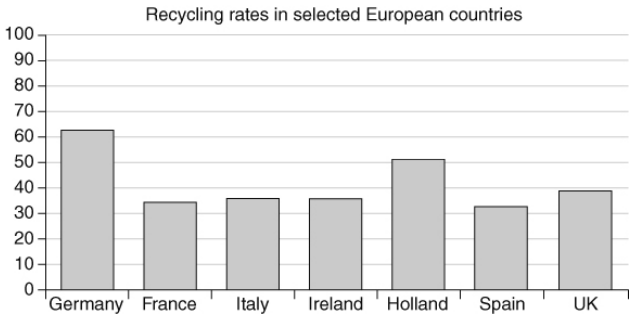
Carbon emission saved: The amount of CO_2 saved is significant for aluminium so recycling will help reduce greenhouse gases.

Price per tonne: The price of aluminium is much higher than glass, so may be more profitable.

b The council should concentrate on improving the recycling of aluminium as it will create more benefit in all the factors considered.

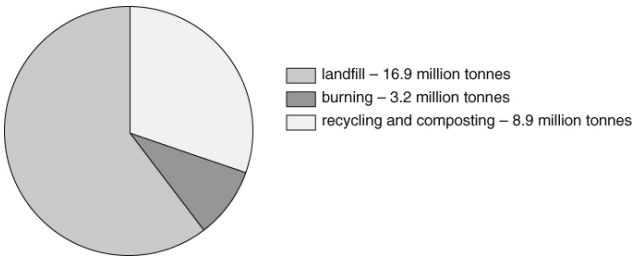
9Ee-6 Dealing with waste

1 a



b Germany

2 a



b 29 million tonnes

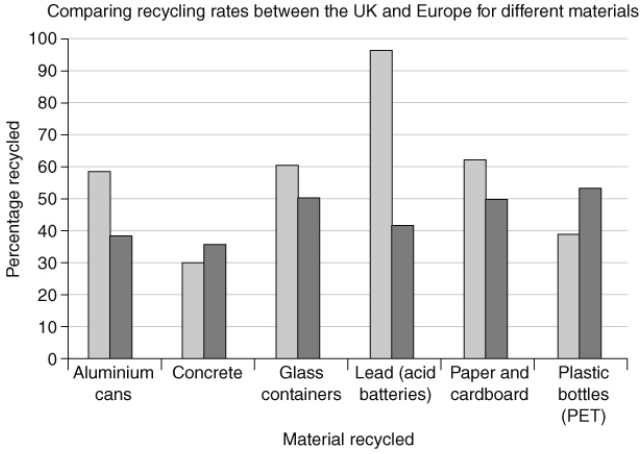
c any one from: it is a wasteful use of land that could be used for farming; landfill waste can produce dangerous substances leading to pollution and poisoning wildlife; once in a landfill the materials cannot be recycled so increasing the need for newly manufactured materials. Other answers possible.

3 a run out

b energy (costs)

9Ee-7 Recycling ideas

1



2 a paper and cardboard, glass bottles and plastic bottles (PET)

b concrete

3 a missing words: collected, remove ink, pulp, squeeze (and dry)

b trees (wood/timber)

4 a The concrete is crushed into small pieces (and graded by size).

b sand, cement and aggregate

c any two of: steel, wood, plaster, copper piping, copper wire

d can be used for the foundations of buildings or roads

5 lead (from acid batteries)

6 a sand, calcium oxide or sodium carbonate

b It is sorted by colour.

c 250

9Ee-8 Dealing with glass

1 a 25 million tonnes

b 69%

2 a recycled waste glass

b Rejects from glass manufacturing and bottle banks or recycling collections.

3 Clear glass has a range of uses, some of which might be difficult to collect. (Green and amber glass are mostly used for bottles, which are easier to collect and recycle.)

4 Advantages: less use of landfill, less energy used, natural resources saved.

5 a 3.5 kg **b** 9 kg

6 Using them carefully so we will have enough to use in the future.

7 a green glass **b** clear glass

8 Milk bottles are used near to their source, so are easily transported back for reuse. Green wine bottles are used far away from their source so it is too expensive to return them for reuse.

9 For making new road-laying material and 'sand' for golf course bunkers.

10 Could increase the number of bottle banks, employ more people to collect glass or introduce compulsory deposits for glass bottles. (Other answers possible.)

9F Reactivity

9Fa Types of explosion

Student Book

1: 9Fa Demolition

1 Physical change: no new substances are formed; chemical reaction: new substances are formed.

Physical change: can be reversed; chemical reaction: difficult to reverse.

2 Possible answers: flying debris could hit spectators, the building may only partially collapse, the building may be left leaning at a dangerous angle, some of the explosives may not detonate.

3 The particles hit the walls of the container.

4 increase the temperature, decrease the size of the container, increase the number of gas particles in the container

2: 9Fa Types of explosion

1 **a** liquid to gas

b No new substance is formed and the gas changes back to liquid when it cools down.

c There is a sudden increase in volume and a huge transfer of energy to the surroundings.

2 **a** physical, because no new substance is formed or liquid wax can easily be changed back to solid wax or the solid wax has melted and melting is a physical change

b chemical, because new substances have been formed or the reaction cannot be reversed

c chemical, because new substances have been formed or the reaction cannot be reversed

3 petrol evaporated

4 chemical reaction, as the petrol is burning to form new products

5 increased

6 carbon + oxygen → carbon dioxide + heat; $C + O_2 \rightarrow CO_2$ + heat

7 The liquid nitrogen boiled rapidly and the increase in temperature raised the pressure.

8 Diagram should show a container of the same size as the room temperature container in the Student Book (Topic 9Fa Types of explosion, diagram E, left-hand container), but with more particles. Explanation to include: increasing the number of gas particles means that the particles are closer together and hit the walls of the container more frequently.

Activity Pack

9Fa-1 Changes

1 Physical changes – boiling, melting. Chemical reactions – burning, neutralising.

2 True statements: New substances are made during a chemical reaction. A physical change is usually easier to reverse than a chemical reaction.

3 A liquid was set on fire and it burnt with a yellow flame – chemical reaction.

A liquid was cooled down and it changed into a solid – physical change.

4 Box B. There are more particles in the same volume so they will collide with the walls of the container more often.

9Fa-2 Physical and chemical changes

Lemon juice and bicarbonate of soda – chemical reaction

Water and copper sulfate crystals – physical change

Water and baking powder – physical change

Water and crushed ice – physical change

Copper sulfate solution and iron filings – chemical reaction

9Fa-3 The imploding can

Order: B, D, G, F, A, E, C.

9Fa-4 Pressure

A digital or poster presentation to include images and reference to:

Increasing the temperature gives the particles more energy and they hit the walls of the container more often and with more force.

Decreasing the size of the container makes the particles closer together so they hit the walls of the container more frequently.

Increasing the number of gas particles makes the particles closer together so they hit the walls of the container more frequently.

9Fa-5 Changes and pressure

1 **a** Condensation – physical change

b Neutralisation – chemical reaction

2 **a** chemical reaction

b physical change

3 Physical change – the pool of liquid. Reason – the wax has melted/liquid wax can be easily changed back to solid.

Chemical reaction – the candle burning with a yellow flame. Reason – new substances are being made/the burning cannot be reversed.

4 Gas pressure is caused by the force of the particles hitting the walls of the container.

5 **a** True

b False

c True

9Fa-6 Explaining physical changes

1 **a** any sensible suggestions, for example: melting, boiling, condensing, freezing

b any sensible suggestions, for example: burning, neutralisation, displacement

2 Physical change – no new substances formed or usually easy to reverse

Chemical reaction – new substances formed or difficult to reverse

3 **a** Physical change – no new substance formed, or the gas could be cooled and changed back to a liquid.

b Chemical reaction – new substances have been formed, or it would be difficult to reverse the reaction to get the liquid back.

4 The gas particles are moving quickly and randomly in all directions.

5 Increasing the temperature gives the particles more energy and they hit the walls of the container more often and with more force.

6 Decreasing the size of the container makes the particles closer together so they hit the walls of the container more frequently.

7 Increasing the number of gas particles makes the particles closer together so they hit the walls of the container more frequently.

9Fa-7 Pressure, volume and temperature

1 **a** As the temperature increases, the volume of gas increases.

b The volume of a gas is directly proportional to the temperature.

2 **a** As the temperature increases, the pressure of the gas increases.

b The pressure of a gas is directly proportional to the temperature.

3 **a** As the volume increases, the pressure of the gas decreases.

b The pressure of a gas is inversely proportional to the volume.

9Fb Reactivity

Student Book

1: 9Fb Reactivity

1 **a** potassium, sodium, lithium, calcium or magnesium (accept aluminium, zinc, iron, tin, lead)

b copper (accept mercury, silver)

c mercury or silver

2 list of metals in order of reactivity, with the most reactive at the top

3 **a** sodium + water → sodium hydroxide + hydrogen

b magnesium + sulfuric acid → magnesium sulfate + hydrogen

c zinc + oxygen → zinc oxide

4 rubidium, barium, cobalt

5 **a** nucleus

b neutrons have no electrical charge (electrons do); accept the idea that neutrons are much bigger/heavier than electrons (although students are not expected to know this); accept neutrons are only found in the nuclei of atoms but electrons are only found outside the nucleus

6 **a** 12 (mass number – atomic number = number of neutrons)

b There is no overall charge on a sodium atom because it has the same number of positively charged protons as it has negatively charged electrons.

7 The mass number is 7 and the atomic number is 3, and these should be written one above the other (mass number uppermost) to the left of the symbol for lithium (Li).

Activity Pack

9Fb-1 Reactivity of metals

1 (potassium + water →) potassium hydroxide + hydrogen (products can be in either order)

2 (magnesium + hydrochloric acid →) magnesium chloride + hydrogen (products can be in either order)

3 zinc + oxygen → zinc oxide

4 Most reactive — Metal **X**
Metal **Z**
Least reactive — Metal **Y**

5 zinc

9Fb-3 The reactivity series

Metal	Symbol of metal	Product(s) formed when metal reacts with…		
		oxygen	water	dilute sulfuric acid
potassium	K	potassium oxide	potassium hydroxide + hydrogen	violent reaction
sodium	Na	sodium oxide	sodium hydroxide + hydrogen	violent reaction
calcium	Ca	calcium oxide	calcium hydroxide + hydrogen	calcium sulfate + hydrogen
magnesium	Mg	magnesium oxide	magnesium hydroxide + hydrogen (or no reaction)	magnesium sulfate + hydrogen

Metal	Symbol of metal	Product(s) formed when metal reacts with…		
		oxygen	water	dilute sulfuric acid
zinc	Zn	zinc oxide	no reaction	zinc sulfate + hydrogen
copper	Cu	copper oxide	no reaction	no reaction
gold	Au	no reaction	no reaction	no reaction

9Fb-4 Rusting presentation

A poster or digital presentation on prevention of rusting, including some of the following points:

Paint, oil, grease, covering with plastic, or coating with another metal all provide a physical barrier. This prevents air and water from reaching the iron or steel so rusting does not occur. Disadvantages – if the covering or coating is damaged or wears off, air and water will be able to reach the iron and rusting will occur. The coatings or coverings need to be replaced if they are damaged. Sacrificial protection involves attaching a block of a more reactive metal, e.g. zinc or magnesium, to the surface of the iron or steel. The more reactive metal corrodes in preference to the iron. Disadvantages – the more reactive metal wears away and has to be replaced regularly or the iron will rust. Zinc and magnesium are relatively expensive in comparison to iron.

9Fb-5 Writing balanced equations

1 **a** $H_2 + Cl_2 \rightarrow 2HCl$

b $2H_2 + O_2 \rightarrow 2H_2O$

c $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$

d $2Al + 6HNO_3 \rightarrow 2Al(NO_3)_3 + 3H_2$

2 **a** $2Mg + O_2 \rightarrow 2MgO$

b $2Na + 2H_2O \rightarrow 2NaOH + H_2$

c $Fe + H_2SO_4 \rightarrow FeSO_4 + H_2$

9Fb-6 Reactions of metals

1 **a** Observations to include any from: fizzing/effervescence/bubbles, melts, changes to a silver ball, moves, on surface of water, gets smaller, disappears, orange sparks (note – hydrogen or sodium hydroxide formed are not observations)

b sodium + water → sodium hydroxide + hydrogen

2 **a** effervescence/fizzing/bubbles

b zinc + hydrochloric acid → zinc chloride + hydrogen

3 **a** magnesium burns, bright white light, white powder left

b magnesium gains oxygen

4 (most reactive) M, N, L (least reactive)

9Fb-8 Balancing equations

1 **a** $2Ca + O_2 \rightarrow 2CaO$

b $2K + 2H_2O \rightarrow 2KOH + H_2$

c $Zn + 2HCl \rightarrow ZnCl_2 + H_2$

2 **a** $2Cu + O_2 \rightarrow 2CuO$

b $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$

c $Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$

3 **a** $2Zn + O_2 \rightarrow 2ZnO$

b $2Li + 2H_2O \rightarrow 2LiOH + H_2$

c $2Al + 6HCl \rightarrow 2AlCl_3 + 3H_2$

4 $Mg + 2H_2O \rightarrow Mg(OH)_2 + H_2$

9Fc Energy and reactions

Student Book

1: 9Fc Energy and reactions

1 The fireworks contain an oxidiser/oxidising agent that provides extra oxygen for the fuel to burn.

2 so the explosion will take place more quickly

3 oxygen relights a glowing splint

4 **a** combustion, neutralisation or displacement

b thermal decomposition

5 The temperature of the surroundings increased so this is an exothermic reaction.

6 **a** The molecules did not have enough energy to break their bonds.

b provide the mixture with some energy, e.g. touch the balloon with a flame

7 **a** Energy is transferred from the surroundings to the gunpowder. This breaks some bonds to start the reaction.

b Energy is transferred from the gunpowder to the surroundings when the gunpowder explodes.

2: 9Fc Percentage change

1 Students should show knowledge that:

- the iron rusts
- oxygen is removed from the air
- this reduces the volume
- a calculation can be done to show how the new volume and the original volume can be converted into a percentage.

2 11.1%

3 **a** 0.4

b $^2/_5$

4 Change in mass: 4.0 – 2.4 = 1.6 g

Percentage change:

$^{1.6}/_{2.4}$ x 100 = 66.7% (to 1 decimal place)

5 52.4%

6 40%

7 56 g

8 4.8 g

Activity Pack

9Fc-1 Oxygen and energy

1 Place a *glowing splint* into the gas. If the gas is oxygen, the splint *relights*.

2 Methane burning in air.

3 This is an **endothermic** process because the temperature of the surroundings **decreased**.

4 combustion and neutralisation

5 oxidising agent or oxidiser

6 powdered gunpowder, as it has a larger surface area.

9Fc-2 Measuring temperature change

4 Polystyrene is an insulator and will reduce the energy transferred to or from the surroundings.

5 Stirring makes sure the reaction/dissolving was complete.

6 use more solid/solution or increase the concentration of the solution

9Fc-3 Hydrocarbons and gases

1 hydrocarbons: CH_4, C_2H_6, C_3H_8, C_4H_{10}

not hydrocarbons: $C_6H_{12}O_6$, C_3H_9N, C_2H_5Cl, CO_2

2 **a** reactants: hydrocarbon + oxygen

b products: carbon dioxide + water

c An input of energy such as a flame or a spark.

3 oxygen: 1 light a splint and blow it out so that it is glowing; 2 place the glowing splint in the gas; 3 the splint relights

carbon dioxide: 1 bubble the gas; 2 through limewater; 3 it turns milky

water: 1 add anhydrous copper sulfate; 2 it changes from white; 3 to blue

9Fc-4 Self-heating cans

1 The calcium oxide and water start to react as soon as they are in contact with each other, so the reaction would take place before the user was ready to use the product if they were not separated.

2 The temperature of the contents/surroundings increases so this is an exothermic reaction.

3 Advantages, any from: no need for a separate supply of fuel to heat the contents; easier to carry one can than separate can and fuel, e.g. when camping; no danger from other fuels, e.g. bottled gas; no need for lighter/matches to provide an initial input of energy.

Disadvantages, any from: the chemicals take up a lot of space in the can so less room for the contents or a bigger can is needed; the can will be heavier with the calcium oxide and water in it; more waste to dispose of; expensive.

4 Hot packs – exothermic reactions; e.g. catalysed rusting of iron or dissolving calcium chloride in water.

Cold packs – endothermic reactions; e.g. dissolving ammonium nitrate in water.

9Fc-5 Breaking and making bonds

1 Bonds broken: 2 H–H, 1 O=O (allow O–O)

2 Bonds made: 4 O–H (allow H–O)

3 The reaction between hydrogen and oxygen is exothermic. This means that the energy needed to break the bonds is **less** than the energy released when the new bonds form.

4 Bonds broken: 4 C–H/H–C, 2 O=O/O–O

5 Bonds made: 2 C=O/C–O, 4 O–H/H–O

6 The reaction between methane and oxygen is exothermic. This means that the energy needed to break the bonds is **less** than the energy released when the new bonds form.

9Fc-6 Gases, hydrocarbons and energy

1 carbon dioxide – turns limewater milky; hydrogen – pops a lighted splint; oxygen – relights a glowing splint

2 C_2H_6 and C_2H_4 are hydrocarbons.

3 **a** reactant – ethane or oxygen

b product – carbon dioxide or water

c oxygen

d ethane, carbon dioxide or water

4 hydrogen burning in oxygen

9Fc-7 Exothermic or endothermic

1 **a** and **b**

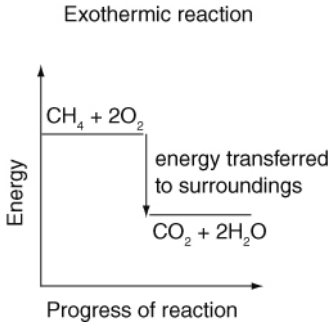
Reactants	Initial temperature/°C	Final temperature/°C	Temperature change/°C	Type of change
hydrochloric acid and sodium hydroxide	18	30	+12	exothermic
ethanoic acid and sodium carbonate	18	12	–6	endothermic
magnesium and copper sulfate solution	18	65	+47	exothermic
ammonium nitrate and water	18	15	–3	endothermic

2 **a** Bar chart with metals on the *x*-axis and temperature rise on the *y*-axis. Bars are not touching and are the correct heights.

b The higher the metal added is in the reactivity series, the greater the temperature rise.

9Fc-8 Energy level diagrams

1



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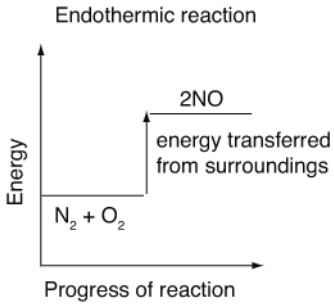


9Fd Displacement

Student Book

1: 9Fd Displacement

1 **a** aluminium and iron

b aluminium oxide and iron oxide

2 aluminium

3 **a** chlorine + sodium bromide → sodium chloride + bromine

b chlorine is more reactive than bromine; because it displaces the bromine from its compound

4 **a** any metal above copper in the table in diagram B of Topic 9Fb Reactivity, in the Student Book

b any metal below iron in the table in diagram B of Topic 9Fb Reactivity, in the Student Book

5 **a** The zinc has a coating of pink/brown copper metal; accept the blue copper sulphate solution changes colour.

b zinc + copper sulfate → copper + zinc sulfate

c Zinc is more reactive than copper and has taken the place of the copper in copper sulfate.

6 **a** magnesium nitrate + copper

b no reaction

c iron nitrate + silver

d no reaction

e no reaction

7 X, Z, W, Y

8 silver

Activity Pack

9Fd-1 Displacement reactions

1 **a** pink/brown metal is copper; colourless solution is zinc nitrate

b zinc + copper nitrate → copper + zinc nitrate

2 **a** iron is more reactive than copper

b magnesium is more reactive than silver

3 **a** B

b C

9Fd-2 Metallic reactions

1 12 experiments

2 look for a colour change, or measure the temperature change

3 A metal higher in the reactivity series will displace a less reactive metal from a compound. For example, magnesium + copper sulfate → copper + magnesium sulfate

4 student's own results table

5 completed student's own results table

6 reactions that should work: magnesium with zinc sulfate, iron sulfate and copper sulfate; zinc with iron sulfate and copper sulfate; iron with copper sulfate

7 magnesium three reactions, zinc two reactions, iron one reaction, copper zero reactions

8 magnesium + zinc sulfate → zinc + magnesium sulfate

magnesium + iron sulfate → iron + magnesium sulfate

magnesium + copper sulfate → copper + magnesium sulfate

zinc + iron sulfate → iron + zinc sulfate

zinc + copper sulfate → copper + zinc sulfate

iron + copper sulfate → copper + iron sulfate

9 Expected predictions: Calcium will displace all of the metals from their salt solutions. Lead will only displace copper from copper sulfate solution. None of the metals will displace calcium from calcium nitrate solution. Magnesium, zinc and iron should displace lead from lead nitrate solution.

9Fd-3 Investigating displacement reactions 1

These are some possible answers. See WSI Assessment grid for more details and levels.

1 some from: volume of solution, concentration of solution, amount of metal, particle size of metal, initial temperature of solution, amount of mixing

2 some from:

Volume of solution – measure out the same volume each time using a measuring cylinder.

Concentration of solution – use solution from the same beaker/bottle to ensure it is the same concentration.

Amount of metal – use the same mass of metal each time.

Particle size of metal – use powdered metals.

Initial temperature of solution – use the copper sulfate solution at room temperature.

Amount of mixing – stir each one the same number of times.

3 Possible prediction: The more reactive the metal, the greater the temperature rise.

4 Student's results recorded.

Sample results:

Metal	Initial temperature/ °C	Final temperature/ °C	Temperature rise/°C
magnesium	20	50	30
zinc	20	45	25
iron	20	32	12

5 Student's bar chart.

6 Different metals gave different temperature rises. Magnesium gave the biggest temperature rise and is the most reactive metal. Iron gave the smallest temperature rise and is the least reactive metal.

7 Student's own answer, including suitable explanations for any results that did not agree.

8 The higher the metal in the reactivity series, the greater the temperature rise.

9 Possible answers: It was easy to carry out but difficult to know when the reaction had finished. The amounts of metals on the spatula might be different.

10 Possible answers: Stir the mixture more to make sure the reaction has finished. Weigh the metals to make sure the masses are the same.

9Fd-4 Investigating displacement reactions 2

These are some possible answers. See WSI Assessment grid for more details and levels.

1 Possible prediction: The more reactive the metal, the greater the temperature rise.

2 The more reactive metals are higher in the reactivity series. They will displace copper from copper sulfate solution and transfer more energy to the surroundings as they do so. This means that the temperature will rise more.

3 independent variable – metal used; dependent variable – the temperature rise

4 some from: volume of solution, concentration of solution, amount of metal, particle size of metal, initial temperature of solution, amount of mixing

5 some from:

Volume of solution – measure out the same volume each time using a measuring cylinder.

Concentration of solution – use solution from the same beaker/bottle to ensure it is the same concentration.

Amount of metal – use the same mass of metal each time.

Particle size of metal – use powdered metals.

Initial temperature of solution – use the copper sulfate solution at room temperature.

Amount of mixing – stir each one the same number of times.

6 Student's own plan. Check that it is safe and will work before the student carries out the experiment.

7 Student's results recorded.

Sample results:

Metal	Initial temperature/ °C	Final temperature/ °C	Temperature rise/°C
magnesium	20	50	30
aluminium	20	20	0
zinc	20	45	25
iron	20	32	12

8 Student's bar chart.

9 Magnesium gave the biggest temperature rise and is the most reactive metal. Iron gave the smallest temperature rise and is the least reactive metal. Or, generally, the higher the metal in the reactivity series, the greater the temperature rise.

10 Most of the results agreed with my prediction but aluminium was unusual as there was no temperature change.

11 The reactive metals displace copper from copper sulfate solution. (Word equations may be given.) Energy is transferred to the surroundings in an exothermic reaction so the temperature of the surroundings/solution increases. The more reactive the metal, the more energy is transferred. Aluminium is high in the reactivity series so I expected the temperature rise to be between that produced by zinc and by magnesium.

12 The experiment worked well but it was difficult to tell when the reaction was finished. To improve it, I could stir more with the thermometer to make sure the reaction was finished and wait until the temperature just started to fall; then I would know that the reaction had finished. I could try a different sample of aluminium to see if that gave the same result.

9Fd-5 Writing balanced equations

1 **a** no reaction

b $Mg + FeSO_4 \rightarrow MgSO_4 + Fe$

c no reaction

d $Fe + CuSO_4 \rightarrow FeSO_4 + Cu$

e $Ca + ZnSO_4 \rightarrow CaSO_4 + Zn$

2 **a** magnesium, zinc, iron, copper

b The most reactive metal reacts with the most chloride solutions. Magnesium reacts with all the others, zinc with two and iron with one.

c magnesium + zinc chloride → magnesium chloride + zinc

magnesium + iron chloride → magnesium chloride + iron

magnesium + copper chloride → magnesium chloride + copper

zinc + iron chloride → zinc chloride + iron

zinc + copper chloride → zinc chloride + copper

iron + copper chloride → iron chloride + copper

d $Mg + ZnCl_2 \rightarrow MgCl_2 + Zn$

$Mg + FeCl_2 \rightarrow MgCl_2 + Fe$

$Mg + CuCl_2 \rightarrow MgCl_2 + Cu$

$Zn + FeCl_2 \rightarrow ZnCl_2 + Fe$

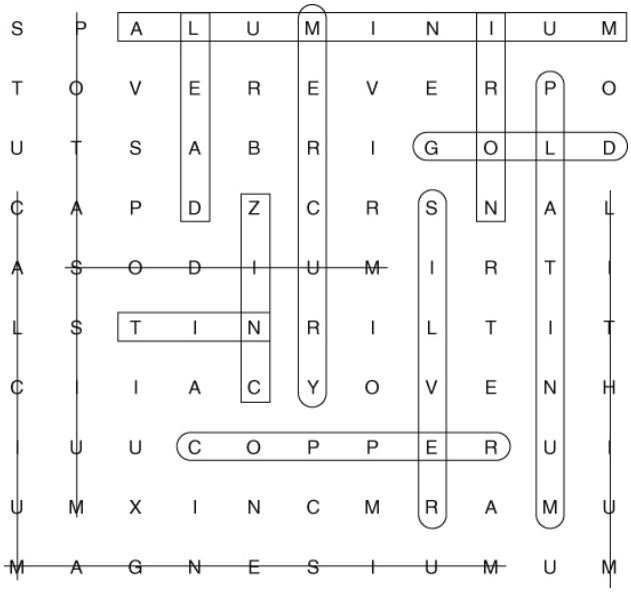
$Zn + CuCl_2 \rightarrow ZnCl_2 + Cu$

$Fe + CuCl_2 \rightarrow FeCl_2 + Cu$

9Fd-6 Reactivity

1–4

High reactivity	Medium reactivity	Low reactivity
lithium	tin	mercury
calcium	aluminium	platinum
potassium	iron	gold
sodium	lead	silver
magnesium	zinc	copper



5 A reaction in which a more reactive metal takes the place of a less reactive metal in a compound.

6 iron + copper oxide → copper + iron oxide

9Fd-7 Reactions between metals and compounds

1 Zinc is more reactive than iron.

The bonds between zinc and oxygen are stronger than the bonds between iron and oxygen.

2 **a** crystals: silver; solution: copper nitrate

b copper + silver nitrate → copper nitrate + silver

3 **a** J, M, K, L

b The most reactive metal reacts with the most metal oxides. J reacted with all the other metal oxides, M reacted with two others, K reacted with one and L reacted with none.

c metal J + M oxide → J oxide + metal M

metal J + K oxide → J oxide + metal K

metal J + L oxide → J oxide + metal L

metal M + K oxide → M oxide + metal K

metal M + L oxide → M oxide + metal L

metal K + L oxide → K oxide + metal L

9Fd-8 Balancing equations

1 **a** no reaction

b $Mg + CuO \rightarrow MgO + Cu$

c no reaction

d no reaction

e $Ca + FeO \rightarrow CaO + Fe$

f no reaction

g $Zn + FeO \rightarrow ZnO + Fe$

h $Mg + PbO \rightarrow MgO + Pb$

2 **a** $Ca + MgSO_4 \rightarrow CaSO_4 + Mg$

b no reaction

c $Zn + CuCl_2 \rightarrow ZnCl_2 + Cu$

d no reaction

e $Zn + 2AgNO_3 \rightarrow Zn(NO_3)_2 + 2Ag$

f $Fe + Pb(NO_3)_2 \rightarrow Fe(NO_3)_2 + Pb$

g $Cu + 2AgNO_3 \rightarrow Cu(NO_3)_2 + 2Ag$

h $Mg + Ag_2SO_4 \rightarrow MgSO_4 + 2Ag$

3 **a** $Cl_2 + 2KI \rightarrow 2KCl + I_2$

b $Br_2 + 2KI \rightarrow 2KBr + I_2$

9Fe Extracting metals

Student Book

1: 9Fe Extracting metals

1 **a** carbon

b (hot) air

2 **a** oxidation

b carbon has gained oxygen

3 a substance that takes oxygen away from another substance

4 **a** oxidation and reduction occur at the same time

b carbon – is oxidised, is the reducing agent; copper oxide – is reduced, is the oxidising agent.

5 **a** any two from zinc, tin, lead, copper

b any one from potassium, sodium, calcium, magnesium, lithium, aluminium

6 **a** Carbon is more reactive than zinc and less reactive than aluminium.

b Carbon is not a metal and the reactivity series is a list of metals in order of reactivity.

7 Students think up their own ideas; for example, the large amount of electricity needed for the electrolysis was not available until the 19th century, or the technique of extraction using electrolysis had not yet been invented.

2: 9Fe Materials management

1 **a** Ore or mineral (the ore is the rock, the mineral is the compound in the rock from which the metal is extracted).

b Bauxite (or aluminium oxide or cryolite)

2 The materials managers are needed to provide a reliable source of coal, coke and limestone (the necessary raw materials).

3 Storage problems shown in photo C can be caused by over-ordering materials.

4 **a** An inventory is a list of the stock (of raw materials) held in a place.

b They could over-order or run out of stock (raw materials).

5 Materials are usually ordered in large quantities as this saves money (is cheaper).

6 **a** 400,000 tonnes

b 100,000 tonnes of coke in storage with 50,000 tonnes used every week

∴ number of weeks coke will last 100,000/50,000 = 2 weeks

∴ coke will run out before the next delivery, which is in 3 weeks.

c mass of limestone used up each week = 25,000 tonnes

∴ mass of limestone used up in 4 weeks = 4 × 25,000 = 100,000 tonnes

mass of limestone presently in stock = 250,000 tonnes

∴ mass of original limestone left after 4 weeks = 250,000 – 100,000 = 150,000 tonnes

mass of limestone in next delivery = 100,000 tonnes

∴ mass of limestone in stock after next delivery = 150,000 + 100,000 = 250,000 tonnes

2: 9Fe Alfred Nobel

1 Answer to include: energy transferred from a detonator to the explosive to start the reaction; this is used to break some bonds; chemical energy transferred from the explosive as kinetic energy to the surroundings during the explosion.

2 Answer to include: iron is extracted by heating iron oxide with carbon; carbon removes the oxygen from the iron oxide so the iron oxide is reduced.

3 Answer to include: aluminium is extracted by electrolysis of the molten ores; aluminium forms strong bonds with oxygen and needs a powerful method of reduction to form the pure metal.

4 Answer to include: aluminium is more reactive than iron; carbon is more reactive than iron but less reactive than aluminium; carbon removes the oxygen from iron oxide but not from aluminium oxide; aluminium needs a more powerful method for extraction, so electricity is used.

Activity Pack

9Fe-1 Extracting metals

1 gold (accept iron as gold is found as an element)

2 **a** gains

b loses

3 tin oxide + carbon → tin + carbon dioxide

4

Extracted by electrolysis of the molten ore	Extracted by heating the ore with carbon	Occurs as the metal in the Earth's crust
calcium	lead	gold
sodium	zinc	silver

9Fe-2 Extracting metals from metal oxides

1 Student's predictions.

2 Copper and lead should be produced, in agreement with predictions.

3 Student comparison between results and predictions.

4 copper oxide + carbon → copper + carbon dioxide

lead oxide + carbon → lead + carbon dioxide

5 **a** Carbon has been oxidised to carbon dioxide as it has gained oxygen.

b Copper oxide and lead oxide have been reduced to copper and lead as they have lost oxygen.

9Fe-4 Understanding metal extraction

When carbon forms carbon dioxide, it is oxidised because … it gains oxygen.

Tin can be extracted from tin oxide by heating with carbon because … carbon is more reactive than tin.

Iron is not extracted from iron oxide by electrolysis because … electrolysis is too expensive.

When lead oxide forms lead, it is reduced because … it loses oxygen.

Aluminium is extracted from aluminium oxide by electrolysis because … carbon is not reactive enough to remove the oxygen from the metal oxide.

Gold does not need to be extracted from an ore because … it exists as the metallic element in the Earth's crust.

9Fe-5 Ions in electrolysis

1 **a** negative

b positive

2 **a** Ca^{2+} **b** K^{+} **c** Ba^{2+} **d** Li^{+} **e** Ga^{3+}

3 For electrolysis to occur, the ions have to move to the electrodes. Ions can move in a liquid but they cannot move through a solid.

9Fe-6 Obtaining metals

1 An ore is a rock that contains enough of a metal or metal compound to be worth mining for extraction.

2 two from: silver, gold, platinum

3 either heating the ore with carbon or electrolysis

4 more difficult

5 Gold has been used for a long time because it occurs as the metallic element in the Earth's crust. It does not need to be extracted from an ore. Sodium needs electrolysis/electricity to obtain it from its ore. Electricity has only been available for a (relatively) short time.

9Fe-7 Metals and reactivity

1 **a** Carbon has been oxidised as it has gained oxygen.

b Lead oxide has been reduced as it has lost oxygen.

2 **a** carbon

b tin oxide

3 **a** aluminium, iron, lead, potassium, sodium, zinc

b electrolysis

c heating with carbon

4 Carbon is less reactive than calcium so it cannot displace calcium from its ore/calcium oxide, or calcium forms stronger bonds with oxygen than carbon forms with oxygen.

5 It is expensive and other, cheaper, methods can be used to extract iron.

6 Metal X – electrolysis, as X is more reactive than carbon.

Metal Y – heating the ore with carbon, as carbon is more reactive than metal Y.

Metal Z – no need to extract it from an ore as it occurs in the native state so it can be dug out of the ground.

9Fe-8 Explaining oxidation and reduction

1 **a** Reduction, as the sodium ion has gained electrons.

b Neither, as no electrons are gained or lost.

c Oxidation, as chloride ions have lost electrons.

d Reduction, as the aluminium ion has gained electrons.

2 **a** $K^{+} + (1)e^{-} \rightarrow K$

b $Ca^{2+} + 2e^{-} \rightarrow Ca$

c $2Br^{-} - 2e^{-} \rightarrow Br_2$

d $Fe^{3+} + 3e^{-} \rightarrow Fe$

9G Transition to further study – Chemistry

9Ga Ions

Student Book

1: 9Ga Art and chemistry

1 rusting and combustion (in the blowtorch); the rusting is a much slower reaction than that in the blowtorch

2 exothermic – energy is transferred to the surroundings, increasing their temperature

3 **a** 1500 oxygen atoms

b $PbCO_3$ (lead, carbon, oxygen), HgS (mercury, sulfur), $Fe(NO_3)_3$ (iron, nitrogen, oxygen) and K_2S (potassium, sulfur)

4 **a** neutralisation

b sulfuric acid + copper oxide → copper sulfate + water

Some students may have written a symbol equation instead: $H_2SO_4 + CuO \rightarrow CuSO_4 + H_2O$

c bonds

2: 9Ga Ions

1 negative

2 the negative charge of the electrons is balanced by an equal and opposite positive charge from the nucleus

3 positive

4 **a** bonds

b The bonds are not like sticks joining the atoms together OR it doesn't show that the atoms are in a constant state of motion.

5 The electrons are able to move freely.

6 S^{2-} (ensure appropriate use of the superscript convention)

7 **a** positive OR Mg^{2+}

b lost

8 drawing to show a positively charged ion labelled potassium/K next to a negatively charged ion labelled bromine/Br (although note that a bromine ion is referred to as 'bromide')

9 The ions cannot move.

10 The sodium and chloride/salt ions in the sea water will carry an electrical current through the water, which may injure the swimmer.

3: 9Ga Weather control

1 Any two suitable indoor conditions, such as: temperature, humidity, air quality.

2 Any two suitable weather conditions, such as: making rain in dry areas, storm reduction, creating snow for winter sports.

3 By ionising the clouds, or seeding with silver iodide.

4 A particle (an atom or molecule) that has an electrical charge.

5 To make fresh water available for drinking or for growing crops when needed.

6 Any suitable suggestion, such as: may mean the rain doesn't fall where it normally does, which could cause problems for that area.

7 **a** Total for ioniser = –1, total for silver iodide = +2, suggesting silver iodide might be the better method.

b Any suitable point, such as: risk of too much rain, risk of rain falling in the wrong place.

Activity Pack

9Ga-2 Introducing ions

1 As for the top half of figure B in Topic 9Ga Ions of the Student Book. Whilst students do not need to know about the relative sizes of atoms and ions, the diagram in the book shows that electron loss leads to a decrease in atom diameter and electron gain has the opposite effect. Students tend not find this idea conceptually too difficult, although the reasons behind the changes in size are much more complex and will only be met at A level.

2 As for the bottom half of figure B in Topic 9Ga Ions of the Student Book, with the atom on the left small and the ion on the right large with the electron gain arrow between them. The atom on the left should be labelled Cl and the ion on the right Cl^-.

3 a grid of alternate small ions (labelled Na^+) and large ions (labelled Cl^-)

9Ga-4 Looking at ions

1 **a** The nucleus is in the middle of the atom.

b The electrons are (swirling) around the nucleus / in the outer part of the atom.

2 **a** The nucleus is positively charged.

b The electrons are negatively charged.

3 **a** and **b**

magnesium atom = neutral,	magnesium ion = positive, electron loss
oxygen atom = neutral,	oxygen ion = negative, electron gain
bromine atom = neutral,	bromine ion = negative, electron gain
aluminium atom = neutral,	aluminium ion = positive, electron loss

c neutral because the positive charge on the nucleus balances the negative charge of the electrons

d metals lose electrons, non-metals gain electrons

9Ga-5 Ionic and metallic bonding

1 **a**

Element name	Symbol	Charge on atom	Charge on ion	Symbol for ion
aluminium	Al	0	+3	Al^{3+}
bromine	Br	0	–1	Br^-
calcium	Ca	0	+2	Ca^{2+}
chlorine	Cl	0	–1	Cl^-
lithium	Li	0	+1	Li^+
oxygen	O	0	–2	O^{2-}
potassium	K	0	+1	K^+
sulfur	S	0	–2	S^{2-}

b metals lose electrons, non-metals gain electrons

c CaS

d diagram showing a grid of ions (not just one of each ion); calcium and sulfide ions alternate in each row and in each column; calcium ions should be shown much smaller than sulfur ions; the ions could be labelled (C^{2+}, S^{2-})

e The ions cannot move in solid CaS but can in the molten state.

2 **a** The atoms have lost electrons ('to the sea') and so are left with a charge.

b There are strong forces of attraction between the negative 'sea' and the positive ions.

c The electrons are free to move and so can carry a charge from place to place.

9Ga-6 Ionic compounds

1 **a** FALSE. There are the same number of sodium ions and chloride ions and so the ratio is 1 : 1.

b TRUE.

c FALSE. The bonds are the forces between the opposite charged ions. So a positive ion will attract all of the negatively charge ions around it and form ionic bonds with all of them.

d FALSE. In sodium chloride, each sodium atom is bonded to six chloride ions. (It is a three-dimensional structure.)

2 **a** 10 from: gallium nitride (GaN), magnesium sulfide (MgS), magnesium oxide (MgO), sodium chloride (NaCl), sodium bromide (NaBr), gallium sulfide (Ga_2S_3), gallium oxide (Ga_2O_3), gallium bromide ($GaBr_3$), gallium chloride ($GaCl_3$), magnesium nitride (Mg_3N_2), magnesium oxide (MgO), magnesium chloride ($MgCl_2$), magnesium bromide ($MgBr_2$), sodium nitride (Na_3N), sodium oxide (Na_2O), sodium sulfide (Na_2S)

b The pattern is that the greater the number of electrons lost/gained by the ions the higher the melting point. The greater the difference in charge between two ions, the more they will attract each other. The more the ions attract, the more energy has to be supplied to move the particles away from one another.

3 Lithium fluoride because there is less of a difference between the charges on the different ions than in the other two, which means that the ions are easier to move apart from one another, allowing water molecules to pull them apart more easily and dissolve the compound. The ions in the solution are then free to move and so carry electrical charges (allowing the solution to conduct electricity).

9Gb Energy transfers

Student Book

1: 9Gb Energy transfers

1 **c**alcium, because the more electrons there are the more they can help hold the ions/atoms together

2 magnesium, because magnesium atoms all contribute two electrons to the metallic bonding but sodium ions only contribute one / there are more free electrons in magnesium

3 Magnesium is too difficult to vaporise. / Magnesium has a much higher boiling point.

4 The boiling point of aluminium will be higher, because the more electrons that are holding the ions/atoms together the harder they are to move apart, and so the more energy is needed to move them apart and so the higher the boiling point.

5 An ionic compound of sodium (sodium nitrate) has a higher melting point than sodium metal.

6 Some or all of these points:

Endothermic	Exothermic
products have more energy than reactants	products have less energy than reactants
surroundings decrease in energy	surroundings increase in energy
surroundings decrease in temperature	surroundings increase in temperature
involve a transfer of energy	involve a transfer of energy

7 Q, because the products have more energy than the reactants

8 **a** exothermic, because energy is transferred to the surroundings by light (which you can see) and by heating

b similar to P in diagram F in Topic 9Gb Energy transfers in the Student Book

9 **a** endothermic, because energy is being removed from the surroundings, which causes their temperature to fall

b physical change – no new substances have been formed

c one or more of: they slow down, (stronger) bonds form between the particles/molecules, they lose energy

Activity Pack

9Gb-2 Sorting energy transfers

1 Students should end up with two groups: changes that are exothermic (cards A, B, E, F, H) and changes that are endothermic (cards C, D, G, I).

2 Students could further split their cards into physical changes and chemical reactions. Encourage students who have not done this to describe what they have done and then to re-sort their cards: chemical reactions that are exothermic (cards A, E, F), chemical reactions that are endothermic (cards G, I), physical changes that are exothermic (B, H), physical changes that are endothermic (C, D).

3 Cards should explain that in each exothermic change energy is transferred from (*ex*its) the substance(s) undergoing change to the surroundings (which is anything else that is in contact with the substance(s)). In each

endothermic change, energy is transferred from the surroundings and enters the substance(s) undergoing change.

4 Cards A, E and F should have a reaction profile in which the energy level of the products is lower than that of the reactants. Cards G and I should have reaction profiles in which the products have more energy than the reactants. The other cards are physical changes.

9Gb-3 Energy transfers during changes

1 bread baking in an oven – endothermic

water condensing on a window – exothermic

ice cubes melting – endothermic

a burning candle – exothermic

substances reacting in a 'cold pack' – endothermic

reaction profile X – exothermic

reaction profile Y – endothermic

photosynthesis – endothermic

cooking an egg – endothermic

ice forming on a pond – exothermic

sweat evaporating from skin – endothermic

respiration – exothermic

9Gb-4 Exo or endo?

1 **a** Energy is transferred (~~from~~ / to) the wall of the test tube (from / ~~to~~) the reactants. This reaction is (exothermic / ~~endothermic~~).

b Energy is transferred (from / ~~to~~) the leg (~~from~~ / to) the substances in the cold pack. This is an (~~exothermic~~ / endothermic) change.

c In this (chemical reaction / ~~physical change~~) energy is transferred (~~from~~ / to) the surroundings. This change is (exothermic / ~~endothermic~~).

d In this (chemical reaction / ~~physical change~~) energy is transferred (from / ~~to~~) the surroundings. This change is (~~exothermic~~ / endothermic).

e Energy is being transferred (from / ~~to~~) the surroundings (~~from~~ / to) the water in the clothes. This is an (~~exothermic~~ / endothermic) process.

f Energy is being transferred (from / ~~to~~) the surroundings (~~from~~ / to) the water. This change is (~~exothermic~~ / endothermic).

2 **a** the work top and the air around the ice cube

b Energy is transferred from the surroundings to the ice cube, and the loss of energy causes a drop in temperature (of the surroundings).

9Gb-5 Predicting properties 1

1, 2 and **3** calcium 2 free electrons, chromium 3, cobalt 3, lithium 1, magnesium 2, nickel 2, potassium 1, sodium 1, strontium 2

4 There are more electrons to carry electrical charge.

5 The more free electrons the stronger the metallic bonding (there are more electrons to act as a 'glue', a greater number of charges on the ions attracts the electrons more strongly).

9Gb-6 Properties and changes

Question	Substance(s) undergoing change	Surroundings	Energy transfer into or out of the surroundings?	Exothermic or endothermic?
1 a	natural gas	air (above hob)	into surroundings	exothermic
1 b	ice cube	glass and air around the cube	out of surroundings	endothermic
1 c	chips	air in oven (tray on which chips are sitting)	out of surroundings	endothermic
1 d	substances in glowlight	air around glowlight (and/or plastic of glowlight tube)	into surroundings	exothermic
1 e	carbon dioxide and water	light from Sun	out of surroundings	endothermic

2 Endothermic: energy has been taken in by the reactants so that the products have more energy than the reactants.

3 **a** a reaction profile in which the energy level of the products is lower than that of the reactants, showing an exothermic reaction

b a reaction profile in which the energy level of the products is higher than that of the reactants, showing an endothermic reaction

4 **a** metallic bonding

b There are more electrons to act as a 'glue', the ions have a higher positive charge and so attract the electrons more strongly.

c higher, because the metallic bonding is stronger; this means more energy is needed to overcome the bonds within the metal and start the atoms moving

9Gb-7 Breaking and making bonds

1 **a** (436 + 242) – (2 × 431) = –184 kJ

b exothermic

c reaction profile showing the energy level of the atoms when all the bonds are broken as higher than that of the reactants, and the energy level of the products as lower than the energy level of the reactants

2 **a** (412 + 242) – (338 + 431) = –115 kJ

b exothermic

c reaction profile the same as for **1c** but award additional credit if there has been an attempt to show that the overall difference between the energy levels of the reactants and products is less than that for **1c**

9Gc Rates of reaction

Student Book

1: 9Gc Rates of reaction

1 The rate of the reaction in photo A is much faster than that in photo B.

2 **a** when the line becomes horizontal

b one of the reactants has been used up

3 **a** 30/8 = 3.75 cm^3 of gas per second

b The rate is changing/decreasing/slowing down during these 8 seconds.

4 **a**
V = 3 × 3 × 3 = 27
SA = 6 × (3 × 3) = 54
SA:V = 54/27 = 2

b Calculate the surface area:volume ratio if the cube is now split into 27 cubes of side 1 cm.

V = 27 × (1 × 1 × 1) = 27
SA = 27 × (6 × (1 × 1)) = 162
SA:V = 162/27 = 6

c It would increase it.

5 They must collide (some students may add that they need to collide hard enough or with enough energy).

6 **c**opy of graph E with a line added that rises at a steeper gradient than the existing line, but follows the same curved pattern and (crucially) levels out at the same value as the original line, but in a shorter time.

7 There is a greater concentration/number of the reacting particles and so they are more likely to hit each other. Note that students have not formally been taught this and so this question requires quite a bit of thought.

Activity Pack

9Gc-2 Reaction rates

There is more than one way in which the sentences and images can be arranged to make a sensible order. A possible order is given below but students' ordering should be peer-assessed for clarity.

- Some reactions happen slowly and some happen quickly.
- The speed at which changes occur in a reaction is the '*rate* of reaction'.
- We can show how a reaction progresses on a graph.
- The steeper the slope, the faster the rate.
- A graph of rate of reaction is horizontal when the reaction has stopped.
- To increase the rate of reaction we can increase surface area.
- Large lumps of a reactant mean that the particles inside the lumps aren't exposed to the particles they are reacting with.
- Increasing the surface area increases the number of particles that can collide, and this increases the rate of reaction.
- For a reaction to happen, two particles must collide.
- Some particles in a substance have more internal energy than others and so move faster.
- Some particles may not have enough energy and so will not react when they collide.
- Only particles with enough energy will react when they collide.

9Gc-3 Looking at reaction rates

1 3 – rusting, 2 – calcium + water, 1 – hydrogen + oxygen

2 **a** sensible suggestion, such as cm^3

b line X

c Powdered zinc has a greater surface area; so the reaction goes faster; and the steeper line on the graph shows this.

d 1 minute 20 seconds

e (5 minutes) – (1 minute 20 seconds) = 3 minutes 40 seconds

f First 3 minutes 40 seconds needs to be converted into seconds = 220 seconds. Volume of gas released = 110 cm^3. Mean reaction rate = 110/220 = 0.5 cm^3/s

Accept a different compound unit reflecting the answer to Question 2.

Give credit for correct working, even if the readings taken from the graph are incorrect.

g Yes. The volume of gas produced is the same in each case.

h Additional line sketched on the graph. Give credit for:

- following the same gradient as line Y
- starting the line at 5 minutes on the *x*-axis
- finishing between 6 minutes 40 seconds and 7 minutes (inclusive)
- finishing at a volume of 55 cm^3.

3 They must collide.

9Gc-4 Calcium carbonate and acid

1 **a** line graph with: suitable scale, labelled scale, labelled axes, title, neat plotting of points, accurate plotting of points, points joined dot to dot or with a smooth curved 'line of best fit'

b 99.4 g at 270 s for the 'small lumps' line, labelled on graph

c 100.0 ± 0.1 g

2 **a** Carbon dioxide gas is lost.

3 120 s

4 **a** small lumps

b This is the line that has the steepest gradient.

c (102.0 – 100.2) = 1.8 g

1.8/40 = 0.045 g/s mass lost

5 **a** Yes. The total loss in mass (i.e. production of carbon dioxide) is the same.

b hydrochloric acid, because a chloride salt has been formed

6 The particles have to collide.

7 **a** The small lumps: the same mass of calcium carbonate is used in both experiments so the volume of calcium carbonate added is the same. However, smaller lumps will have more surface area and so the surface area:volume ratio for the smaller lumps is higher.

b With the greater surface area, more of the particles of calcium carbonate are exposed to the acid. Diagram showing this.

The more particles exposed, the greater number of collisions between acid particles and calcium carbonate particles.

The greater the number of collisions the faster the reaction.

9Gc-5 Variables that affect rates of reactions

1 **a** the first 50 seconds

b This is the steepest gradient on the graph OR because 12.5 cm^3 of gas is produced, which is more than in any other 50 second period.

c 14/60 = 0.23 cm^3/s

d
- as the reaction progresses, the number of reactant particles decreases
- the fewer reactant particles, the fewer collisions between them
- the fewer collisions, the slower the rate

2 **a** P – y: a more dilute acid is used but the same volume of acid

b
- in a more dilute solution, there are fewer reactant particles
- the fewer reactant particles, the fewer collisions between them
- the fewer collisions, the slower the rate
- the fewer reactant particles in total, the less gas will be produced

a Q – z: a higher temperature was used and with half the amount of magnesium

b
- the fewer reactant (magnesium) particles in total, the less gas will be produced
- the higher the temperature, the more internal energy the reactant particles will have
- the more internal energy of the reactant particles, the more likely they are to collide
- the more internal energy of the reactant particles, the more likely they are to react when they collide
- the more collisions, the faster the rate
- the more energetic the collisions, the faster the rate

a R – x: smaller pieces but the same mass of magnesium

b
- the smaller pieces will have a greater surface area (but with the same volume)
- this will expose more magnesium particles to acid
- the more magnesium particles that are exposed, the greater the number of collisions
- the more collisions, the faster the rate

9Gd Chemical equations

Student Book

1: 9Gd Chemical equations

1 sodium nitrate, copper chloride, calcium sulfate

2 potassium hydroxide + hydrochloric acid → potassium chloride + water

3 **a** 1:1

b 1:3

4 $MgCO_3 + H_2SO_4 \rightarrow MgSO_4 + H_2O + CO_2$

5 It is soluble, which you can tell because the state symbol says that it is in aqueous solution.

6 $MgCO_3(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2O(l) + CO_2(g)$

7 **a** $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

b $CH_4(g) + 2O_2(g) \rightarrow 2H_2O(l) + CO_2(g)$

c $H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$

8 In the first, the reactants are nitric acid and sodium hydroxide, while the products are sodium nitrate and water. In the second, the reactants are hydrochloric

acid (or hydrogen chloride) and copper oxide, while the products are copper chloride and water.

2: 9Gd Standard form

1 **a** 0.008/0.000 008 = 1000 times (or worked out from the caption, which says that 1 mm is 1000 times bigger than 1 μm; working is not needed)

b 0.000 008/0.000 000 08 = 100 times (or worked out from information in the caption; working is not needed)

2 **a** $6 \times 6 \times 6 \times 6 \times 6 \times 6$

b $10 \times 10 \times 10$

c $2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2$

3 **a** 4^3

b 10^5

c 2^4

d 10^7

4 **a** $10^3 = 10 \times 10 \times 10 = 1000$

b $10^4 = 10\,000$

c $10^6 = 1\,000\,000$

d $10^{-2} = 0.01$

e $10^{-4} = 0.0001$

5 4.6×10^9 years

6 3 474 000 m

7 1×10^{-12} kg

8 1000 kg/m^3

9 0.000 000 003 s

10 pea = 8×10^{-3} m; red blood cell = 8×10^{-6} m; flu virus = 8×10^{-8} m; haemoglobin molecule = 6.5×10^{-9} m; iron atom = 1.4×10^{-10} m

Activity Pack

9Gd-2 Formula snap

CO_2	carbon dioxide	CH_4	methane
$CuSO_4$	copper sulfate	HCl	hydrogen chloride
H_2O	water	CuO	copper oxide
H_2SO_4	sulfuric acid	HNO_3	nitric acid
KI	potassium iodide	MgO	magnesium oxide
$MgCl_2$	magnesium chloride	NaOH	sodium hydroxide
NaCl	sodium chloride	NO	nitrogen monoxide
$ZnCl_2$	zinc chloride	SO_2	sulfur dioxide
$Fe(NO_3)_3$	iron nitrate	Na_2CO_3	sodium carbonate
$Mg(NO_3)_2$	magnesium nitrate	$Fe(OH)_2$	iron hydroxide
Al_2O_3	aluminium oxide	$Al_2(SO_4)_3$	aluminium sulfate

9Gd-3 Completing equations

1 magnesium oxide

2 $CuSO_4$, H_2O

3 SO_2

4 $ZnCl_2$

5 NaOH

6 H_2SO_4

7 HNO_3

8 CuO

9 MgO

10 NaOH, HCl

9Gd-4 Formulae and symbol equations

1

Formula	Names and ratio of elements		
Na_2CO_3 sodium carbonate	sodium	carbon	oxygen
	2	1	3
LiCl lithium chloride	lithium	chlorine	
	1	1	
Al_2O_3 aluminium oxide	aluminium	oxygen	
	2	3	
NaOH sodium hydroxide	sodium	oxygen	hydrogen
	1	1	1
$ZnSO_4$ zinc sulfate	zinc	sulfur	oxygen
	1	1	4
$Ca(NO_3)_2$ calcium nitrate	calcium	nitrogen	oxygen
	1	2	6
H_2SO_4 hydrogen sulfate	hydrogen	sulfur	oxygen
	2	1	4

2 **a** magnesium chloride

b magnesium sulfate, hydrogen

c water, lithium chloride

3 **a** $CaCl_2$

b HCl

c CO_2

d Cu

4 $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

9Gd-5 Equations

1 **a** Cu(s)

b O_2(g)

c H_2O(l)

d CO_2(g)

e NaCl(aq)

f HCl(aq)

2 **a**

Formula and name of compound	Names and ratio of elements		
KI potassium iodide	potassium	iodine	
	1	1	
$Pb(NO_3)_2$ lead nitrate	lead	nitrogen	oxygen
	1	2	6

Formula and name of compound	Names and ratio of elements		
PbI_2 lead iodide	lead	iodine	
	1	2	
KNO_3 potassium nitrate	potassium	nitrogen	oxygen
	1	1	3

b $2KI(aq) + Pb(NO_3)_2(aq) \rightarrow PbI_2(s) + 2KNO_3(aq)$

3 **a** $Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$

b $MgCO_3(s) \rightarrow MgO(g) + CO_2(g)$

c $Fe(s) + CuO(s) \rightarrow FeO(s) + Cu(s)$

d $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

e $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$

f $CuO(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2O(l)$

g $HNO_3(aq) + NaOH(aq) \rightarrow NaNO_3(aq) + H_2O(l)$

h $2KCN(aq) + CuSO_4(aq) \rightarrow Cu(CN)_2(s) + K_2SO_4(aq)$

i $BaCO_3(s) + 2HNO_3(aq) \rightarrow Ba(NO_3)_2(aq) + CO_2(g) + H_2O(l)$

j $4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$

9Gd-6 Standard form questions

1 **b** 10×10

c $2 \times 2 \times 2 \times 2 \times 2$

d $6 \times 6 \times 6$

e $10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10$

f 10

2 **a** 4^4

b 10^5

c 2^2

d 10^8

e 10^3

3 **a** 100

b 1 000 000

c 0.001

d 0.000 01

4 **a** 3.4029×10^2 m/s

b 1.81×10^5 kg

c 1×10^{-5} m

d 1.5×10^{-7} m

e 1.49×10^8 km

f 1×10^{-12} g

g 65 000 000 = 6.5×10^7 years

h 4.04×10^{-23} g

5 **a** $6779 \times 1000 = 6\,779\,000 = 6.779 \times 10^6$ m

b $365 \times 24 \times 60 = 525\,600 = 5.256 \times 10^5$ minutes

9Gd-7 Balancing symbol equations

1 **a** $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

b $CuO(s) + 2HCl(aq) \rightarrow CuCl_2(aq) + H_2O(l)$

c $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

d $CaCO_3 \rightarrow CaO + CO_2$

e $Na_2CO_3 + 2HCl \rightarrow 2NaCl + CO_2 + H_2O$

f $2Na + 2H_2O \rightarrow 2NaOH + H_2$

g $Mg(OH)_2 + H_2SO_4 \rightarrow MgSO_4 + 2H_2O$

h $4Al + 3O_2 \rightarrow 2Al_2O_3$

i $3H_2SO_4 + 2Fe \rightarrow Fe_2(SO_4)_3 + 3H_2$

j $MgCl_2(aq) + 2AgNO_3(aq) \rightarrow 2AgCl(s) + Mg(NO_3)_2(aq)$

2 See state symbols for questions **1a** and **1b** above.

9Gd-8 Symbol equations and solubility

1 **a** NaCl

b NaBr

c $MgSO_4$

d $CaCO_3$

e $NaNO_3$

f $MgCl_2$

2 –1 (minus 1). The calcium ion has a charge of 2+ and so two OH^- ions are needed to balance the charges.

3 **a** $2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$

b $2KCl(aq) + Ag(NO_3)_2(aq) \rightarrow 2KNO_3(aq) + AgCl_2(s)$

c $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

d $2HCl(aq) + CuO(s) \rightarrow CuCl_2(aq) + H_2O(l)$

e $H_2SO_4(aq) + CaO(s) \rightarrow CaSO_4(s) + H_2O(l)$

f $BaCl_2(aq) + Na_2SO_4(aq) \rightarrow 2NaCl(aq) + BaSO_4(s)$

9Ge Equilibria

Student Book

1: 9Ge Equilibria

1 reactant: hydrogen peroxide; products: oxygen, water

2 **a** ammonia (NH_3), hydrogen chloride (HCl)

b ammonium chloride (NH_4Cl)

3 $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

4 $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

5 The forward reaction reaches equilibrium at 130 seconds / when 70% of the reactants have become products.

6 **a** 30%

b because the percentages of the reactants and products are not changing but there are still reactions going on

7 **a** $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

b Energy is transferred to the substances that are reacting.

2: 9Ge Frescos

1 **a** a reversible reaction

b The overall percentages of the reactants and products are not changing but there are still reactions going on.

2 The reaction is exothermic, which means that energy is transferred to the surroundings.

3 **c**alcium to sulfur to oxygen in the ratio 1:1:4

4 $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$

$SO_3(g) + H_2O(l) \rightarrow H_2SO_4(l)$

5 Oxygen and calcium atoms form ions with opposite charges, and the two types of ions attract one another.

Activity Pack

9Ge-2 Reversible and irreversible reactions

Reversible reactions	Irreversible reactions
Shown in equations using this symbol: ⇌	Shown in equations using this symbol: →
The reaction is never complete.	The reaction can be completed.
The forward and backward reactions reach a dynamic equilibrium.	Only the forward reaction occurs.
The reaction can start from either side of the equation.	The reaction can only start from one side of the equation.

9Ge-3 Identifying reversible reactions

1 Reversible reactions are cards: A + I, C + K, E + J, H + L

2 hydrogen + nitrogen ⇌ ammonia

methane + oxygen → water + carbon dioxide

dinitrogen tetroxide ⇌ nitrogen dioxide

hydrogen peroxide → water + oxygen

sulfur trioxide ⇌ sulfur dioxide + oxygen

hydrogen + chlorine → hydrogen chloride

sulfur + oxygen → sulfur dioxide

nitrogen monoxide + chlorine ⇌ nitrosyl chloride

3 $H_2(g) + 3N_2(g) \rightleftharpoons 2HN_3(g)$

$CH_4(g) + 2O_2(g) \rightarrow 2H_2O + CO_2(g)$

$N_2O_4(g) \rightleftharpoons 2NO_2(g)$

$2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$

$2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)$

$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$

$S(s) + O_2(g) \rightarrow SO_2(g)$

$2NO(g) + Cl_2(g) \rightleftharpoons 2NOCl(g)$

9Ge-4 Reversible reactions and equilibrium

1

Reaction	Reversible	Irreversible
adding water to white copper sulfate to turn it blue and then heating the blue copper sulfate to turn it white	✓	
baking a cake		✓
burning magnesium in air and forming a white powder, and then adding the white powder to sulfuric acid		✓
heating green copper carbonate to form black copper oxide and gases, and then adding hydrochloric acid to the copper oxide to form copper chloride		✓
$NH_4Cl \rightleftharpoons NH_3 + HCl$	✓	
phosphorus trichloride is reacted with chlorine gas to form phosphorus pentachloride, which is then heated and decomposes to form chlorine and phosphorus trichloride	✓	

2 **a** hydrogen + nitrogen → ammonia

b the start of the ammonia line on the graph is circled

c they are not changing

d The amounts of the different substances are not changing/are in equilibrium and this is because the rate of the backward reaction is the same as the rate of the forward reaction.

9Ge-5 Rates, equilibrium and energy

1 **a** reversible reaction

b $CaCO_3(s) \rightleftharpoons CaO(s) + O_2(g)$

c calcium carbonate → calcium oxide + oxygen

d calcium oxide + oxygen → calcium carbonate

e Endothermic – a supply of energy (from being heated) is needed to get the compound to decompose.

f Exothermic – the backward reaction is the reverse of the forward reaction in terms of both products/reactants and energy transfer.

2 **a** $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

b P

c S

d The rate of the forward reaction is the same as the rate of the backward reaction. The overall percentages/amounts of the different products and reactants are not changing.

e 20% – the same as it was in the initial part of the question, because the conditions are the same.

f Endothermic – because the question says that the forward reaction is exothermic.

9Ge-6 Temperature, pressure and reversible reactions

1 **a** $N_2O_4(g) \rightleftharpoons 2NO_2(g)$

b Vial A – a small amount of brown NO_2 gas has formed, giving the vial a faint yellow colour.
Vial B – a much larger amount of brown NO_2 gas has formed, giving the vial an orange colour.
Vial C – most of the original gas is now NO_2 and so the vial is brown.

c The overall amounts/percentages/concentrations of the two gases are not changing. The forward reaction is occurring at the same rate as the backward reaction.

d $N_2O_4 \rightarrow 2NO_2$ is endothermic (but students may have written out the original equation as $2NO_2 \rightleftharpoons N_2O_4$ in which case $2NO_2$ N_2O_4 is exothermic)

e It would become pale yellow. The dynamic equilibrium is much more in favour of N_2O_4 at lower temperatures (as for vial A) OR energy will be lost from the mixture and so the reaction goes in the exothermic direction.

2 **a** $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

b Higher pressure increases the rate (more ammonia is made). (Note though that students may have written their answers to part **a** the other way around and, if this is the case, answers in terms of decreasing the forward reaction should be accepted.)

c There is less space between the reactant gas particles and so more collisions occur.

d Higher temperatures increase it (more nitrogen and hydrogen is made). (Note though that students may have written their answers to part **a** the other way around and, if this is the case, answers in terms of decreasing the backward reaction should be accepted.)

e The forward reaction is exothermic, so the backward reaction is endothermic, which means that when the temperature of the reaction increases energy is taken in and more hydrogen and nitrogen are formed.

3 **a** At higher altitudes there is less pressure, so there will be fewer collisions between haemoglobin and oxygen molecules, so the haemoglobin will pick up less oxygen as it passes through the lungs. (Note that, in fact, lower air pressures also decrease the diffusion of oxygen across membranes in the lungs.)

b The forward reaction (haemoglobin + oxygen → oxyhaemoglobin) is exothermic so the backward reaction is endothermic; when the body temperature rises more oxyhaemoglobin is broken down.

9I Forces and motion

9Ia Forces and movement

Student Book

1: 9Ia Moving things

1 for naming the forces, for describing what they are doing

Gravity (weight) is pulling the lighthouse downwards. An upward force from the ground acting on the wheels is stopping the lighthouse sinking into the ground. There is a forward force from the machine pulling the lighthouse and friction acting against the direction of motion. Some students may also mention air resistance, but this is likely to be negligible at the speed the lighthouse is moving. However, if there is any wind, there will be a force of air resistance due to the wind.

2 **a** Friction acts to slow the movement down. Students should avoid using terminology such as 'tries to slow it down' if possible.

b make the surfaces smoother; use a lubricant between the surfaces

3 **a** food

b the Sun

c A full answer would be: energy stored in nuclear fuel in the Sun → energy transferred by light → energy stored in plants (chemical energy) → energy stored in humans (chemical energy). Some students may add a step for energy transferred via animals (this step would go between plants and humans).

2: 9Ia Forces and movement

1 The snow reduces the friction between the runners and the ground. There would be too much friction if there was no snow to act as a lubricant.

2 **a** weight

b force from wind pushing on sails

c water resistance

3 2000 N. The upthrust balances the weight.

4 The speed will increase because the forward force (caused by the wind pushing on the sails) will then be larger than the force of water resistance and there will be a resultant force acting forwards.

5 The force from the sails will get less, so it will no longer be big enough to balance the force of water resistance. The resultant force will be acting backwards so the boat will slow down.

6 The racing car has a more powerful engine, so the forwards force is greater. This means the racing

car will be moving faster before the air resistance increases enough to balance the force from the engine.

The racing car has a more streamlined shape than a family car, so the air resistance is less for a given speed.

7 **a** The drag will increase because the parachute has a much larger area than the skydiver.

b The air resistance will balance the weight of the skydiver at a much lower speed because of the increased drag, so the terminal velocity of the skydiver will be much lower.

Activity Pack

9Ia-1 Forces and movement

A – 8; **B** – 2; **C** – 4, 7, 10 and 15; **D** – 1 and 7; **E** – 3 and 7; **F** – 9; **G** – 12; **H** – 11; **I** – 6 and 14; **J** – 5 and 7

9Ia-4 Forces on a journey

1 Answers may vary; this is one possible response:

It was getting quite late by the time we reached the harbour. For the first part of the journey the roads were wet and slippery and several times the coach almost slowed to a halt ① as the wheels got bogged down in muddy ruts. On one occasion we even had to get out to push and the horses strained to pick up speed ② again afterwards.

Once we were on a better road they kept up a steady pace ③ and we made better time. The driver reined in the horses and applied the brakes as we drew to a stop ④ by the harbour wall.

There was a small boat waiting to take us and our luggage out to the ship. Some men were already loading some barrels of water. One of the barrels came out of its sling and fell ⑤ – luckily the men below just managed to push the boat away from the wall and the barrel splashed harmlessly into the water. It only just floated ⑥, but they managed to get a rope around it and load it into the boat. They were a bit more careful after that, and got us and our boxes down safely.

There was a stiff wind blowing from the land, which helped the rowers pick up speed ⑦, and we were soon at the clipper that was to take us across the ocean. We climbed a ladder up the side of the ship and our boxes were hauled up by rope ⑧. We were the last to arrive, and as soon as the boat had set off for the shore again the captain ordered the sails to be set and the ship began to move ⑨ majestically out into the bay.

2 for identifying forces and stating whether they are balanced or unbalanced, and for correct explanations of reasoning.

Some students may mention vertical forces of weight and force from the ground/water (or weight and upthrust) being balanced in the situations below where no vertical change in speed is mentioned.

(1) Unbalanced: the friction from the muddy road (and from friction in the wheels and air resistance) is greater than the pulling force from the horses, because the coach slows down. Some students may also mention the vertical forces being unbalanced when the coach slides into the ruts – here the weight of the coach is greater than the upward force provided by the ground.

(2) Unbalanced: the force from the horses is greater than the friction (and any air resistance) as the coach is picking up speed.

(3) Balanced: if the coach is keeping a steady pace, then the forward force from the horses must be balancing the combined rearward forces of friction and air resistance.

(4) Unbalanced: smaller force from horses and greater friction force from applying brakes means the backward force is larger than the forward one, which is why the coach comes to a stop.

(5) Unbalanced: the weight of the falling barrel is greater than air resistance.

(6) Balanced: if the barrel is floating the upthrust must be equal to its weight.

(7) Unbalanced: the total force from the wind pushing the boat and the force from the oars is greater than the water resistance, so the boat picks up speed.

(8) Balanced: implied steady speed of ascent, so upward forces from rope/legs and arms climbing is equal to the weight of the barrel/person.

(9) Unbalanced: force from sails is greater than water resistance as the ship begins to move.

9Ia-5 Grand Prix race 1

1 **a** A **b** B, D **c** C **d** E

2 **a** Weight downwards and upthrust force from the ground.

b Balanced – the cars are not changing speed in any direction, so any forces on them must be balanced.

3 weight, upthrust, force from engine, friction, air resistance

4 **a** B and D

b C

c A and E

5 **a** Y

b X

c The force of the air resistance gets bigger as the car gets faster, and the car is travelling fastest at E.

9Ia-6 Calculating resultants

1 **a** 700 N – 500 N = 200 N downwards

b She will accelerate downwards (move faster downwards).

c 2000 N – 700 N = 1300 N upwards

d The resultant is acting in the direction opposite to her movement, so she will slow down.

2 **a** Sketch showing forward force of 70 N, rear forces of 5 N (labelled friction) and 55 N (labelled air resistance). Lengths of arrows should be roughly proportional to the sizes of the forces they represent.

b 70 – 5 – 55 = 10 N forwards

c It will increase, because the resultant force is acting in the same direction as it is moving.

3 **a** 130 – 100 – 50 = –20 N (or 150 N – 130 N = 20 N). Force acting backwards/against direction of travel.

b It will slow down.

4 **a** In Question 2 – air resistance depends on speed, so if it is the same cyclist, the situation with the greatest air resistance must represent the highest speed.

b The brakes have been applied.

5 **a** Force B, because it changes suddenly. Air resistance and friction would increase gradually as the speed increases.

b 76 – 37 – 17 = 22 N, acting forwards

c 0 N – if the speed is not changing the resultant force must be zero.

d 76 N – if the resultant is zero, the combined resistance forces must equal the pushing force.

9Ia-7 Grand Prix race 2

1 **a** Weight and upthrust from the ground.

b Balanced – the car is not changing speed in a vertical direction.

c The resultant is zero.

2 **a** Forward force from the engine, backward forces from friction and air resistance.

b Unbalanced – the car is speeding up so the forward forces must be greater than the backward forces.

c The resultant force is acting forwards.

3 **a** Unbalanced – the car is slowing down so the backward forces must be greater than the forward forces.

b Smaller – the driver is braking, so there will be no forward force from the engine.

c Bigger – the car is travelling faster, so the air resistance will be bigger, and the driver is braking, so the friction force will also be bigger.

4 **a** The forward force from the engine will be bigger than the combined forces of air resistance and friction.

b The forward force from the engine will exactly balance the combined forces of air resistance and friction.

5 **a** There is a sideways force of friction between the tyres and the road, as well as a forward force from the engine and backward forces from friction and air resistance.

b The effect of the forward and backward forces will depend on their relative sizes. The sideways force will make the car change direction.

6 **a** No horizontal forces. Weight is acting downwards and upthrust is acting upwards. These forces are balanced, so the resultant is zero.

b Vertical forces as in part **a**. There is a forward force from the engine and a backward force from water resistance (and some air resistance). The forces are unbalanced, with the thrust greater than the water resistance, so the resultant is acting forwards.

c Vertical forces as in part **a**. There is no forward force (assuming the power is cut), there is a rearward force from water resistance. The forces are unbalanced and the resultant is acting to the rear.

9Ia-8 Forces in 2 dimensions

1 **a** The resultant force line measures 1.65 times the length of the 100 N line, so this represents a resultant force of 165 N.

b The forces are partly acting against each other.

c 10° from the centreline of the log, towards the larger force

d The log will be pulled sideways as well as forwards (or the log will turn towards the larger force).

2 Correct scale drawing, similar to the final one on the worksheet. At a scale of 1 cm = 20 N, there should be a 4 cm long line at 20° above the horizontal and a 4 cm line 20° below the horizontal, and the rest of the parallelogram should be drawn correctly.

Resultant force line on the diagram (to this scale) should be 7.5 cm long, representing a force of 150 N, along the axis of the log.

3 Resultant force in forward direction = 700 N. Scale drawing showing right-angled triangle with sides representing 700 N and 200 N. The resultant should be 728 N, at an angle of 16° to the forward direction.

9Ib Energy for movement

Student Book

1: 9Ib Energy for movement

1 any three from: food (or named types of food, such as fat, sugar, etc.), fuels (or named fuels, such as petrol, oil, wood, gas, etc.), cells/batteries, muscles, etc.

2 The humans moving the oars get their energy from food. The energy in animals/meat came from energy stored in plants, which came originally from the Sun.

The energy stored in moving air (wind) is caused by convection currents, which arise because of energy transferred to the Earth from the Sun.

3 one from: mass, speed

4 Coal is made from the remains of plants. These plants originally got their energy from the Sun.

5 **a** as elastic potential (strain) energy in the bent bow

b It is transferred to the arrow, where it is stored as kinetic energy.

6 **a** any two objects in raised positions: a box on a shelf, a diver on a diving board, water behind a dam, boulder at the top of a hill, etc.

b the height of the object and its mass (accept strength of gravitational field in place of one of these factors)

7 **a** any three from: wind, moving water (or tides, waves, hydroelectricity), solar, wood (if grown sustainably)

b fossil fuels (or coal, oil, gas), nuclear fuel, geothermal energy, wood (if not grown sustainably)

8 **a** energy stored in the chemicals in coal

b wasted – a low efficiency means that only a small amount of the total energy transferred was transferred to useful energy

c energy transferred to the engine or surroundings by heating; energy transferred to the surroundings by sound

9 **a** store of nuclear energy in Sun → (transferred by light) energy stored in chemicals in plants → energy stored in man (some students may add an animal/meat stage before this) → (energy transferred by forces) energy stored in movement of child and swing

b As the swing moves, air resistance acts to slow it down. Some of the kinetic energy is transferred to the surroundings and ends up stored as thermal energy. There will also be friction between the moving and stationary parts of the swing.

2: 9Ib Operating ships (Student Book)

1 **a** English is the internationally agreed language for shipping (as it is for aviation).

b To help them understand how the ship works, and about the weather and ocean currents.

c To be able to keep a lookout for other ships, to make sure they don't run into each other.

2 Ships can be carried along by currents, so deck officers need to know about currents to help them plan the ship's route. Weather, such as wind, also affects ships, so deck officers need to understand weather conditions and weather forecasts.

3 Ships can sail all over the world. Some countries will not allow ships to sail in their waters if the crews are not trained to an acceptable standard. Internationally recognised qualifications mean that all countries agree on the training standards.

4 Aeroplanes travel much faster than ships. Some goods are urgent, such as mail/parcels, small items needed for manufacturing, some kinds of fresh vegetables, etc.

5 Their wind propulsion only works when the wind is blowing from particular directions. They would need to use a normal engine if the wind was not blowing, or not in the correct direction for where they wanted to go.

6 **a** Nuclear fuel produces a lot more energy per kilogram, so the nuclear-powered ships can go for a lot longer (many months) without refuelling. For submarines, nuclear fuel is very useful as it does not need oxygen to burn and it does not give off carbon dioxide. A submarine often needs to stay under water for weeks at a time and could not carry enough oxygen to burn fossil fuels.

b Cargo ships do not need to stay at sea for long periods without refuelling, as they call at ports to load and unload cargo. Also, nuclear engines are very complicated and expensive, and need highly trained engineers to run them. Using nuclear power would make the cost of the ships too great.

Activity

1 Any sensible answers are acceptable, but the advantages and disadvantages should be set out in a neat table.

Costs – only likely relative costs are expected. The kite is likely to be the cheapest solution. Although a lot of equipment is needed for the solar-powered option, solar cells are an established technology, as are electric motors. The vertical rotor arrangement is likely to be the most expensive, as they are bigger and a new technology.

Weather – the two wind-powered options will only work when the wind is strong enough (but not too

strong) and blowing in a suitable direction. The solar option will only work in daylight, and then will not work effectively in cloudy or stormy conditions. However, batteries could be used to extend the operating time if sufficient solar cells are installed.

Other considerations could include the vertical rotors and the solar cells getting in the way of cranes when loading or unloading (whereas the kite can be folded up and packed away).

2 Any answer is acceptable as long as it is accompanied by sensible reasoning. However, the expected answer is spinning rotors, as the Baltic is too far north for solar power to be reliable and provide a lot of energy, and launching and retrieving the kite for many short trips would be too time-consuming.

Activity Pack

9Ib-1 Energy for movement

1 and 2

a chemical energy (blue)

b electricity (red)

c elastic potential energy (blue)

d fossil fuels (green)

e gravitational potential energy (blue)

f heat and light (red)

g kinetic energy (red)

h nuclear energy (blue)

i non-renewable resource (green)

j renewable resource (green)

k sound (red)

l thermal energy (blue)

3 A way of comparing the useful energy transferred to the total energy transferred (middle box).

9Ib-4 Investigating pendulums 2

1 Air resistance will act against the motion of the bob, and there may also be friction at the point of suspension.

2 These will result in the energy stored in the bob as gravitational potential energy and kinetic energy gradually being transferred to the surroundings and raising their temperature (thermal energy).

9Ib-6 Energy transfers and stores 1

1 **a** A, C, F

b B

c E

d D

2 In the chemical substances in coal (A); the horse's muscles (or in its food) (C); the wood/coal/fuel (F); wind (B); in the pendulum weights inside the clock (E); the stretched elastic (D).

3 **a** A, B, C, D

b F

4 **a** heating the locomotive and its surroundings, sound and light

b heating the surroundings and sound

c heating the pot and surroundings, sound and light

5 **a** B, C, F

b A

c Coal (A) is non-renewable because it takes a vast amount of time to form, so will run out one day. The wind will not run out, and both wood and food are unlikely to become scarce.

9Ib-7 Energy transfers and stores 2

1 **a** none

b It has all been transferred to thermal or kinetic energy stores in the air around it, or thermal energy in the elastic bands.

2 Answers may vary, but should include arrows to boxes labelled 'thermal energy' to show energy dissipation both from the glider and from the elastic bands.

3 **a** at the bottom of the swing, when the pendulum is moving fastest

b at either end of the swing, when the pendulum is stationary and in its highest position

4 Diagram similar to that on the worksheet, with the boxes labelled 'kinetic energy' and 'gravitational potential energy'.

5 It does not take into account energy transferred to the air, which will end up as thermal energy, or any energy transferred to the clamp and stand by making it move.

9Ib-8 Bungee jumping

1 Students are not expected to get all the details given here.

A: all the stored energy is gravitational potential energy (GPE). Weight is acting downwards and will accelerate the jumper downwards. There is a negligible force of air resistance. The bungee cord is slack so there is no energy stored as elastic potential energy (EPE).

B: GPE is reducing as they get lower, and the amount of stored kinetic energy (KE) is increasing. The bungee cord is slack so there is no energy stored as EPE. Weight is acting downwards, but there will be some air resistance acting upwards so the acceleration will not be as great as in A, but they will still be accelerating.

C: GPE is still reducing as they get lower. The bungee cord has become taut and is beginning to stretch so there is some EPE which will increase

as the cord stretches further. Weight is acting downwards, and air resistance and the force from the bungee cord are both acting upwards. The rate of acceleration downwards will reduce. As the cord stretches further the upward forces will increase and eventually the resultant upward force will be greater than the weight and their downward speed will reduce.

D: They are at the lowest point of the jump. GPE is at a minimum and they have stopped moving, so kinetic energy is also zero and there is no air resistance. EPE is maximum. The force from the bungee is acting upwards and is greater than their weight, so they will begin to accelerate upwards.

E: They are moving upwards, so GPE is increasing. The bungee cord is getting shorter so EPE is decreasing. KE is increasing at first, until the upward force from the bungee cord reduces to a point where it is equal to the sum of the weight and air resistance (which is now acting downwards). After that point they will start to slow down again and KE will reduce as GPE continues to increase.

F: The bungee cord is no longer stretched, so EPE is now zero. They are still moving upwards so they still have some KE, and GPE is still increasing. The only forces on them now are downwards (weight and air resistance) so they will slow down and KE reduces.

G: They are at the highest point of the 'bounce' so GPE is maximum and KE and EPE are zero. They are not as high as originally as air resistance has transferred some energy to the surroundings by heating (and also to the bungee cord and the jumper).

They will eventually stop bouncing because some of the original energy that was stored as GPE is transferred to the surroundings each time they jump. Their final height will be similar to that shown in C and E.

9Ic Speed

Student Book

1: 9Ic Speed

1 mm/year or cm/year

2 **a** mean speed = distance/time = 54 km ÷ 9 hours = 6 km/h

b Unless the horse kept a constant speed throughout the whole journey, it would have been travelling faster than this some of the time and slower some of the time.

3 44 km/h = 44 x 1000/3600 = 12.2 m/s

4 **a** 100 km

b 1 hour

c between 5 and 7 hours (or, on the downhill part)

5 distance = 40 km, time = 4 hours, speed = 40 km ÷ 4 hours = 10 km/h

6 Answers will vary. Give credit for axes with labels and scales, and sensible speeds shown!

7 **a** 5 m/s + 2 m/s = 7 m/s

b 5 m/s – 2 m/s = 3 m/s

2: 9Ic Equations and graphs

1 speed = 8 km/h, time = 0.5 hour; distance = 8 km/h × 0.5 hour = 4 km

2 speed = 24 km/h, distance = 6 km;

time = distance/speed = 6 km ÷ 24 km/h = 0.25 hour (or 15 minutes)

3 Graph with suitable title and scales, with axes labelled.

Line joining points: (0, 0), (0.5, 8), (1.0, 12), (1.25, 18)

4 **a** vertical difference = 20 – 0 = 20 m

horizontal difference = 4 – 0 = 4 s

gradient = 20 m ÷ 4 s = 5 m/s

b vertical difference = 80 – 60 = 20 m

horizontal difference = 10 – 8 = 2 s

gradient = 20 m ÷ 2 s = 10 m/s

5 **a** 1 hour **b** 0.5 hours

6 Graph with suitable title and scales, with axes labelled.

Line joining points: (0, 5), (4, 5), (4, 20), (6, 20), (6, 0), (8, 0), (8, 10), (10, 10)

Students may join each horizontal line with sloping lines, as on figure D in the Student Book.

Activity Pack

9Ic-1 Speed

1 miles per hour; hours; km/h; metres; metres per second

2 **a** speed, time

b mph (miles per hour)

3 The total distance travelled divided by the total time taken.

4 The bus has to stop at traffic lights and bus stops, so its mean speed is less than its top speed.

5 **a** F on the section of line from 10 to 30 minutes

b ⇌ on the section from 30 to 40 minutes

c 10 minutes

d 35 miles

e speed = 25 miles/0.5 hours = 50 mph

9Ic-2 Walking speed

1 fast, distance, time (either order), speed, time, metres, time, metres/second

4 Jo's group. Part of the time Dani's group measured would be taken up with speeding up and slowing down.

9Ic-4 Match the speeds

speed limit on motorway	112 km/h	31 m/s
speed limit in towns	48 km/h	13 m/s
fastest sprinter	36 km/h	10 m/s
normal walking pace	5 km/h	1.4 m/s
fastest racehorse	70 km/h	19 m/s
fastest sailing ship	34 km/h	9 m/s
fastest car	1128 km/h	341 m/s
fastest train	574 km/h	159 m/s
tortoise walking	0.36 km/h	0.1 m/s
fastest land animal	110 km/h	31 m/s
fastest fish	110 km/h	31 m/s
fastest bird	322 km/h	89 m/s

9Ic-6 Cycling speeds 1

1 The total distance divided by the total time.

2 **a** It counts how many times the wheels have gone round altogether.

b It measures the time the wheels have been turning.

c It takes the total distance and divides it by the total time.

3 2 m/s

4 **a** 20 m

b 20 m ÷ 4 s = 5 m/s

5 20 km/h × 2 h = 40 km

6 **a** 2 hours

b 40 km

c Tony cycled quite fast at the beginning of the ride and then stopped for a short rest. Afterwards he cycled at a slower speed than before.

9Ic-7 Relative speed calculations

1 **a** 60 mph

b 20 km/h

2 25 km/h

3 10 km/h

4 **a** 55 km/h – 30 km/h = 25 km/h

b 30 km/h – 55 km/h = –25 km/h

5 The sign is different. In part **a**, car B is going faster than car A, so relative to car A it appears to be moving forwards (or a person in car A would see it as moving forwards). In part **b**, for someone looking at car A from car B, car A would seem to be moving backwards.

9Ic-8 Cycling speeds 2

1 **a** 2 × 10 = 20 m

b 20 m ÷ 4 s = 5 m/s

2 The computer needs to know how far the bicycle has travelled for each turn of the wheels to be able to calculate the speed.

3 **a** 20 km/h × 1.5 hours = 30 km

b 30 km ÷ 15 km/h = 2 hours (allow for errors carried forward)

4 **a** 2 m

b 2 m/s

c 1.5 m

d 1.5 m/s

e lower

5 The computer will calculate that the bicycle has gone further than it really has for each turn of the wheels, so the speed it calculates will be too high.

6 Graphs should show the first leg covering 30 km in 1.5 hours, then a short horizontal section, then a further 30 km section taking 2 hours.

7 The car is travelling at 15 mph relative to Tony.

9Ic-9 Airspeed and groundspeed

1 The airspeed is the speed at which air is moving past the aeroplane. If there is some wind, there will be air passing the aeroplane even if it is not moving over the ground.

2 **a** If the aeroplane is flying in the same direction as the wind, the air it is flying through is moving in the same direction so its groundspeed will be greater than its airspeed.

b If the aeroplane is flying in the opposite direction the wind will be blowing it backwards while it is trying to move forwards, so its groundspeed will be less than its airspeed.

3 **a** 130 km/h. If there is no wind, its groundspeed will be the same as its airspeed.

b 100 km/h

c 160 km/h

4 **a** Airspeed – as it is the speed of the air over the wings that determines how much lift the wings produce.

b Groundspeed – this is the speed the aeroplane is moving over the ground so determines the distance required to stop. The aeroplane stops when its groundspeed is zero, but it could still have some airspeed if there is some wind (accept similar explanations).

c If they take off into the wind their groundspeed is less than their airspeed, so they can take off and land on shorter runways. There is also wear on tyres and brakes that is reduced if groundspeeds are lower, but students would not be expected to state this.

5 **a** Groundspeed, as the distance between the departure and destination points is a distance over the ground.

b GPS can only measure groundspeed while the aeroplane is actually flying. If a pilot wishes to predict flying time, she needs to know what the wind speed *will be* during the flight.

6 If she flies directly north, the wind will carry her to the west and she will miss her destination. If she aims to the east of Newtown she will end up flying north over the ground and will reach her destination.

9Id Turning forces

Student Book

1: 9Id Turning forces

1 long bar with a pivot/fulcrum

2 a pivot – the turning point for a lever

3 **a** any other force multiplier, such as scissors, nutcracker, crowbar, spade

b any other distance multiplier, such as legs, sugar tongs, fishing rod

4 moment = force × perpendicular distance = 20 N × 0.2 m = 4 N m

5 **a** The effort distance is longer than the load distance, so the effort can be a smaller force than the force needed to open the bottle.

b The effort distance is much smaller than the load distance, so the effort moves only a small way and the load distance moves much further.

6 The 600 N force/the man pulling is the effort; the 1800 N force/weight of the barrel is the load.

7 **a** smaller, because the perpendicular distance between the weight of the barrel and the pivot is now smaller

b moment = 1800 N × 0.5 m = 900 N m

Activity Pack

9Id-1 Turning forces

1 lever – a long bar that can be used to increase the size of a force (or how far it moves)

pivot – the point that the lever turns around

effort – a force put on a lever

load – the weight or force on something

force multiplier – a lever that makes a force bigger

distance multiplier – a lever that makes something move further

bottle opener – a lever that can be used to take the tops from bottles

2 **a** The right-hand lever.

b It is a longer lever, so it will make the force bigger for the same amount of effort.

3 **a** A down arrow to the right of the diagram.

b Boy B must move further from the pivot/to the right (or boy A could move in towards the pivot).

9Id-2 Investigating levers 1

same, load

balance, short, further, pivot

fewest

easier

9Id-5 Levers and moments 1

1 Labels from top to bottom.

diagram A: load, effort, pivot

diagram B: pivot, load, effort

2 **a** longer

b A longer spanner will multiply the force more.

3 **a** One boy weighs twice as much as the other, but he is sitting twice as far away, so the moments are the same in each direction.

b His side of the seesaw would go up.

9Id-6 Levers and moments 2

1 load, effort and pivot correctly labelled

2 **a** B – They need to provide a greater force to cut through bones, so the distance from the pivot to the handles (where the effort is applied) must be bigger.

b It is easier to cut accurately as they are smaller.

3 When you push at the handle, the effort is further away from the hinge (pivot) so less force is needed.

4 **a** 400 N × 1.5 m = 600 N m

b 300 N × 1.2 m = 360 N m

c 150 N × 0.2 m = 30 N m

d 120 N × 0.25 m = 30 N m

5 **a** 2 m

b 300 N

c 4.5 m

9Id-7 Gears

1 **a** circumference = 2 × 3.14 × 17 cm = 106.8 cm

b 2 × 3.14 × 10 cm = 62.8 cm

c circumference = 2 × 3.14 × 5 cm = 31.4 cm

number of turns = 62.8/31.4 = 2

d 2

e circumference = 2 × 3.14 × 35 cm = 219.8 cm

distance = 2 × 219.8 = 439.6 cm

f 106.8 : 439.6 = 1 : 4.1

2 **a** A distance multiplier – the tyre moves approximately four times the distance that the pedals move.

b Smaller – if the distance is greater the force must be smaller.

3 **a** 20 N × 17 cm = 340 N cm

b force = moment/distance = 340 N cm/10 cm = 34 N

c moment = 34 N × 5 cm = 170 N cm

d force = moment/distance = 170 N m/35 cm = 4.9 N

e force on tyre : force on pedals = 4.9 N : 20 N = 1: 4.1

It is the same ratio, because if the wheel moves 4.1 times as far as the pedals, the force on the pedals must be 4.1 times the force at the wheel.

4 **a** circumference of rear sprocket = 2 × 3.14 × 2.5 = 15.7

number of turns of sprocket for 62.8 cm of chain = 4

distance moved by wheel = 4 × 219.8 = 879.2 cm

(accept shorter answers that show understanding that, as the small sprocket is half the radius of the large one, the distance moved by the wheel will be twice as far)

ratio = 62.8: 879.2 = 1:14

b The tyre moves twice as far for one turn of the pedals.

c The force will be less if the distance moved is greater.

d When pedalling on the flat, when not as much force is needed but they want to go faster.

9Ie More machines

Student Book

1: 9Ie More machines

1 Any uses of ramps, such as loading lorries or ships, emergency escape chutes from aeroplanes (which reduce the downward force on exiting passengers, so they do not hit the ground as fast), zig-zag roads up hillsides, wheelchair ramps into buildings (although this is also connected with the need for wheels to move easily on the ramp).

2 Any uses of pulleys, such as on cranes, in lifts, some weights machines in gyms, raising blinds (although these usually do not change the force required, only its direction).

3 If there were more pulleys she would have to pull the rope further, which might be difficult in a small sailing boat.

4 **a** work done = force × distance = 1000 N × 2 m = 2000 J

b work done = 500 N × 4 m = 2000 J

c The values are the same. The ramp allows a smaller force to be used, but it has to move further (or the block has the same amount of gravitational potential energy at the top; however, it was lifted, so it must have taken the same energy to lift it).

5 There will be some friction between the block and the ground as the block is pushed up the ramp. This means that the force needed will be a little more than 500 N, so the total energy transferred (work done) will be more than 2000 J.

6 The box is not moved upwards or deformed/stretched, so it is not storing elastic or gravitational potential energy. A force is needed to move the box because of friction between the box and the floor. The energy is transferred by heating, and stored as thermal energy in the box and/or the floor.

2: 9Ie Supplying the energy

1 *Advantages*: the 'engine' of a train could be very small and light (in photo A, in the Student Book in 9Ie Supplying the energy, the open truck at the front is the 'engine'); the train did not have to carry fuel; polluting smoke was only produced at the pumping stations, not all the way along the track/through towns.

Disadvantages: leaking air means it would have taken more energy to run the trains than if each train had its own engine; they were more expensive.

2 *Advantages*: no polluting gases emitted by the train; pollution from the power stations used to provide the electricity is easier to control (by removal of the waste gases, rather than discharge directly to the air from the diesel train); electricity can be produced from renewable resources; the trains are quieter (a little – there is still noise from the wheels/tracks/moving air).

Disadvantages: can only run on electrified tracks (whereas a diesel engine can run on any lines); installing the electrical wires is expensive; electrical wires increase the visual impact of the railway; possible dangers from people coming in contact with the wires/live rails.

3 Graph should be correctly labelled with suitable scales. The graph should show the correct total travel time (1.5 hours) and distance (70 km). The rail journey should show one horizontal section in the middle of the journey.

4 **a** A lever is a long bar that can pivot. If a force is applied further from the pivot/fulcrum than the load being lifted, a smaller force is needed.

Loads can be moved using ropes threaded through pulleys – the more pulleys are used the smaller the force needed but the further the force has to move.

It takes a smaller force to push something up a ramp than it does to lift it directly, but the object has to be moved further.

b If a machine allows a smaller force to be used to move something, the force applied has to move further. Overall the work done/energy transferred is the same.

In practice, using a smaller force usually requires more energy, as there is more opportunity for energy to be transferred/dissipated via friction.

Activity Pack

9Ie-1 Simple machines

A machine is something that … makes it easier to move things.

A ramp is … a slope that allows us to use a smaller force to move something upwards.

The shallower the ramp … the smaller the force needed to push something up it.

Pulleys and ropes … can be used as force magnifiers.

When you lift a load using a pulley … the force you apply moves further than the load.

Work is … the amount of energy transferred when a force moves something.

Work is calculated by multiplying … the force by the distance it moves.

The units for work are … joules (J).

9Ie-3 Investigating ramps 1

3 **a** Forcemeter method: advantages include no friction losses in pulley, ramp can be set up on the floor instead of needing a bench (safer). Disadvantages are the difficulty in pulling the trolley at a constant speed that is the same for each test, difficult in reading a moving forcemeter.

Weight method: advantages include the ease of applying a constant force to the trolley (this will be the force needed to balance the component of its weight acting along the ramp, plus a little more to compensate for friction in the wheels). Disadvantages are that friction in the pulley may affect results, only step changes in the force can be applied.

b Either method can be selected, so long a reasonable justification is given.

9Ie-5 Moving the stones

Refer to the marking grid for the Open-ended Assessment task in the ASP.

9Ie-6 Lifting loads 1

1 1000 N

2 force multiplier

3 make it shallower/longer

4 force multipliers

5 B

6 B (accept A if the answer to **Q5** was A, but only if the following explanation is given – if the force is less it has to move further (or equivalent explanation))

7 **a** lever

b any two examples of levers in use

9Ie-7 Lifting loads 2

1 **a** 1000 N

b 1000 N × 1 m = 1000 J

2 **a** 1000 J – the same work is needed with and without the ramp (or similar explanation)

b force = work/distance = 1000 J/3 m = 333 N

3 **a** 33 N. Explanations could calculate the force using work = 100 N × 1 m = 100 J and force = 100 J/3 m, or could explain that the ratio of weight to force needed will be the same as for the 1000 N crate.

b Total force = 333 N + 33 N = 366 N. Work = 366 N × 3 m = 1098 J.

4 B

5 B (accept A if the answer to **Q5** was A, but only if the following explanation is given – if the force is less it has to move further as the total work is the same each time).

6 Work done lifting the weight = 60 N × 1 m = 60 J. This is the same as the work done pulling on the rope, so distance = 60 J/30 N = 2 m. (Accept explanations in terms of half the force needing twice the distance.)

7 **a** force = work/distance = 60 J/4 m = 15 N (or explanation in terms of twice the distance meaning half the force needed as in A)

b There may be friction in the pulleys.

8 a 60 cm, because this is how far the force has moved

b It is stored as strain/elastic potential energy in the rope

c If a stretchy rope was used, energy would be wasted in stretching the rope instead of being used to lift the load.

9Ie-8 Mechanical advantage

1 effort distance/load distance = 1.5 m/0.3 m = 5

2 **a** 6 cm/30 cm = 0.2

b distance magnifier

c Explanations may vary, but should include some of the following points: a force magnifier will have a mechanical advantage greater than 1, a distance magnifier will have a mechanical advantage less than 1. This is because, for a lever to be a force magnifier, the effort must be further from the pivot than the load, so the effort distance divided by the load distance will be greater than 1. For a distance magnifier, the load distance is bigger than the effort distance so the ratio is less than 1.

3 Explanations may vary, but should include some of the following points: the work done is the same whether the load is lifted vertically or pushed up the ramp, as energy cannot be created or destroyed. This means that force × distance moved in the direction of the force is the same whichever method is used. The 'magnification' of the force is the force

needed to lift it vertically (V) divided by the force needed to pull it up the ramp (effort E). $V \times h = E \times d$, so $V/E = d/h$.

4 The force needed to pull the object up the ramp. The object is not rubbing against anything if it is lifted vertically.

5 Smaller. If there is friction between the object and the ramp, the pulling force will have to overcome this friction as well as provide the force needed to move the object up against gravity. So the weight of the object will be divided by a bigger force and the ratio (which is the mechanical advantage) will be smaller.

6 If the lever does not bend, the work done by the effort force moving through a distance is equal to the work done by the load moving through a distance. The energy transferred by the effort force moving will be stored as gravitational potential energy in the raised load. If the lever bends, some energy will be transferred to the lever itself and stored as elastic potential energy. So a greater effort force will be needed to transfer the same amount of GPE to the load, and the mechanical advantage will be less.

9J Force fields and electromagnets

9Ja Force fields

Student Book

1: 9Ja Mission to Mars

1 **a** gravity

b The masses of the objects and the distance between them. If the masses are greater, the force is greater. If the distance between them increases, the force becomes smaller.

2 **a** north pole and south pole (or north-seeking pole and south-seeking pole)

b the space around a magnet where it affects magnetic materials

c The Earth has a magnetic field, and a compass needle is a small magnet. The north end of the compass needle is attracted to the north magnetic pole. The north magnetic pole acts like the south pole of a magnet.

3 **a** a cell and a complete circuit made of conducting material/wire

b using an ammeter connected in series in a circuit

c The voltage from a cell pushes the current around the circuit. The voltage across a component is a measure of the energy transferred by the current.

d using a voltmeter connected across (in parallel with) the cell or other component

2: 9Ja Force fields

1 **a** two bar magnets drawn with N and S ends together

b two bar magnets drawn with N and N together, or with S and S together

2 **a** closest to the poles of the magnet

b at the sides of the magnet

3 If the magnet is allowed to swing, this is the end that points north.

4 **a** weight = 900 kg × 10 N/kg = 9000 N

b weight = 900 kg × 3.7 N/kg = 3330 N

5 **a** Oberon, because it has the greatest mass

b If they were different sizes, the surface of one would be further from the centre. This could affect the gravity at the surface, so choosing two moons of the same size makes a more fair comparison.

6 move the bucket to a higher shelf/add mass to the bucket/fill the bucket with something

Activity Pack

9Ja-1 Force fields

A force field … is a space where a non-contact force has an effect.

Two examples of force fields … are magnetic fields and gravitational fields.

The two ends of a bar magnet … are called the north pole and the south pole.

Two north poles close to each other … will repel each other.

A north pole will attract … a south pole near it.

The strength of a magnetic field … is strongest close to the magnet.

Gravity … is a force that attracts objects with mass to each other.

Two large masses … have a greater force between them than two small masses.

The force of gravity … is greater when masses are close together.

When you move an object up in a gravitational field … you store gravitational potential energy in it.

The gravitational field strength of the Earth … is 10 N/kg.

9Ja-4 Force field questions

1 **a** Magnetic field completed to be symmetrical with the upper half provided.

b From the north pole to the south pole of the magnet.

2 **a** 1 for the person on the left, 2 for the person on the mountain, 3 for the astronaut on the Moon.

b 1 is closer to the Earth than 2, so his weight is greater. Gravity is not as strong on the Moon/the Moon's gravitational field is weaker than the Earth's, so 3 has the smallest weight.

3 **a** 80 N

b 15 N

c 5 kg

d 10 N

9Ja-5 Lifting the load

1 It takes a lot of fuel and costs a lot to lift each kilogram.

2 by throwing away parts no longer needed

3 kerosene and liquid oxygen

4 **a** It will gradually reduce as the fuel is used up.

b It will suddenly decrease when the first stage is separated.

c It will gradually decrease again as fuel is used.

5 **a** Its strength gets less as the spacecraft gets further from the Earth.

b Its weight would get less even if its mass stayed the same.

9Ja-6 Finding the mass of the Earth

1 **a** The force of gravity between it and the Earth is pulling it towards the centre of the Earth.

b The mass of the mountain is attracting it, and pulling it slightly sideways.

c He said that all objects with mass have a force of gravity, and the size of the force depends on the mass. The mass of the mountain is very small compared with the mass of the Earth, so the angle of the plumb line from the vertical is very small.

2 **a** The attraction of the mountain for the plumb line is very small compared with the force of gravity from the Earth as a whole, and as gravity gets weaker with distance he needed to be as near to the mass of the mountain as he could.

b It was a way of checking his measurements (and also the combined difference of the plumb lines on both sides would be a bigger value, and so slightly easier to measure/calculate accurately).

3 He needed very accurate results, as the angles he was measuring were so small. Taking lots of measurements would allow him to see how reliable his results were, by spotting measurements that did not seem to fit with the others, and he could allow for small errors by taking mean results.

4 **a** their masses and volumes

b It was assumed that all the rocks in the mountain had the same density as the rocks on its surface (whose density could be measured directly).

5 If the Earth was partly hollow, its density would be much less than the density found from these experiments.

6 Other nearby mountains could have affected the results.

9Ja-7 Changing gravity

1 **a** The Earth is not perfectly spherical.

b They are closer to the centre of the Earth.

2 **a** 0.052 N/kg

b 5.2 Gal

3 It would be too complicated to work out the exact value for every place on Earth.

4 **a** Because the differences in gravity from one place to another are so small.

b 0.001 Gal or 0.00001 N/kg

5 **a** Because the dense rock has more mass in a certain volume than other rock, and a greater mass will produce a greater gravitational force.

b It would reduce it, as less mass produces a smaller force.

9Jb Static electricity

Student Book

1: 9Jb Static electricity

1 on the outside/around the nucleus

2 They have the same number of positive and negative charges.

3 They are on the outside. The positive charges are inside the nucleus and cannot move.

4 **a** It has more electrons than before, so it now has more negative charges than positive charges.

b It has lost the same number of electrons as the rod has gained, so it has the same imbalance of charge.

5 **a** They will repel, because they will both have the same type of charge/have positive charges.

b They will attract, because they have opposite charges.

6 All the strands of her hair have the same charge, so they are all repelling each other.

7 Draw a diagram like F, but with the arrows pointing away from the central object and a plus sign in it. This should be explained as the direction of the field being the direction a positive charge would move, and a positive charge would be repelled by an object with a positive charge.

Activity Pack

9Jb-1 Electricity and magnetism

1 nucleus, positive, electrons, negative;
equal, atom, charge

2 **a** electrons
b negative

3 Some of the electrons in the cloth move onto the rod.

The polythene rod ends up with more negative charges than positive charges.

The cloth ends up with more positive charges than negative charges.

The amount of charge on the cloth is the same as the amount of charge on the rod, but with the opposite sign.

4 **a** repel
b attract
c repel

5 electric field

9Jb-2 Attraction and repulsion – charges

3 same charge

4 same charge

5 different – they are different materials (or if they were the same as each other they would have repelled, as the rods did in steps C and D)

6 repel each other; attract each other

7 They should describe hanging a charged polythene rod in the stirrup (the worksheet tells them this will have a negative charge). The new material is rubbed and brought close to the polythene rod. If the two rods attract each other, the new material has a positive charge. If they repel, the new material has a negative charge.

9Jb-3 Comparing non-contact forces

Affects only objects made from iron, cobalt or nickel (magnetism).

Can cause attraction or repulsion (static electricity, magnetism).

Produces a force field (all).

Size of the force depends on mass (gravity).

Size of the force depends on the number of electrons transferred (static electricity).

Can only cause attraction (gravity).

Can be felt all the time (gravity).

Can affect any object (gravity, static electricity).

The effects of the force on other objects can be modelled using a diagram with lines on (all).

Can only be produced on insulating materials (static electricity).

Size of force depends on distance from object (all).

9Jb-4 Static dangers

a Key points are – stay inside buildings or cars if possible, do not shelter under isolated tall objects such as trees, adopt the 'lightning crouch' if caught in the open.

b They connect themselves to the object being worked on, usually via a wrist strap and conducting wire, so they do not build up any charge relative to the electronics.

c The aircraft and tanker are both connected to the ground and usually to each other, so any charge spreads through the wire rather than making a spark. No tanks are opened until this has been done.

d Similar to **c** the tanker is bonded to the tanks and to the ground before fuelling starts.

9Jb-5 Static questions 1

1 **a** gravity
b magnetism

2 nucleus, positive
electrons
electron
equal to, no
electrons
electrons
positive

3 **a** same
b repel

4 The charges must be the same, because the two rods repel each other.

5 The space around a charged object where it can affect things.

9Jb-6 Static questions 2

1 **a** A central nucleus with a positive charge is surrounded by electrons with negative charges. The total amount of positive and negative charge is equal, so the atom has no overall charge.

b Negative charges, because the positive charges are in the nucleus and cannot be moved.

2 **a** Electrons have been transferred from the cloth to the rod.

b It will have the same size charge, but the charge will be positive. It has lost the same number of electrons as the rod has gained.

3 Electrons are transferred from the glass rod to the cloth.

4 They will attract each other because they have opposite charges.

5 The type of charge gained depends on the two materials being rubbed. If the two materials are the same, both rods will have the same charge and so will repel each other.

6 **a** Running the comb through her hair has transferred electrons to (or from) the hair, so the hair has a charge of static electricity. Because all the strands of hair have the same charge they repel each other and stick out.

b It will also have a static charge of the same size as the total charge on the hair, but of the opposite charge.

7 The clothes have been rubbing against each other in the tumble dryer and so electrons have been transferred between them. Clothing with opposite charges will be attracted and will cling together.

The clothes keep their charge well because of the dry air.

9Jb-7 Attracting uncharged objects

1 **a** The positive charge attracts electrons in the pieces of paper. These move to the edges of the atoms closest to the rod. The negative charge near the surface of the paper and the positive charge on the rod attract each other.

b The force is not strong enough to pick up anything larger.

2 The charge must be the same on both, because like charges repel. (Also, the two materials are conductors, so if the charges were opposite they would attract each other and the net charge would cancel out.)

3 **a** The positively charged rod attracts electrons in the metal.

b Electrons in the rod and the gold leaf are attracted to the positively charged rod, and move up towards the cap. This leaves both the bottom of the rod and the gold leaf with a positive charge, so they repel each other.

4 The negative charge on the rod repels electrons in the metal cap. These move down the metal rod. As these extra electrons are all repelling each other they spread out, and some also go onto the gold leaf. The gold leaf and the rod both have a negative charge, so they repel each other.

5 In the electroscope, the electrons that are moved by the charged rod can move throughout the metal cap, rod and gold leaf. In an insulating material, the only movement is to change where electrons are in the atom they are in.

6 **a** It can be made very thin, so it only takes a very small force to move it. This means it can be used to detect very small charges.

b To protect the thin gold leaf from draughts/damage, or so there is no movement due to draughts that might be mistaken for a movement due to static charge.

9Jc Current electricity

Student Book

1: 9Jc Current electricity

1 It conducts electricity because it is a metal. Copper is used because it conducts electricity better than many other metals.

2 **a** correct symbol for a cell

b correct symbol for a bulb

3 **a** It will increase, because it is easier for the current to go through one bulb than through two *or* because the resistance is less.

b It will be brighter, because the current is bigger.

4 When all three switches are closed, the current through the extra two bulbs will be the same as the current through the single bulb when only one switch is closed. So the current in the main part of the circuit/through the cell will be three times the original amount.

5 copy of the parallel circuit with a switch in the part of the circuit next to the cell

6 **a** it will increase/it will double

b They will both double (OR the bulb will have 8 V and the motor 4 V across them), because the higher voltage of the cell is divided between the components in the same ratio.

2: 9Jc Working with electricity (Student Book)

1 **a** Any three from: starter motor, spark plugs, fan, heater, lights, radio/entertainment, working remote door locks, etc. Accept any other sensible suggestions.

b Any three from: lighting, heating, fridges, freezers, tills, public address system. Accept any other sensible suggestions.

2 It helps the electrician to be sure which wires she is working on and to check the correct connections are being made.

3 A good answer will consider risks to both the electrician and the people using the circuits they work on. For example:

- they work safely, so they do not get electric shocks, or have accidents when working in risky places, such as up pylons or on building sites
- they need to be able to install or repair wiring so that it is safe to use.

4 electric shock; causing fires

5 Answers should include some of the following: how many lights/switches and where they are, how many power sockets and where they are, what high-power items there may be, such as

showers/cookers/water heaters, other electrical equipment that will be permanently wired in, like air conditioners and fire alarms, etc.

6 **a** Possible answers include: fault in the switch on the brake pedal, faulty bulb, faulty connection between car and trailer, faulty connections within the wiring in the car, faulty connections within the wiring in the trailer, breaks in the wires in the car or trailer.

b The fault is in the connection between the car and trailer, or somewhere on the trailer.

c Possible answers are: visually inspect the bulbs and/or remove the bulbs and apply a current in a test circuit, use an ohmmeter/multimeter/continuity tester to check the connections between the car and trailer, test the connections within the trailer, or test the wires in the trailer.

Practical

Students' checklists should include items such as 'check bulb is not broken', 'check battery is not flat', etc. (depending on the type of circuit provided for them).

Activity Pack

9Jc-1 Current electricity

1 **a** cell

b series circuit

c switch

d bulb

e ammeter

f amps

g voltage

2 left-hand circuit: 4 V, 0.1 A

right-hand circuit: 0.1 A, 3 V

9Jc-3 Revising electricity

1 E, F, I, J or L

2 A, B, C, D, G, H or K

3 A and I

4 B

5 any two from: B, D, G, H, K

6 any one from: A, C, E, F, G, H, I, J, L

7 N

8 B, D, K

9Jc-4 A model circuit

1 **a** the lorries

b the factory

c the coal loader

2 No – the lorries move themselves around.

3 **a** it increases **b** it increases

4 **a** There are more lorries, and the lorries are all carrying more coal.

b The extra lorries represent the higher current, and the extra coal represents the extra energy given to the current.

5 another light bulb added to the circuit

6 The voltage supplied by the cell is represented by the amount of coal in each truck. Some of this coal is delivered to each factory as the trucks pass through, which represents part of the energy being transferred to each component. The trucks return empty to the loader, which shows that all the initial energy has been distributed to the factories/components.

7 **a** The road would split in two and then rejoin, with a factory on each branch of the road.

b i All the lorries pass through the loader, but then some lorries go to one factory and some go to the other, along the two different roads.

ii The amount of coal in each truck represents the voltage. Each truck still carries the same amount of coal, which represents the voltage across each branch being the same.

9Jc-5 Electricity questions

1 **a** current, series

b current, parallel

c voltage, parallel

d voltage, series, voltage

2 C

3 2 A, the current is the same everywhere in a series circuit.

4 4 A, as adding another cell (assumes cell provides same voltage) will double the voltage, so the current will double.

5 **a** They will be dimmer/half as bright, as the resistance is higher and there is the same number of cells, so the current will be smaller.

b 0.5 A

c both 0.5 A

6 There is the same voltage across each bulb, or the voltage across each branch of a parallel circuit is the same as the voltage supplied by the cell, and each branch has only one bulb in it (whereas there are two in B), so the current will be greater.

7 **a** 0.8 A

b 0.4 A – the current in the main part of the circuit splits up to go through the branches in the parallel circuit (and as both branches have the same components in them, the current will divide equally).

c 6 and 7 will read 1.6 A; 8 and 9 will read 0.8 A.

8 **a** The switch should be in the same branch as bulb X.

b The switch should be adjacent to the cell, or on any part of the circuit before the split.

9Jc-6 Flashing lights

1 **a** battery, bulb, heater coil, metal contacts, switch

b on

c bulb, heater coil

2 The currents are the same, as they are all part of the same circuit.

3 **a** There is no current flowing as the contacts are open.

b It will not be lit.

4 **a** It will cool down (until it reaches the temperature of its surroundings).

b It will become straight again.

c The contacts will close and the bulb will come on again.

5 The bulb will be dimmer because the resistor will make the current in the circuit smaller.

6 **a** The bulb will be on for a longer time. The lower current will mean the heater coil is not as hot, so it will take longer for the bimetallic strip to heat up enough to bend and break the contacts.

b The time between flashes depends on how long it takes for the bimetallic strip to cool down. This does not depend on the size of the current, so adding the resistor will not affect this time.

9Jc-7 Power

1 how much energy is transferred each second

2 **a** watts

b The watt is another name for 1 joule per second.

c amp-volts or similar suggestion

3 The current is how many electrons are flowing through a component, and the voltage is how much energy the electrons are transferring. So the more electrons that flow, and the more energy they are transferring, the greater the total amount of energy transferred.

4 current = power/voltage

5 **a** motor: 0.4 W; bulb 0.8 W

b The current is the same everywhere in the circuit, because it is a series circuit.

9Jd Resistance

Student Book

1: 9Jd Resistance

1 **a** amps

b volts

2 any three insulators, such as plastic, glass, wood

3 **a** to insulate person from the wires/stop them getting an electric shock

b They must have a high resistance to act as insulators.

4 voltage = 5 A × 20 Ω = 100 V

5 resistance = 18 V/3 A = 6 Ω

6 Answers should describe passing current through wires of different lengths, measuring the current and voltage, and calculating the resistance. For a fair comparison, the wires should all be of the same thickness and material.

7 B has the highest resistance. For any particular voltage, B has the lowest current flowing through it, so it must have the highest resistance.

2: 9Jd Rounding numbers

1 **a** 0.3 kg

b 0.258 kg

2 It would be zero if rounded to one or two decimal places (and so no use for working out how to get the lander down safely).

3 Any two between 0.65 A and 0.74 A. (Note that the upper limit could actually be 0.7499999 recurring – but the examples in the text are only given to 2 d.p. so 0.74 is acceptable as an answer.)

4 2.1 Ω

5 2.14 Ω – As both numbers used to work out the answer were given to 2 d.p., the answer can also be given to 2 d.p.

6 **a** 500 000 kg to 1 s.f.

b 510 000 kg to 2 s.f.

c Engineers working out fuel needed or how long to fire the engines would use the accurate value. Journalists or reporters might use one of the rounded values.

7 **a** The rounded value is 300 000 000 m/s for 1, 2, 3 significant figures.
Speed = 299 800 000 m/s to 4 s.f.

b The accurate number rounded to 1, 2 or 3 significant figures is 300 000 000 m/s.

It is only when rounded to 4 s.f. that you can tell how many significant figures have been used.

Activity Pack

9Jd-1 Resistance

1 ohms, Ω;

A; volts

2 **a** middle wire

b top wire

3 difficult, current; good, low; poor, high; good

4 resistance; 4 A × 10 Ω = 40 V

5 voltage/current; 6 V/0.2 A = 30 Ω

9Jd-5 Calculating resistances 1

1 a V, A, Ω

b 6, 5, 5, 3

2 a 4 Ω, because a longer wire has a higher resistance.

b 1 Ω, because thicker wires have lower resistance.

3 a high

b plastic

c Conductors have low resistances and insulators have high resistances. This is a high resistance. Plastic is the only insulator in the list.

9Jd-6 Decimal places and significant figures

1 a 3.92 N/kg

b 3.9 N/kg

c The numbers in the question are given to only one decimal place, so the answer should also be to one decimal place.

2 If the first two were rounded to one decimal place they would both be zero, which would make it impossible to compare them.

3 copper: 0.021 Ω (2 s.f.); aluminium: 0.034 Ω (2 s.f.); graphite: 640 Ω (2 s.f.); nichrome: 1.3 Ω (2 s.f.)

4 a 2

b copper: 0.0032 Ω (2 s.f.); aluminium: 0.051 Ω (2 s.f.); graphite: 960 Ω (2 s.f.); nichrome: 1.9 Ω (2 s.f.).

5 a 147 098 290 km × 1.7 = 250 06 093 km

b It is larger by 834 661 km.

c 150 000 000 km

d 255 000 000 km

e It is larger by 5 767 568 km.

f The difference between the calculated and true value is much greater in part **e** than in part **b**.

g Answers may vary, but could include the following points: using significant figures during calculations introduces a rounding error compared with the more precise value; carrying out calculations on this rounded number can make the error bigger; so it is best to only round at the end of a calculation.

9Jd-7 Calculating resistances 2

1 a Higher than 2 Ω, because longer wires have a higher resistance, or 4 Ω, because if the wire doubles in length its resistance doubles.

b 1 Ω (or any value less than 2 Ω), because thicker wires have lower resistance.

2 a 12 V/6 Ω = 2 A

b 10 A × 5 Ω = 50 V

c 6 V/3 Ω = 2 A

3 The wires would all have to be the same length and the same thickness for the results to show which has the lowest resistance (i.e. the comparison would have to have been a fair test).

4 a 5000 V/0.1 A = 50 000 Ω

b No. Metals are conductors, so have very low resistance.

5 a resistance = 12 V/0.4 A = 30 Ω

b R1 = 4 V/0.4 A = 10 W; R2 = 2 V/0.4 A = 5 Ω; R3 = 6 V/0.4 A = 15 Ω

c The resistances of the individual resistors add up to the same as the overall resistance of the circuit. So for a series circuit, add up all the resistance to find the total resistance.

9Jd-8 Adding resistances

1 a resistance = 12 V/0.4 A = 30 Ω

b R1 = 4 V/0.4 A = 10 Ω; R2 = 2 V/0.4 A = 5 Ω; R3 = 6 V/0.4 A = 15 Ω

c The resistances of the individual resistors add up to the same as the overall resistance of the circuit. So for a series circuit, add up all the resistance to find the total resistance.

2 a resistance = 10 V/2 A = 5 Ω

b It is half the value of each individual resistor.

3 a Each resistor has 10 V across it, so current = 10 V/10 Ω = 1 A

b 3 A, the currents through each resistor combine (or similar explanation).

c resistance = 10 V/3 A = 3.33 Ω

4 In circuit B, 1/R = 1/10 + 1/10 = 2/10 = 1/5, so R = 5 Ω

In the circuit with three parallel resistors, 1/R = 3/10, so R = 10/3 = 3.33 Ω

These answers are the same as those calculated in earlier questions.

5 a Current through top branch: total resistance = 15 W, current = 10 V/15 Ω = 0.67 A

Current through bottom branch = 10 V/20 Ω = 0.5 A

b 0.67 A + 0.5 A = 1.17 A

c 5 Ω resistor: voltage = 0.67 A × 5 Ω = 3.35 V

10 Ω resistor: voltage = 0.67 A × 10 Ω = 6.7 V

(the two values do not add up to 10 because of rounding used here)

9Je Electromagnets

Student Book

1: 9Je Electromagnets

1 a It stops being magnetic/an electromagnet.

b A bar magnet is a permanent magnet/is always magnetic.

2 decreasing the number of coils of wire, using a smaller current, not having a core made of a magnetic material

3 Make an electromagnet and count how many paperclips it picks up (or any other valid method of measuring the strength). Count the number of paperclips picked up for several different currents and see if there is a pattern.

4 The current in the low-current circuit turns the coil of wire into an electromagnet. This attracts the iron block and pulls it into the coil. The metal bar is pushed against the contacts and closes the gap in the high-current circuit.

5 have a bigger current in the wire, use a stronger magnet/stronger magnetic field

6 **a** make it go faster/produce a bigger force

b make it go slower/produce a smaller force

c make the coil spin in the opposite direction

2: 9Je Humans in space

1 Muscles will weaken/bones will get thinner, but not by as much as they do on the space station. The gravity/gravitational field on Mars is weaker than on Earth.

2 **a** A gravitational field exists around all objects with mass. Objects with mass are attracted to each other.

A magnetic field exists around magnets, electromagnets and the Earth. Magnetic fields attract objects made from magnetic materials, and can attract or repel other magnets.

An electric field exists around objects with an electric charge. Electric fields can attract other objects, and can attract or repel other charged objects.

b Similarities – all exert a force without contact/act at a distance; for all the field gets weaker as you get further away from the object causing it.

Differences – they are caused by different properties of objects; gravity only attracts objects, the other two fields can attract or repel.

3 **a** to control/limit the current in a circuit

b Measure the current flowing through it and the voltage across it. Use the formula resistance = voltage/current to calculate the resistance.

4 **a** a coil of wire on a core made from magnetic materials, and a magnetic field produced by permanent magnets or electromagnets

b increase the current in the coil or increase the strength of the magnetic field.

Activity Pack

9Je-1 Electromagnets

Electromagnet

An electromagnet is a coil of wire with a current flowing through it.

The shape of its magnetic field is similar to the shape of a bar magnet's magnetic field.

It can be made stronger by increasing the current, the number of coils of wire, or by giving it a core (centre) made from a magnetic material.

Relay

A relay allows you to use a small current to switch on a circuit with a much bigger current.

This makes it safer to use the circuit with the high current.

The relay is a coil of wire with an iron block inside it that can move.

When a switch is pressed, a current flows through the coil in the relay.

The coil becomes an electromagnet and attracts the iron block.

When the iron block moves it closes a switch in the circuit that has the high current.

Motor

When a wire carrying a current is in a magnetic field the wire experiences a force.

This force is called the motor effect.

It only happens if the wire is at right angles to the direction of the magnetic field.

An electric motor is a coil of wire that can spin in a magnetic field.

A current flowing through the wire makes the coil spin.

9Je-4

1 Diagram completed showing the magnetic field symmetrically below the electromagnet.

2 **a** Their magnetic fields are similar shapes.

b A bar magnet always has a magnetic field, the electromagnet only has one when a current is flowing.

3 **a** Weaker magnetic field

b Magnetic field changes direction

c Stronger magnetic field

d Stronger magnetic field

4 **a** The magnetic field from the coil of wire/electromagnet attracts the iron block and the metal bar connects the contacts in the high-current circuit.

b A high current can be switched on without a person having to touch any part of the high-current circuit.

9Je-5 Electric bells

1 labels from bottom left: electromagnet, cell, switch

2 line drawn on the circuit from the cell through switch, springy iron strip, coil, and back to the cell

3 **a** It will be magnetised/become magnetic.

b It will attract the springy iron strip.

c The striker attached to the end of the iron strip will hit the gong.

4 There is a gap in the circuit/there is a gap between the contacts.

5 **a** It will stop being magnetic.

b It will spring back to its original position.

6 The current will be able to flow again, so the electromagnet will be magnetised again, the springy iron strip will be attracted to it and the striker will hit the gong. The movement of the springy iron strip will break the circuit, and it will then spring back to its original position. This will keep on happening.

7 The switch is continually making (joining) and breaking the circuit.

9Je-6 Relays and starter motors

1 When the ignition key is turned, electricity flows in the ignition circuit. This magnetises the coil wire, which attracts the iron block. This iron block makes a connection between the two contacts in the starter motor circuit, which completes the circuit and lets a much larger current flow to the starter motor.

2 The driver does not need to touch the circuit that has the high current flowing in it, so it is safer if anything goes wrong.

3 The wires in the starter motor circuit are thick, so they would cost more than the thin wires in the ignition circuit. Having the thick wires shorter saves some money.

4 The lighting circuit uses high voltage, which could be dangerous if anything went wrong. Using a relay means that the person switching on the lights does not have to touch the high-voltage circuit.

5 When the switch is pressed, electricity flows through the coil of wire and it becomes an electromagnet. The electromagnet attracts the top part of the L-shaped piece of metal, which turns around the pivot. The bottom of the L-shaped piece of metal pushes the two contacts together in the circuit which goes to the floodlights, and turns them on.

6 iron, cobalt or nickel – it must be made of a magnetic material.

9Je-7 Circuit breakers

1 A fuse contains a piece of wire that melts if the current gets too high, and so breaks the circuit.

2 for safety, to stop anyone being hurt by faulty electrical equipment

3 **a** It is attracted into the coil/electromagnet.

b The switch opens so no more current can flow.

4 Use more coils of wire, or put an iron core inside the coils.

5 It is easier to reset a circuit breaker than to mend a fuse.

9Je-8 Rail guns

1 **a** Arrows should continue the direction of current shown in the diagram (top left to bottom right along the armature, left to right along rail B).

b circles around rail B similar to those shown for rail A, with arrows going upwards between the rails

c They reinforce each other, as they are both going upwards between the rails.

d upwards

e force arrow added to the armature diagonally down to the left

f When the projectile leaves the rails the armature is no longer connecting the rails.
The circuit is broken and so there is no magnetic field between the rails and no current through the armature to provide the force.

2 **a** A larger current will increase the strength of the magnetic field around the rails. This stronger magnetic field, and the increased current through the armature, will increase the force on the armature.

Longer rails will allow the force to be applied to the armature/projectile for longer – so it has time to build up a greater speed.

b A higher current. There is not enough space inside a ship to have very long rails.

c A space vehicle would have much more mass than a weapon launched from a ship, so would need a much bigger force to accelerate it. A space launcher can use a fixed ground site, on which there would be no space constraints.

3 Strong – to withstand the weight of the space vehicle. (In addition there will be forces trying to push the rails apart due to the magnetic fields around them, but students are not expected to know this.)

Good conductor – so the large currents needed do not need high voltages/so the rails do not heat up too much due to the high currents.

High melting point – both the high current and the friction between the rails and the moving armature will heat the rails, so they must be able to withstand this without melting/becoming weaker.

9K Transition to further study – Physics

9Ka Differences

Student Book

1: 9Ka Physicists

1 **a** observation → question → hypothesis → prediction → investigation or observation (depending on the type of question) → data → hypothesis supported or new hypothesis needed

b Astronomers cannot carry out investigations. Particle physicists carry out practical investigations and are not limited to only making observations.

2 **a** any two scientific questions for which practical investigations can be carried out (such as Does the amount of water vapour in the air depend on its temperature?)

b any two scientific questions that can only be answered by observation (such as How does the number of mammals in a habitat depend on the weather conditions? Does the type of rock depend on the height of the land? Do other stars have planets orbiting around them?)

3 **a** Summer weather is usually warmer and drier/less stormy than winter weather.

b Weather is warmer in the summer because the North Pole is tilted towards the Sun so the Sun's rays are more concentrated (and/or the days are longer so the Sun heats the ground/air for longer). (Students are not expected to attempt an explanation for the differences in rainfall and general weather patterns.)

2: 9Ka Differences

1 **a** a cell or power pack or mains electricity

b how much energy is being transferred by the component for a given current

2 The air in the room is warmer than the drink, so energy is transferred from the air to the drink until both are at the same temperature.

3 As the air cools down, energy is transferred from the water to the air and the water cools down. When the water reaches 0 °C it starts to freeze. Energy is still being transferred from the water to the air, but latent heat is also being released by the water as liquid turns to solid, and this stops the temperature falling. The temperature remains constant until all the water has frozen. Once all the water is solid, no more latent heat is given out and so the temperature of the ice continues to fall.

4 **a** the soil, because soil has a lower specific heat capacity than water, so for the same amount of energy supplied its temperature will rise more (or similar explanation)

b The temperature rise would probably be between that for the dry soil and that for the water, as the wet soil contains both.

5 At night the land cools down faster than the sea because it has a lower specific heat capacity, so the air above the land is cooler than the air above the sea. The air above the sea is less dense than the air above the land, and so it tends to rise and create lower air pressure over the sea. Air above the land is at higher pressure, so it flows out over the sea. The breeze blows from land to sea, and is called a land breeze.

6 Latent heat is energy absorbed or given out when a substance changes state, and results in the temperature of the substance staying constant while it is changing state. Specific heat capacity is a measure of the energy needed to raise 1 kg of the substance by 1°C and does not involve any changes of state.

Activity Pack

9Ka-2 Specific heat capacity 2

4 **a** and **b** Student's calculated values are likely to be higher than the accepted values, as energy will be transferred from the material being heated during the heating process. It will therefore appear that more energy is needed for each degree of temperature rise.

5 Suggestions could include insulating the block, using a more powerful heater (so less time is spent heating the block), or measuring the energy needed for a smaller temperature rise (a shorter heating time will give less time for energy to be transferred, and a lower final temperature will reduce the temperature difference between the block and its surroundings, so reducing the rate at which energy is transferred).

9Ka-3 Warming and cooling 1

1 air, water, ice (or ice, water), warmer
melted, 20 °C, 20 °C
ice cube, water in the beaker, solid, liquid

2 warmer, water, air, goes down
0 °C, freeze, release
go down, the same as

3 liquid, gas (or gas, liquid), faster, more, decreases
less, rises
rising, convection

9Ka-4 Warming and cooling 2

1 **a** Energy will be transferred from the air in the room into the ice and water, as the air is warmer. Energy will continue to be transferred until the ice melts and the resulting water as well as the water in the glass reach the same temperature as the air in the room. So the final temperature of all three substances is likely to be a little below 20 °C (accept 20 °C as the final temperature).

b The ice remains at 0 °C while it is melting. The energy needed to turn the ice to liquid water is called latent heat. Once the ice has melted, the resulting water will need the same amount of energy as the water in the glass to reach the same temperature as its surroundings.

2 The cooking oil will warm up faster, because they are both the same mass and the oil needs less energy per gram to increase its temperature by 1 °C (or its specific heat capacity is less).

3 **a** The water, as its specific heat capacity is greater and both substances have the same mass and same temperature rise.

b The water – as it is storing more energy, it will take longer for that energy to be transferred to the surroundings. (The rate of energy transfer depends on a number of variables, including the temperature difference, but does not depend on the specific heat capacity of the materials concerned.)

4 **a** It will increase (in warmer air, any liquid water around will also become warmer and so there will be more particles with enough energy to become a gas).

b It will decrease (the water vapour will also become warmer, and fewer particles will be moving slowly enough to form water droplets).

c It will get greater (as more water vapour evaporates than condenses again, the balance will be towards more evaporation and more water as vapour in the air).

5 The temperature of the ground drops at night (when the Sun is no longer warming it). The air above the ground will become cooler, as energy is transferred from it to the cooler ground. If there is water vapour in the air, the increase in condensation in the cooler air (and the reduction in evaporation) may cause drops of liquid water to form. These will fall to the ground as dew.

6 Energy is transferred from the warm ground to the air above it.

7 **a** The air near the ground in the valley floor and on the mountain sides will be warmed by the warmer ground and will start to rise. A convection current forms with the air moving up the sides of the valley and back down in the centre of the valley.

b As the air moving up the valley sides cools, water vapour in the air will start to condense faster than any droplets of liquid water evaporate. At the top of the mountains, more water will form drops of liquid, which we see as clouds.

9Ka-5 Specific heat calculations

1 **a** energy = 1 × 4182 × 50 = 209 100 J

b energy = 1 × 840 × 50 = 42 000 J

c energy = 1 × 449 × 50 = 22 450 J

2 Compare the energy stored in each material, compared with room temperature of approx 20 °C. (Accept answers that use 70 °C, as this will provide a fairly valid comparison.)

From Q1, the hot water bottle will store five times as much energy as the brick, so it will provide five times as much energy as it cools down.

3 **a** Number of seconds in an hour = 60 × 60 = 3600 energy supplied in 1 hour = 100 J × 3600 s = 360 000 J temperature change = 360 000/(32 × 830) = 13.6 °C

b temperature change = 360 000/(20 × 4182) = 4.3 °C

c The sand gets a lot warmer than the water. Energy is transferred from warmer to cooler objects, so the air above the sand and water will warm up, but the air above the sand will be warmer than the air above the water. This air will rise, and set up a convection current. The cooler air from above the sea will move in to take the place of the rising air.

d Possible reasons include: clouds reducing energy arriving from the Sun; energy in the warm sand or water being conducted to other parts of the substance; more than the top 2 cm may warm up directly, which would reduce the temperature rise.

4 **a** temperature difference = 30 °C
energy = 1 × 4182 × 30 = 125 460 J

b temperature change = 125 460/(2 × 4182) = 15 °C

c new temperature = 50 + 15 = 65 °C

5 temperature difference = 60 – 8 = 52 °C
energy needed to change temperature of 2 kg of water by 52 °C = 2 × 4182 × 52 = 434 928 J
total mass of mixed water = 7 kg
temperature change when adding this energy to 7 kg of water = 434 928/(7 × 4182) = 14.9 °C
final temperature = 8 + 14.9 = 22.9 °C.

6 bath: energy = 180 kg × 4182 × 52 = 39 143 520 J
shower: energy = 62 × 4182 × 34 = 8 815 656 J
Heating the bath water takes approximately 4.4 times as much energy as heating the water for a shower.

9Ka-6 Boiling the kettle dry

1 **a** melting, evaporating

b condensing, freezing

2 **a** temperature change = 100 – 8 = 92 °C
energy needed = 0.5 × 4182 × 92 = 192 372 J

b energy = 0.5 × 2 260 000 = 1 130 000 J

c It takes approximately six times as much energy to evaporate water at 100 °C than it does to heat tap water to boiling point (actual ratio is 5.87).

d total energy = 1 322 372 J
no. of seconds = 1 322 372/2000 = 661 s (or about 11 minutes)

3 **a** energy to raise temperature of ice from –10 °C to 0 °C = 2 × 2000 × 10 = 40 000 J; plus energy to melt 2 kg of ice at 0 °C = 2 × 334 000 = 668 000 J; plus energy to warm the water from 0 °C to 18 °C = 2 × 4182 × 18 = 150 552 J.

total energy transferred to the ice = 858 552 J

b The energy has been transferred from the air in the room.

c If the room is warmer, there is a greater temperature difference between the air in the room and the ice, so energy will be transferred to the ice at a faster rate.

4 **a** Some of the liquids evaporate, which absorbs energy.

When part of the liquid evaporates, it is the particles with the highest energies that leave the liquid. The average speed of the remaining particles is therefore lower. As the temperature of a substance depends on the speed of the particles, the temperature drops.

b Water has a higher specific latent heat of evaporation than alcohol, so it absorbs more energy when it evaporates, so you could expect that it will feel colder.

c The ethanol molecules are closer to their boiling point, so more of the molecules in the liquid will have enough energy to form a gas. So although water needs more energy to turn into a gas, the alcohol evaporates more quickly, so more energy is absorbed and it feels colder.

9Kb Fields

Student Book

1: 9Kb Fields

1 **a** It was transferred to him as the aeroplane he is jumping from took him upwards (or similar answer).

b It will be transferred to kinetic energy as his speed increases, and also to thermal energy in the air pushed out of the way by his body as he falls. When he lands, most of the energy will be transferred to thermal energy stored in the surroundings.

2 **a** gravitational potential energy = 80 kg × 1500 m × 10 N/kg = 1 200 000 J

b The energy of the skydiver will be greater, because the value for *g* on Earth is higher than *g* on the Moon (or because gravity is stronger on the Earth than on the Moon).

3 **a** A mass anywhere in the field would move towards the centre of the Earth. The field is stronger closer to the Earth.

b how strong the force is

4 Diagram D is for a positive charge, so the arrows point outwards. Diagram F is for a negative charge, so the arrows point inwards as a positive charge will be attracted to the negative charge.

5 **a** sketch of the magnetic field of a bar magnet, similar to that in diagram B in the Student Book, Topic 9Ja Force fields.

b any two differences, such as: the magnetic field has curved lines, many of the lines loop around from one end of the magnet to the other, the magnetic field diagram has two poles whereas the electric field diagram just shows one charge

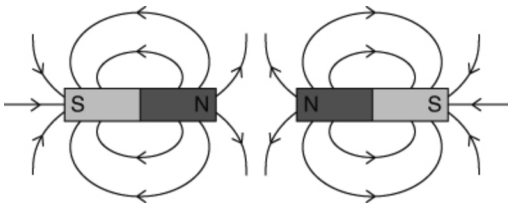
6 The north pole would move to the right and a little upwards at first; then as it reached the middle of the gap it would move upwards.

Activity Pack

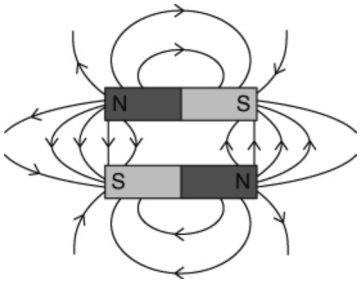
9Kb-1 Magnetic field patterns

1 the direction of the field

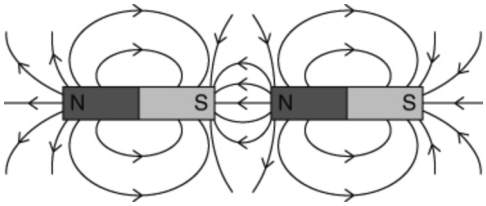
2 **a**



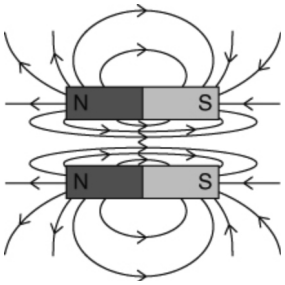
b



c



d

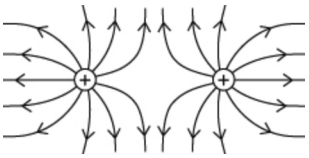


3 **a** It would move diagonally downwards away from the left-hand magnet, and then vertically downwards.

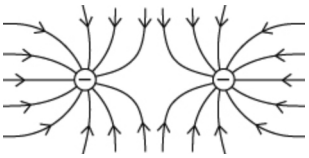
b It would move directly towards the south pole of the bottom magnet.

c It would move diagonally upwards away from the north pole of the bottom magnet, then curve around and go diagonally upwards towards the south pole of the top magnet.

4 a



b



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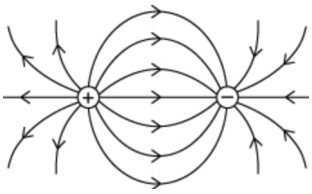


9Kb-2 Falling lead

4 a and **b** The thermal energy stored in the warmed lead will be less than the total gravitational energy stored as the tube was repeatedly upended. As the lead warmed up, some of this energy will have been transferred to the surroundings.

5 If the tube was not vertical each time, some energy will have been transferred to the tube by friction rather than being transferred to thermal energy in the lead.

6 The rate of energy transfer by heating increases if the temperature difference between the two objects increases. Also, as it will take longer for the tube to be turned 100 times, there will be more time for energy transferred to the lead to be transferred to the surroundings.

9Kb-4 Different orbits 1

1 a polar

b geostationary

c Ice: a satellite in a polar orbit passes over both the north and south poles (or similar reasoning).

Weather: a satellite in geostationary orbit stays above the same point on the Earth, so it could take an image of the same place every hour.

2 The satellite stays in the same place in the sky, so the receiver/satellite dish can point to it all the time.

3 a gravity

b B. B is closer to the Earth than A, and the force of gravity is stronger when objects are closer together.

4 a A, because it is higher/further from the Earth

b A, because it will take more fuel/energy to raise it to its height

5 Any from: it is cheaper/easier to launch to a lower orbit; astronauts get there faster; the ISS is not restricted to viewing just one part of the Earth.

9Kb-5 Different orbits 2

1 a height

b height and angle

c angle

2 As they take the same time to orbit the Earth as the Earth takes to spin on its axis they stay over the same point on the Earth.

3 Geostationary – satellite TV receiver dishes are fixed in position, so the satellite needs to stay in the same position relative to the dish.

4 A satellite in a polar low earth orbit will complete 12 or more orbits in the time it takes the Earth to spin once on its axis. Each orbit will therefore move over a different part of the Earth, and eventually all of the Earth will be covered.

5 The tilt of the orbit and its short period allows the ISS to pass over different parts of the Earth on each orbit, as the Earth has turned a little during the time it takes the ISS to complete one orbit. (It will not fly over far northern or southern latitudes as it is not in a polar orbit.)

The low earth orbit means that it is quicker, easier and cheaper to send spacecraft to the ISS (to take supplies or astronauts), as less fuel is needed to get it there.

6 The satellites are closer to the Earth. A camera with the same angle of view would therefore take an image of a much smaller portion of the Earth than it would from geostationary orbit, so more detail will be visible.

7 Geostationary satellites are much further from the Earth than satellites in low earth orbit, so the force of gravity between the satellites and the Earth is less and they do not need to move as fast to stay in orbit. Additionally, geostationary satellites have a lot further to go to complete one orbit, so the two factors (slower speed and greater distance) both increase the time taken per orbit.

8 Students should include some of the following points in their evaluations.

Geostationary satellites: advantages – stay over one point so can provide continuous monitoring of conditions; disadvantages – can only cover one part of the Earth, cannot cover poles/very high latitudes, more expensive to launch, less detailed imagery.

Satellites in low polar orbits: advantages – one satellite can cover all of the Earth over a series of orbits, cheaper to launch, more detailed imagery

because closer; disadvantages – cannot provide continuous monitoring.

9Kb-6 Pumped storage power stations

1 **a** energy = 1000 × 10 × 300 = 3 000 000 J = 3 MJ

b 3 MJ

c Some energy will be transferred by friction in the pipes, turbines and generators and end up as thermal energy in the machinery or surroundings.

2 **a** half an hour = 30 × 60 = 1800 seconds; volume = 20 × 1800 = 36 000 m^3

mass = 36 000 × 1000 = 36 000 000 kg

b energy = 36 000 000 × 10 × 300 = 108 000 000 000 J or 108 000 MJ

3 **a** efficiency = 3500 MJ/5000 MJ × 100% = 70%.

b Sankey diagram showing that the width of the useful energy (electrical energy) should be 70% of the total input energy. Waste energies add up to 30%, mostly shown as heat energy.

9Kb-7 Earth and Moon

1 Student Y is correct. If the same part of the Moon always faces the Earth, the Moon must spin on its axis once per orbit to make this happen.

2 As the same side of the Moon always faces the Earth, to an observer on the Moon the Earth will always appear to be in the same place in the sky and therefore cannot rise and set. (The photo from Apollo 8 showed the Earth 'rising' because it was taken from an orbiting spacecraft.) On Earth, we see moonrise and moonset because the Moon is moving around the Earth at a different rate to the spinning of the Earth, so it does not always appear to be in the same place in the sky.

3 Near the Earth there will be a strong force attracting the spacecraft back towards the Earth. As Apollo 8 gets further from the Earth this force will become weaker, as the strength of gravity gets less when the two masses are further apart. Eventually there will be no resultant force pulling it back to Earth or onwards to the Moon. As it goes further, there will be a force attracting it towards the Moon, which increases in strength as the spacecraft approaches the Moon. The maximum strength of this force is much less than the maximum near the Earth.

4 **a** The fields cancel out when the force is the same size but acting in opposite directions. The strength decreases as you get further from each body, but the Earth has a stronger gravitational field than the Moon, so you have to be further from the Earth than the Moon when the two forces balance.

b The gravitational field of the Sun is much stronger than that of the Earth, so the point at which they cancel each other out will be closer to the Earth than to the Sun.

5 the direction in which a positive charge would move

6 **a** sketch showing the Earth with straight radial lines around it with inward-pointing arrows

b the direction a mass would move

7 **a** the object on the right. The Moon has a smaller/weaker gravitational field than the Earth, and so corresponds to the object with the smallest charge.

b The object on the right would represent the Earth; the one on the left would represent the Sun.

As the difference between the masses of the Earth and Sun is much bigger than the difference between the masses of the Earth and Moon, the point at which the directions change would be closer to the right-hand object.

9Kc Cause and effect

Student Book

1: 9Kc Cause and effect

1 **a** It is not a good description, as our current description of the scientific method includes testing predictions and Aristotle did not do this.

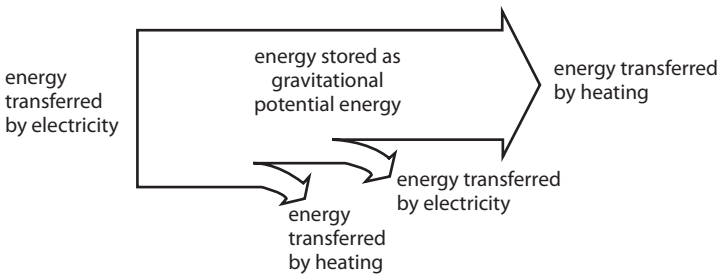
b They used data from experiments to test their ideas.

2 **a** a resultant force in the forward direction

b a resultant force acting sideways

3 no, because there is no way in which the number of pirates can affect the Earth's temperature (or vice versa, probably – accept plausible suggestions of causal link between low mean temperature and piracy)

4 When the weather is warmer sales of ice cream are likely to increase, and so are the numbers of people going swimming. More people going swimming is likely to lead to more drownings.



5 a force from the ball that the footballer feels on their foot

6 **a** The weight of the mass has produced a downward force on the bottom of the spring, which has stretched it.

b If the mass is no longer moving, there must be an upward force on it that exactly balances its weight.

c diagram similar to that in the book, with equal-sized up and down arrows

Activity Pack

9Kc-1 Cause and effect

It's windy. (cause): The wind turbines are moving round. (effect)
(A misconception seen amongst very young children is that the wind turbines make the wind. Arguments for this could include the fact that there is machinery and a connection to the electricity grid for each turbine – show the wind causes the movement in the turbines by disconnecting the electricity supply – the turbines will still turn. Other arguments against this are that it is windy in places where there are no turbines.)

It feels cold outside. (cause): It is snowing. (effect)
(Although cold is not the only necessary condition for having snow. The opposite could also be valid; if it is snowing, melting snow will be absorbing latent heat and contributing to the cold air temperature.)

That man always eats huge meals. (cause): That man is overweight. (effect)
(In some cases the opposite could be valid – in that people with larger body mass need to eat more to keep their body working, particularly if they also get a lot of exercise. However the description 'overweight' generally implies an excess of fat rather than a lot of muscle.)

The pot has been in a hot oven. (cause): The food in the cooking pot is hot. (effect)

Sam is tired. (cause): Sam didn't run very fast in the race. (effect)
(These could be either way round.)

9Kc-2 Correlations

2 **a** and **b** Examples could include:

Ice cream and sunburn: getting sunburnt makes people buy ice cream (possibly true); eating ice cream gives you sunburn (extremely unlikely).

Carbon dioxide and obesity: extra carbon dioxide in the air makes people overweight (extremely unlikely); the carbon dioxide breathed out by obese people is causing atmospheric carbon dioxide to increase (extremely unlikely).

Flu and weather: cold weather gives people the flu (extremely unlikely); people with flu make the weather cold (extremely unlikely).

Trees and life expectancy: trees make people die younger (extremely unlikely); older people kill trees (extremely unlikely).

3 *The weather is hot in the summer*, which both makes people buy more ice cream and means people are more likely to get sunburnt.

More obese people *means they are consuming more food, and modern agriculture releases carbon dioxide from fuels used to run machinery, make fertiliser, distribute food etc.* so they could be contributing to the increase in carbon dioxide.

The weather is cold in the winter *so people are indoors more where viruses can spread* so people get flu more often in the winter.

People live longer *and there are more of them, needing more room to live and grow food* so trees are cut down to make space for homes or farms.

9Kc-3 Weather fronts 1

1 **a** High clouds will get steadily lower as the warm front approaches.

b It will start to rain (then the clouds and rain will stop as the warm front passes).

c The temperature will rise/it will get warmer.

d There will be some clear air, but then there will be high clouds and rain. It will get colder as the cold front passes, and eventually the rain will stop and the clouds will go away again.

2 **a** The particles in warm air move faster than the particles in cold air and take up more space, so warm air is less dense than cold air.

b Warm air will float above cold air, so it will be pushed upwards when the cold air is pushed in.

c It cools down.

d It can hold less water vapour.

e Water vapour in the rising warm air condenses to form droplets of liquid water. These droplets are suspended together in the air as clouds. Within the clouds, the droplets can join up until they are big enough to fall as rain.

3 Answers should contain all the key points given in the answer to Question **2** (on the cards). Students should not just copy their answers to Question **2**, but should combine sentences, avoiding repetition, to produce a concise, cohesive answer.

9Kc-4 Weather fronts 2

1 X – cold air; Y – warm air; Z – cool air

2 **a** Cold air is denser than warm air, so the warm air will float above the cold air.

b It cools down.

c Colder air can hold less water vapour.

d The cold air pushes the less dense warmer air upwards, and the warm air cools down. The colder the air gets, the less water vapour it can hold, and

eventually some of the water vapour condenses to form droplets of liquid water. Clouds are formed from small droplets, but these may join up to form larger droplets that fall as rain.

3 As warm air moves towards cooler air it rises above it because the warm air is less dense. The warm air cools as it ascends, and eventually may cool enough for some of the water vapour it is carrying to condense into droplets of liquid water.

4 Rain from a warm front will last longer. The warm front has a shallower slope/broader band of rain. (Note that cold fronts often move faster than warm fronts and catch them up, forming an occluded front, but this does not change the answer. Students are not expected to know this.)

5 As the warm front approaches high clouds will form. The clouds will gradually get lower and rain will fall. Eventually the rain will stop and the clouds clear, and the air temperature will get warmer. Shortly afterwards more clouds and rain will form, and the temperature will drop again.

6 Typical weather conditions in high pressure areas are settled weather and light winds. In the summer this often leads to haze. In the winter clear skies at night can cause very cold nights with frost.

Air descends in a high pressure area (which is what causes the high pressure), and warms as it descends. Warmer air can hold more water vapour than cold air, so droplets of liquid water (clouds/rain) are less likely to form.

9Kc-5 Causes and correlations

1 **a** The spring gets longer because the weight/force caused by the mass stretches it.

b Your hands get warmer, because of friction between your hands.

c The car slows down/stops, because pressing the brake pedal applied friction to the brakes.

d The bike starts to move downhill, because gravity is pulling it down.

2 **a** Various answers are possible, such as the Sun setting, a cold wind blowing, someone switching on air conditioning, a cold front moves in.

b Various answers are possible, such as the voltage has increased, someone has removed a component from the circuit.

3 **a** X and Y change with time in a similar way.

b X increases as Y decreases (or vice versa).

c X increases as Y increases.

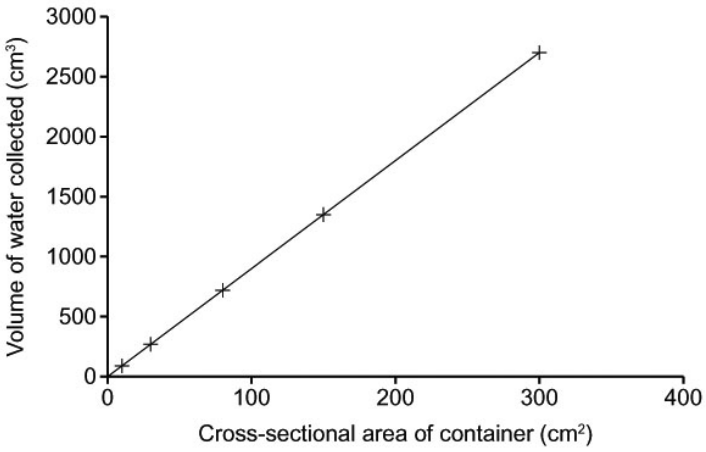
9Kc-6 Wind and weather

1 **a** Correlation: warmer in the day and colder at night (or any similar description). Cause: energy from the Sun heats the Earth during the day, and the warm ground heats the air above it.

b Correlation: warmer weather in the summer and colder in winter (or any similar description). Cause: the Sun's rays are more concentrated in the summer than in the winter, and so provide more energy to warm the ground and/or the Sun shines for longer during the summer, so more energy is transferred.

2 The specific heat capacity of water is greater than the specific heat capacity of land (soil/sand/rock etc.), so when energy from the Sun falls on the ocean and the land, the land heats up more than the water. At night/in the winter, for the same amount of energy radiated, the temperature of the ground drops more than the temperature of the water, for the same reason. (This is a simplified answer for at least two reasons. If the ground is warmer than the water, it will radiate more energy, but students are not expected to provide this detail – and the difference in specific heat capacity is large enough to ensure that the ground still cools down more than the water. But also, energy is transferred through the oceans by convection currents, and this also helps to maintain a stable temperature.)

3 **a** The wind blows across water in the warm Gulf Stream, so the air becomes warmer than it would otherwise be.



b The wind is blowing over long distances of ocean, so evaporation can occur. The relatively warm water and air encourages evaporation. The moisture in the air can fall as rain.

4 **a** Cold, as the wind has blown from a colder part of the Earth.

b The wind has passed over less water than the south-westerly winds, so there is less chance for evaporation to occur. Also the colder water and colder air will reduce the amount of evaporation.

5 Cold/cooler and dry. The wind has blown over the continent, which will be colder than the oceans in the winter. It is likely to be dry because it has not blown over a large body of water from which water can evaporate.

6 **a** southerly/from the south

b mainly dry, as the wind has not blown over much water

7 The air temperature in New York will be affected by the temperature of the land to the south-west of it. The air temperature in the UK is affected by the temperature of the Atlantic Ocean. The land has a greater temperature range than the sea.

9Kc-7 Moving continents?

1 shapes of the continents, locations of similar fossils and locations of similar rock types

2 Wegener's idea had the continents moving *through* the ocean floors; the modern idea has the continents and the ocean floors all parts of the same plate and all moving together. In plate tectonic theory, movement is possible because oceanic crust is being created in some places and destroyed in others. (Wegener did suggest the idea of sea floor spreading at mid-ocean ridges in the first version of his book, but did not follow this up.)

3 **a** He had no mechanism/cause to explain his correlations, and there were other suggestions that explained some of his observations.

b There is a suggested mechanism/cause that is backed up by a lot more evidence.

4 **a** It is denser than the continental crust, so the continental crust floats on top of it.

b The plates can move because new oceanic crust is being formed under the oceans, so there must also be places where it is being destroyed (otherwise the Earth would be getting larger).

c The shapes of the coastlines change rapidly (in geological terms!) as wave erosion removes cliffs, or as deposited sediments extend deltas etc.

9Kd Links between variables

Student Book

1: 9Kd Links between variables

1 **a** Air pressure decreases with height. At first the decrease is large for each increase in height, but at higher altitudes the change is less.

b As the height increases the temperature drops to nearly –60 °C, then rises almost back to zero and then drops again.

2 The line on the graph does not go through the origin.

3 Sketch a graph with mass on the horizontal axis, weight on the vertical axis and a straight line with positive gradient going through (0,0).

4 **a** Both graphs have a similar shape, but the current curve has a smoother shape.

b A directly proportional relationship produces a straight line on a graph that passes through (0,0). An inversely proportional relationship produces a curve with a particular shape. It is easier to see if a line is straight than to see whether a curve is exactly the right shape.

5 **a** graph with correctly plotted points and line drawn (this should be a straight line if the points have been plotted correctly)

b directly proportional, as the points lie on a straight line and the line would pass through the origin if extended (or explanation that if there is zero area then no rain can be collected, so (0,0) would also be a valid point)

2: 9Kd Information from graphs

1 **a** linear

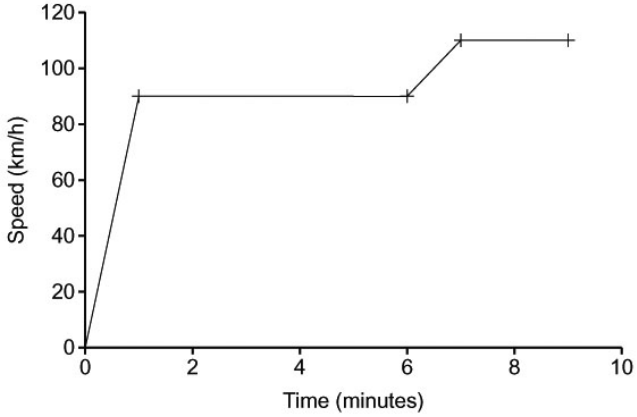
b x is the force on the spring, y is the length of the spring, m is the gradient of the line (which tells you how stiff the spring is), and c is the unstretched length of the spring

2 The car covers 50 km in 1 hour, so it is travelling at 50 km/h.

3 **a** 50 km/h

b just after the 2 hour point

c



4 distance = 20 m/s × 5 s = 100 m

5 area of rectangle = 15 m/s × 5 s = 75 m

area of triangle = ½ × 5 s × 5 m/s = 12.5 m

total distance travelled = 87.5 m

Activity Pack

9Kd-1 Gas pressure and temperature

3 The graph should show a linear relationship (it is only directly proportional if temperatures are plotted using the Kelvin scale).

9Kd-2 Gas pressure and volume

4 distance = 20 m/s × 5 s = 100 m

5 area of rectangle = 15 m/s × 5 s = 75 m

area of triangle = ½ × 5 s × 5 m/s = 12.5 m

total distance travelled = 87.5 m

Activity Pack

9Kd-1 Gas pressure and temperature

3 The graph should show a linear relationship (it is only directly proportional if temperatures are plotted using the Kelvin scale).

9Kd-2 Gas pressure and volume

6 **a** The graph should show an inversely proportional relationship (although students will not be able to check that the shape *does* represent this unless they plot pressure against 1/volume, which should produce a graph showing direct proportion).

9Kd-4 Links between variables

1 First graph: linear relationship (a straight line that does not go through 0,0) and 'If one variable changes in equal steps…'.

Second graph: directly proportional relationship (a straight line that goes through the 0,0) and 'One variable doubles when the other doubles'.

Third graph: inversely proportional relationship (a curved line) and 'One variable halves when the other one doubles'.

2 Straight line drawn on graph, passing through the origin.

3 **a** straight line drawn between (0,10) and (10,40)

b linear relationship

4 **a** zero

b It would go through 0,0, but would have the same slope/gradient and would show a directly proportional relationship.

9Kd-5 Journeys

1 **a** correctly plotted graph

b linear – the points lie on a straight line that does not go through the origin

c *m* should be £2 per mile, *c* should be £3 per journey

d This is the cost when zero miles are travelled.

e cost = (£2 × 7) + £3 = £17

2 Correctly plotted graph with the intercept on the *y*-axis at 40 minutes – this is the time taken to load and unload the van.

3 **a** correctly plotted graph

b taking the end points of the line, gradient = (14 – 4)/(25 – 10) = 10/15 = 0.667 miles per minute

c 40 mph

4 **a** The area can be split into a triangle and a rectangle.

area of triangle = ½ × 50 s × 7 m/s = 175 m

area of rectangle = 50 s × 3 m/s = 150 m

total distance = 175 + 150 = 325 m

b Speed is 10 m/s at 350 seconds, and 3 m/s at 300 seconds.

gradient = (10 m/s – 3 m/s)/(350 s – 300 s) = 7 m/s/50 s = 0.14 m/s^2

9Kd-6 Springs and energy

1 When you exert a force on a spring, the spring pulls back with the same force. So the force exerted by a spring is the same force needed to stretch it to a given length.

2 **a** extension with 10 N force = 0.4 m – 0.1 m = 0.3 m

$k = F/e$ = 10 N/0.3 m = 33.3

b N/m (or newtons per metre)

3 **a** its weight, which depends on its mass and the gravitational field strength

b Work is a way of describing the quantity of energy transferred, and is calculated from the force × the distance moved.

GPE is an amount of energy stored. Weight is calculated from mass and *g*, and this is the equivalent of the force in the work formula. Height is the equivalent of the distance moved in the work formula.

4 The force needed to stretch a spring increases as the extension increases, and depends only on the extension of the spring and the spring constant. The force needed to lift an object depends only on its weight, which does not change (unless you are talking about something like a rocket, where it uses up fuel as it ascends or reaches heights at which the change in the Earth's gravity with altitude becomes significant).

5 As the force is proportional to the extension of a spring, the graph is a straight line through the origin, and so the area under it will always be a triangle. The speed of a moving object can be changed in a number of ways, and so the area under a speed–time graph can have a variety of different shapes.

6 Students may include a sketch graph of extension against force.

area of triangle under graph will be ½ × 10 N × 0.3 m = 1.5 J

7 energy = 0.5 × 33.3 × 0.3 × 0.3 = 1.5 J

8 The force is worked out by spring constant × extension, so if you substitute this into the formula for the area of the triangle under the graph, you get energy = 0.5 × (spring constant × extension) × extension, which is 0.5 × spring constant × (extension)^2

9Ke Models

Student Book

1: 9Ke Models

1 diagram with Earth between Sun and Moon and the Moon totally in the shadow of the Earth.

2 any analogy – most likely to be something like the central heating analogy used to explain electrical circuits

3 possible answers include: 9Ka Differences – graph B (abstract); 9Kb Fields – formula for GPE (abstract), field diagrams (abstract); 9Kc Cause and effect – force arrows on diagrams (abstract); 9Kd Links between variables and Information from graphs – graphs (abstract), formulae (abstract); 9Ke Models – wind tunnel (physical), ball used to model an atom (physical)

4 **a** Particles get closer together and then further apart again – the region where the particles are closer together moves in the direction the sound is travelling.

b Sound waves are longitudinal, waves on the surface of water are transverse. Sound waves travel from a source in three dimensions, the waves on the water surface travel only in two dimensions.

5 Sound waves are longitudinal, light waves are transverse. Sound waves are movements in matter, light waves are not.

6 A wave is a model used to help us to understand some of the properties of light, but it cannot explain all the properties of light.

2: 9Ke Computer game design

1 Any two from: scenery, objects in the game, rules for how the world behaves, aims for the game, or any other sensible suggestions.

2 The background/scenery and characters are computer models, and need to be programmed into the computer.

3 Any sensible suggestions such as: how to create realistic sounds, what kind of music to have, that the action and sounds are synchronised.

4 To understand forces, how fast cars accelerate or brake, how they steer round corners, and so on, so they can build a computer model that will make the car in the game behave realistically.

5 The computer needs to change the image the gamer sees depending on where the gamer is looking.

6 Any two ways, such as allowing the gamer to feel a virtual button that they press, to feel how hard they are pushing something, to detect a blow, etc.

7 It is expensive to develop a game, so they need to check that the idea is popular before they spend money developing it.

Activity

One possible set of responses is:

Concept

Show gamers scene drawings. Ask gamers to rate their agreement with statements such as: this makes me want to play the game, this looks as if exciting things could happen here.

Show gamers main characters. For each one, ask gamers to rate their agreement with: this is a good character, I would like to chat to this person, I would run away if I met this person at night when I was alone.

Show gamers storyline. Ask gamers to rate their agreement with statements such as: this is an interesting story, I would like to play this game.

Partly developed

Allow gamers to play with the characters that have been developed.

Ask them to rate statements such as: it was easy to control the characters; this character did not have enough power.

Ask similar questions to the Concept stage about the characters and the story.

Final test

Allow gamers to play the game for a week.

Ask: what was their favourite part of the game, what didn't they like, did anything make them want to give up, how much would they pay to buy this game.

3: 9Ke Physics research

1 **a** applied research, because more powerful lasers could be useful

b Research into how the Universe began is not likely to have any practical applications.

2 **a** They need to gather data to check/test their models.

b When water condenses it releases latent heat.

c When one variable doubles the other doubles. A graph of a proportional relationship is a straight line through the origin.

Activity Pack

9Ke-1 Solar System weather

Some of the facts students might find are listed below. This is not exhaustive, and students may make comparisons between data in different ways.

Mars

- Two significant surface features are Olympus Mons, the largest volcano in the Solar System, and Valles Marineris, a huge canyon system (which, by analogy with canyons on Earth, indicates the presence of liquid water in the past). Photos obtained by various orbiters.
- Mars is colder than the Earth, as it is further from the Sun, but with similar types of seasonal changes; atmosphere 96% carbon dioxide; no surface liquid water at present; ice caps at both poles made mostly of water ice (which is similar to Earth), but Mars' south polar cap has a surface layer of frozen carbon dioxide. Weathering will be mainly physical, as there is no liquid water to facilitate chemical weathering. Physical weathering will be mostly due to temperature fluctuations, as there is no liquid water to allow freeze–thaw weathering.
- Erosion and transport will be by gravity and the wind.

Venus

- The only pictures are a couple of the surface taken from a lander. Photos from orbit are not possible because of the thick cloud cover. Imagery of the surface is from radar scans.
- The main surface features are volcanoes and smooth volcanic plains. There are no large canyons like the one on Mars.
- Venus is much hotter than Earth, partly because it is closer to the Sun but mostly because of a runaway greenhouse effect; virtually no changes with the seasons (very small axial tilt); thicker (higher pressure) atmosphere, consisting mainly of carbon dioxide; rain does not fall on the surface, but sulfuric acid rain exists in the upper atmosphere. There is very little weathering because the temperature is almost constant and there is no liquid on the surface. With no weathering there is little to erode. Any erosion will happen by wind or gravity.
- More craters are visible than on Earth, because they have not been weathered/eroded as much and are not covered by vegetation or oceans.

Titan

- Photos/radar images of surface features obtained from the Huygens probe and the Cassini orbiter (but not at visible wavelengths) – most imagery of surface features is from radar.
- Titan is much colder than Earth as it is so far from the Sun, but it does have seasonal changes; methane in the atmosphere causes a greenhouse effect, although this is counteracted somewhat by the haze reflecting sunlight.
- The atmosphere is almost all nitrogen. Lakes are thought to be mostly ethane and methane, with some other hydrocarbons. Rainfall is liquid methane.
- The mean temperature on Titan is similar to the freezing point of methane, so it is possible that freeze–thaw weathering may happen. Erosion and transport could happen by wind, gravity and liquids flowing.

9Ke-2 Models for electricity

1 A – physical; B – abstract; C – abstract

2 **a** Model B – because it is a formula that allows you to calculate quantities.

b Model A – because it is a comparison/analogy that makes it easier to think about electricity (or any sensible reason).

3 **a** A cell; it provides energy and pushes the water around the pipes.

b A bulb/resistor/component; it is where energy can be transferred to the surroundings.

c moving charges/the electrical current – because it transfers energy from the boiler/cell to the radiators/components

4 It compares parts of a circuit to something else.

5 Answers may vary, but could include the following points: a model cannot usually represent all aspects of the thing being modelled; some models are better for some purposes than for others; each model has different strengths and weaknesses.

9Ke-3 Models for waves

1 **a** longitudinal

b transverse – this could be modelled by moving one end of the slinky from side to side

c longitudinal – sound waves
transverse – waves on water, light

2 **a** similarities – both are transverse waves; both can be reflected, refracted, etc.
differences – the ripple tank waves here are on the surface of a medium; light waves do not require a medium to travel through; light waves travel much faster than waves on water

b similarities – both waves need a medium to travel through; both can be reflected, refracted, etc.
differences – the waves on water are transverse, sound waves are longitudinal; the ripple tank waves travel on the surface of a liquid, sound waves can travel through solids, liquids and gases; sound waves travel faster than waves on water

3 **a** ray diagram showing reflection, with equal angles of incidence and reflection

b drawing showing wave fronts approaching a barrier and being reflected

c students' own answers, but should be backed up with a sensible reason

4 Answers may vary. Some possible answers are:

a explaining/demonstrating the differences between transverse and longitudinal waves; showing that the medium only vibrates about a fixed position as the waves pass

b showing how waves spread out from a point/source; showing what happens to waves when they reach a barrier/are reflected; students may also mention refraction and/or superposition if these have been demonstrated

c ray diagrams – easier to draw than drawings of wave fronts; easier to think about which way the wave/energy is moving

9Ke-4 Testing, testing

1 **a** physical model

b any other physical model, such as a Solar System model, or molecular models to show the structure of molecules

2 If an aeroplane engine stops working, the aeroplane could crash. If a car engine stops working, the car can usually stop safely on the road.

3 **a** abstract

b any other abstract model, such as a computer model of a hurricane, ray diagrams, graphs or equations

c Any three from: shape of the aeroplane, the speed it will fly, the air pressure/density where it will fly, equations that describe how the air flows around shapes, etc. Accept any sensible suggestions.

4 **a** They can test more conditions (speeds, altitudes, etc.), they don't need a huge building, or any other sensible suggestions.

b Wind tunnel models can be used to check that computer models work correctly (or can be used to help to develop the computer models).

5 Ice reduces friction, so icy roads may lead to crashes if cars cannot maintain a grip on the road or brake as quickly as normal.

6 Cold temperatures and moisture on the road (or in the air).

7 **a** Any three sensible suggestions, such as temperatures, wind speeds, wind directions, air pressure, cloud cover, types of cloud

b Direct observations/taking measurements; using satellites to gather data.

8 Weather models will help the designers to work out what conditions of (for example) air pressure, air density, temperature, icing the aeroplane might encounter, so it can be designed accordingly.

9Ke-5 Adiabatic temperature changes

1 Force is applied to the piston to make it move out, so work is being done on the piston; this means energy is being transferred from the gas to the piston; if the particles in the gas now have less energy, the temperature of the gas will be lower.

2 The expected answer is work done. We do not need to know what is happening to the particles, but if we can measure the force on the piston and how far it moves, we can calculate the energy change, using specific heat capacity and the mass of gas.

3 **a** The temperature of the gas will rise slowly if pumping is done slowly. This will allow time for energy to be transferred to the surroundings, so the final temperature rise appears to be less.

b If the change happens slowly there is time for energy to be transferred between the gas and the surroundings.

9Ke-6 Rising air and lapse rates

1 **a** It will be less dense than the surrounding air.

b temperature change = 10 °C/km × 0.5 km = 5 °C

c temperature = 18 °C – 5 °C = 13 °C

d temperature change = 9.8 °C/km × 0.5 km = 4.9 °C

temperature = 19 °C – 4.9 °C = 14.1 °C

e It is still warmer than the surrounding air, so it will continue to rise.

f unstable, because the rising air continues to rise

2 **a** for the atmosphere: temperature at 1 km = 18 °C – 9 °C = 9 °C

for the warmer parcel of air: temperature at 1 km = 19 °C – 9.8 °C = 9.2 °C

The rising air is still warmer than the surrounding air so it will continue to rise.

b for the atmosphere: temperature at 1.3 km = 18 °C – (1.3 × 9 °C) = 18 °C – 11.7 °C = 6.3 °C

for the warmer parcel of air: temperature at 1.3 km = 19 °C – (1.3 × 9.8 °C) = 19 °C – 12.74 °C = 6.26 °C

The warmer parcel would be cooler than the surrounding air by the time it reached this height, so it would no longer rise.

3 **a** As the air in the thermal rises it cools. Its relative humidity will rise, and it may cool enough so that moisture in the air starts to condense.

b If the rising air has the same relative humidity, it will cool at the same rate as it rises and condensation to form clouds will start to form at the same height.

4 If saturated air cools any further water vapour will start to condense. This will release latent heat, and this will warm the air. So some of the cooling due to rising/expansion will be cancelled by the latent heat released, so the air will not cool as fast as it rises.