

# Answers

## 8A Food and nutrition

### 8Aa Nutrients

#### Student Book

##### 1: 8Aa Food and advertising

###### 1 *Students' own answers:*

e.g. for energy, growth and repair, and health

because food contains nutrients, such as proteins and carbohydrates, which are used for different activities in the body

match some names of nutrients with their uses in the body

2 **a** This (vitamin C) food will make a child's hair wavy.

**b** There is no scientific evidence that a food will make a child's hair go wavy.

3 **a** They contain vitamins/vitamin B1.

**b** They contain a lot of sugar/fat, which can be bad for you/make you fat.

4 **a** the digestive system

**b** any two from: mouth, food pipe/oesophagus/gullet, stomach, small intestine/intestines, large intestine/intestines, rectum, anus, liver, salivary glands (there are others, e.g. pancreas, gall bladder)

**c** description of the function for the organ parts in part b, see the diagram on the 8Ad Digestion spread of the Student Book

###### 5 *Students' own answers:*

eat a lot of fruit and vegetables

answer includes a reason, e.g. 'because they contain lots of vitamins and minerals'

##### 2: 8Aa Nutrients

1 what you eat

2 **a** raw material for your body

**b** energy, growth and repair, health

3 Fibre helps undigested food pass through the intestines by stopping the intestines getting blocked. Water helps to lubricate the food.

4 *Students' own answers*, making use of the different ways of using persuasive language from 8Aa Food and advertising

5 because you lose water when you sweat and water is very important in your body for dissolving things, acting as a lubricant and filling up cells

6 protein, carbohydrates (sugars), fat, sodium

7 because some people are allergic to nuts

8 6.8 g sugars, 26.4 g starch

9 starch

10 **a** iodine solution for starch testing (blue-black colour if starch present), rubbing sample on paper (greasy mark left if fat present), Biuret solution for protein testing (purple colour if protein present)

**b** The powder also contains vitamins, minerals, salt and some water.

#### Activity Pack

##### 8Aa-1 Nutrients

1 what you eat

2 one of: keeping warm, moving, thinking, growing, or any other sensible suggestion

3 **a** vitamins, minerals

**b** wheat flour, modified starch, sugar

**c** milk fat, vegetable oil (cheddar cheese or cream are other options)

**d** 6 g

**e** 24 g

**f** 100 g

**g** fibre (not energy, because energy is not a substance)

**h** to help food move through the intestines

4 starch

##### 8Aa-8 Nutrition labels

1 Julie has a lot of starch in her diet.

2 giving you energy, growing and repairing, keeping you healthy

3 **a** ingredients, nutrition, allergy advice

**b** one of: keeping warm, moving, thinking, growing, or any other sensible suggestion

**c** protein, carbohydrate, fat (completed on the label)

**d** downwards from energy: 1600 kJ, 3 g, 20 g, 7 g, 3 g

**e** fibre (energy is not a substance)

**f** vitamins or minerals

4 **a** To persuade you to buy the product.

**b** WowPow bars contain energy!

**c** They're also delicious!

##### 8Aa-9 Super fibre bars

1 growth and repair, energy, health

2 nuts

3 **a** protein, carbohydrates, (sugar), fats, vitamin B1

**b** 12 g

**c**  $25 - (2 + 15 + 6) = 2$  g

**4** The protein per 100 g should be 8 g and not 6 g and the vitamin B per 100 g should be 5.6 mg and not 0.34 mg.

**5 a** fat, protein, sugar

**b** Drop iodine solution onto the bar and look for blue/black colour; rub the bar onto a piece of paper and hold it up to the light to look for a greasy mark.

**6** to keep your intestines healthy/stop constipation/help move food through the intestines

**7 a** It implies the bar contains lots of fibre when in fact it contains hardly any.

**b** *Students' own responses.*

### 8Aa-10 Sorghum syrup

**1 a** carbohydrate

**b** fats (oils), proteins, vitamins and minerals

**2** the lowest of the lines/the non-reducing sugar line

**3 a** 1.8%      **b** 18%

**4** From 70 days after planting until 100 days, the amount of both types of sugar within the plant increases, but the reducing sugars increase more quickly than the non-reducing sugars. The total sugar content reaches a peak after 130 days, after which the levels of both sugars decrease at the same rate. A higher-level answer will indicate the rises and falls of the graphs and will include details of the rates of increase/decrease.

**5 a** Yellow, because it contains 1–1.5% reducing sugars.

**b** Orange, because now the solution contains both the original reducing sugars and also the reducing sugars convert into non-reducing sugars by boiling in acid. So, the total sugar content is between 1.5% and 2%.

**6** anywhere between 82 and 92 days

**7 a** After 130 days because this is when the sorghum contains the most sucrose.

**b** *Students' own responses.*

### 8Ab Uses of nutrients

#### Student Book

#### 1: 8Ab Uses of nutrients

**1** carbohydrates (e.g. starch, sugars), fats/lipids (e.g. solid fats, oils), proteins, vitamins, minerals

**2** He has eaten more food than he needs (the energy content of his food is greater than the energy requirement for his daily activities).

**3** for energy

**4** as energy, as an energy store and to help stop heat escaping from your body (a heat insulator)

**5 a** 1570 kJ

**b** 11–14 year old boys need 10 700 kJ, girls need 9500 kJ. So boys need  $10\,000/1570 = 6.37$  lots of 100 g quantities of the food = 640 g (to two significant figures). By the same reasoning girls need 610 g. Another way of doing this calculation is to work out the energy per gram at the start and divide the amount of energy needed by this figure.

**c** 2 hours of slow walking uses 940 kJ so  $940/1570 = 0.6$  lots of 100 g = 60 g

OR 1570 kJ is provided by 100 g therefore 940 kJ is provided by  $100/1570 \times 940 = 60$  g (to two significant figures)

60 g provides enough energy for 2 hours' slow walking

**6 a** 15–17 years old

**b** This is a time of very fast growth and changes in the body.

**7 a** Ravi

**b** He has to move around more, which requires more energy than sitting at a desk.

**8** The carbohydrates she does not need for energy will be turned into fat in the body and stored: this will increase her mass.

**9** for energy, for growth and repair, for health

**10 a** carbohydrate, e.g. potatoes, bread (starches), sweets, cakes (sugars); proteins, e.g. fish, meat, eggs, nuts; fats/lipids, e.g. milk, butter, cooking oils; vitamins, e.g. fruits, vegetables (or specific examples, e.g. vitamin A from eggs, vitamin B12 from red meat); minerals, e.g. fruits, vegetables (or specific examples, e.g. calcium from milk, iron from spinach)

**b**

Nutrient	Why nutrient is needed
carbohydrates	energy
fats	energy storage (and insulation)
proteins	growth and repair
vitamins and minerals	health

Some students may say that all nutrients are needed for health.

**11** not having very much energy or being short of breath (students should link their answers with knowledge that iron is used in red blood cells, which are responsible for carrying oxygen around the body)

#### Activity Pack

#### 8Ab-1 Uses of nutrients

**1** carbohydrate – as a fuel – potatoes

protein – for growth and repair – meat

fat – for storing energy – butter (or milk)

vitamin C – to help hold tissues together – fruits

calcium – for strong bones – milk (or butter)

**2 a**  $(7 \times 180) + (8 \times 350) + (2 \times 250) + (2 \times 400) + (3 \times 470) + (2 \times 250) = 1260 + 2800 + 500 + 800 + 1410 + 500 = 7270 \text{ kJ}$

**b** more energy

**c** Males need more energy than females.

**d** less energy

**e** Older people need less energy than people in their twenties.

**f** She would become overweight.

**g** Any extra carbohydrate that she does not use up would turn into fat and be stored.

### 8Ab-3 Matching energy and foods

Cards are linked thus:

Walking slowly for an hour (470 kJ) = 25 g of cornflakes (375 kJ) + 38 g of milk (95 kJ)

Cycling slowly for an hour (660 kJ) = 80 g of baked potato (280 kJ) + 12 g of butter (380 kJ)

Jogging for 45 minutes (990 kJ) = 70 g of sliced white bread (665 kJ) + 11 g of butter (325 kJ)

Ballet dancing for 2 hours (2560 kJ) = 120 g of sponge cake (2280 kJ) + 56 g of custard (280 kJ)

Cycling up a hill for 10 minutes (440 kJ) = 100 g of banana (350 kJ) + 45 g of apple (90 kJ)

Playing tennis for 90 minutes (2060 kJ) = 100 g of sausage roll (1950 kJ) + 100 g orange juice (110 kJ)

Playing volleyball for 45 minutes (570 kJ) = 22 g of chocolate (484 kJ) + 172 g of tea with milk (86 kJ)

Rollerblading for an hour (1850 kJ) = 150 g of chicken curry (1500 kJ) + 70 g of rice (350 kJ)

Skiing for 2 hours (1640 kJ) = 60 g of samosa (1440 kJ) + 17 g of papadum (200 kJ)

### 8Ab-4 Take away

**1** energy, growth and repair, health

**2 a** carbohydrate; as a fuel for energy

**b** protein; for growth and repair

**c** vitamins/minerals; for health

**3 a** fat

**b** to store energy/for insulation

**4 a** sugar

**b** turns to fat, or causes tooth decay

**5 a** no

**b** The food does not contain all the vitamins you need (for example, there is no vitamin D in the foods).

**6 a** Three whole burger meals. This would give him an excess of 2200 kJ per day.

**b** No. If they eat two, they will get just slightly more energy than they need for the day, but this would not be a balanced diet as it lacks other nutrients such as vitamins.

### 8Ab-7 Foods and energy

**1 a** The amount of energy needed per day increases up to the age of about 15–18 and then starts to slowly decrease again.

**b** men

**c** If the female is very active and the male is not very active.

**d** People continue eating as much as they used to but need less energy as they get older.

**2 a** beef steak – protein; avocado – fat; rice – carbohydrate.

**b** protein – any meat, fish, eggs, nuts; fat – milk, cakes, mayonnaise, oils; carbohydrates – bread, potatoes, sweets

**c** starch

**3** rice

**4** football

**5 a** 2200 kJ (must state the units)

**b** It depends how fast you swim. Swimming faster uses more energy than swimming slowly.

**6 a** They may become overweight because they are eating foods with more energy than they need. The extra food is stored as fat by the body.

**b** Beef. It doesn't contain much fat or carbohydrate, which can be stored or converted by the body into fat stores.

**7 a** avocado (24 mg, compared with 2.5 mg for rice and 20 mg for beef)

**b** beef (67 mg compared with 1 mg for avocado and 4 mg for rice)

**8 a** It dissolves in lipids (fats).

**b** Avocado, because it contains the most fat (lipid).

**9** *Students' own responses.* Possibly using adjectives to add weight, using powerful verbs and not using all of the evidence in the table (for example not mentioning that rice contains much less fibre than avocados).

### 8Ab-8 The work of food scientists

**1 a** The sugar dissolves into the water.

**b** Filter the mixture, evaporate the solution and measure the mass of the solid sugar formed.

**2 a** 63 g

**b** The food also contains water.

**3 a** 1386 kJ/100 g

**b**  $100 \text{ g} \times 4.4 \text{ }^\circ\text{C} \times 4.2 = 18480 \text{ J}$

**c** higher

**d** The fibre will also burn and release energy but humans cannot digest this.

**4** It allows people to keep watch on how much energy their food contains and not eat foods containing more energy than they will use (which will make them overweight).

**5 a** age, gender and activity levels  
**b** Up to the age 15–18 you need increasing amounts of energy, but after this age the amount required goes down slowly. Males need more energy than females. People who are more active need more energy.

**6 a** It dissolves in lipids.  
**b** In the fat because fat is a lipid.  
**c** Vitamin A is needed for healthy skin and eyes.  
**d** Calcium, which is used to help make bones.

**7** *Students' own responses.* Possibly using adjectives to add weight, using powerful verbs and not using all of the evidence in the table (for example, not mentioning the amount of fat that's in the bar).

### 8Ac Balanced diets

#### Student Book

##### 1: 8Ac Balanced diets

**1 a** a diet that contains a wide variety of foods and all the different nutrients you need in the right amounts

**2** They have too much of one or more nutrients in their diet and so their diet is not balanced.

**3 a** B – kwashiorkor because the child has a large belly, C – rickets because the leg bones are poorly formed

**b** eating more fresh fruit and vegetables

**4** They only eat enough energy-containing foods for their needs.

**5 a** obesity

**b** too much to eat/too much sugar and/or fat in the diet; or too little exercise.

**c** heart disease and high blood pressure are the expected answers but some students may include diabetes (Type 2)

**6 a** reference intake = 8400 kJ  
 920 kJ is provided by 100 g  
 therefore 8400 kJ is provided by  $100/920 \times 8400 = 900$  g

**b** It doesn't contain all the vitamins you need (e.g. vitamin A and vitamin C).

**c** It adds vitamin A to the diet.

##### 2: 8Ac Making new foods (STEM)

**1:** Food goes off less quickly / lasts longer.

**2** Two of: people always like new things / healthier / last longer / cheaper / better taste / better looking

**3** Using electricity rather than heat means that the taste of the food doesn't change. It is also quicker and cheaper.

**4** Add iodine solution to a sample of the food. A blue/black colour indicates the presence of starch.

**5** Substitute an artificial sweetener for the sugar. Modify the product by reducing the levels of sugar.

**6** *Students' own responses.*

**a** Students should identify ways in which the pizza base could be made healthier (e.g. reduce the sugar, reduce the fat, increase the fibre). There is no information about minerals or vitamins on the label but some students might suggest that more of these should be added.

**b** Encourage students to use the SCAM bullet points in the text. Ideas could include:

Less sugar: Replace the sugar with artificial sweetener, reduce the levels of sugar/glucose.

Less fat: Replace the oil with a gum, reduce the levels of oil.

More fibre: Replace the bleached white flour with wholemeal/wholegrain flour, combine fibre from another source into the recipe.

**c** Advertising boxes should include reasons why the product is now healthier (e.g. more fibre to help keep your intestines working properly).

#### Activity Pack

##### 8Ac-1 Balanced diets

**1 a** foods containing lots of starch – bread, breakfast cereal; dairy – milk, cheese; fatty and sugary foods – sweets; foods containing lots of protein – bacon, egg; fruit and vegetables – lettuce, orange

**b** A balanced diet.

**2 a** Group B

**b** Group B contains a wide variety of foods that contain all the different nutrients.

**c** Groups A and C are both missing fibre and the vitamins and minerals found in fruits and vegetables.

**d** per day

**3** night blindness – poor eyesight in dim light – lack of vitamin A

obesity – very overweight – too much food

rickets – poorly formed bones – lack of calcium

scurvy – bleeding gums – lack of vitamin C

starvation – very thin – lack of food

**4** any one of: high blood pressure, heart disease, poor circulation, Type 2 diabetes

##### 8Ac-2 Meal matching

Menu A	
1200	Grilled fish
890	Baked potato
400	Small amount of butter
230	Carrots
280	Apple
0	Water

Menu B	
800	2 slices of brown bread
990	Egg salad
800	Yoghurt
10	2 lettuce leaves
400	Small amount of butter
0	Water
Menu C	
400	Grilled chicken
120	Green beans
130	Courgettes
1450	Vanilla ice cream
700	Rice
200	Apple juice with water
Menu D	
1200	3 sausages
650	Mashed potato
100	Gravy
90	Spinach
430	Banana
530	Milk
Menu E	
900	Lamb chop
400	Broccoli
1000	Boiled potatoes (with skins)
150	Mushrooms
420	Fresh fruit salad
130	Tea with milk (no sugar)
Menu F	
780	3 fish fingers
400	Oven chips
300	Peas
230	Custard
1100	Apple crumble
190	Orange juice and water drink

Menu F is the least well balanced because it contains a lot of sugar (in apple crumble, custard).

### 8Ac-3 Scurvy and beriberi

- 1** Your legs swell up, your joints become painful, your gums bleed and your teeth fall out.
- 2** **a** Scurvy is caused by something missing in the diet.

**b** The sailor who ate grass and his scurvy was cured.

**c** He gave sailors different additions to their diets and monitored their progress.

**d** fruit

**3** **a** vitamin C                      **b** deficiency diseases

**4** **a** vitamin B1

**b** pain, paralysis, swelling in the limbs

**c** Rice contained a poison (that was neutralised by the outer layer of rice).

**d** Beriberi was caused by the lack of a nutrient/vitamin/'accessory food factor'.

### 8Ac-4 Traffic lights

**1** **a** 6%                      **b** 18g

**c** 90g (5% of the reference intake is 4.5g, so 1% is  $4.5 \div 5 = 0.9$ g, so 100% is  $0.9 \times 100 = 90$ g)

**2** FAT (green), SATURATES (green), SUGARS (green), SALT (green)

**3**

*Breakfast cereal label (top of page):*

FAT 2.8g per 100g is low (green)

SATURATES 0.4g per 100g is low (green)

SUGARS 18g per 100g is high (red)

SALT 0.8g per 100g is medium (orange)

*Label A:*

FAT 1.5g per 100g is low (green)

SATURATES 0.5g per 100g is low (green)

SUGARS 16g per 100g is high (red)

SALT 1g per 100g is medium (orange)

*Label B:*

FAT 1.9g per 100g is low (green)

SATURATES 1.1g per 100g is low (green)

SUGARS 2.5g per 100g is low (green)

SALT 0.1g per 100g is low (green)

*Label C:*

FAT 8.4g per 100g is medium (orange)

SATURATES 8.4g per 100g is high (red)

SUGARS 20g per 100g is high (red)

SALT 0.1g per 100g is low (green)

*Label D:*

FAT 1.1g per 100g is low (green)

SATURATES 0.2g per 100g is low (green)

SUGARS 3.1g per 100g is low (green)

SALT 1.6g per 100g is high (red)

### 8Ac-5 Balanced meals

**1** **a** Eating a wide range of different foods to get the right amounts of nutrients. This means eating more of foods containing starch, fruits and vegetables and less of foods containing proteins, sugars, fats and oils, dairy products.

**b** If you don't eat a balanced diet you may start to suffer from malnutrition and feel unwell.

**2** **a** the 'Pasta special'

**b** some fruit

**3** **a & b**

Problem	Too much of something	Too little of something	How the problem can be prevented
obesity	✓		eat less (especially fats and sugars)
starvation		✓	eat more
scurvy		✓	eat foods rich in vitamin C
rickets		✓	eat foods rich in calcium

**7** It will raise money for the government. Or It will put people off buying fizzy drinks. It will stop people buying so many fizzy drinks so obesity will be less of a problem and cost the government less in health care.

**8** either diabetes (Type 2) or heart disease or high blood pressure

### 8Ac-7 Food and health

**1 a** He eats too much. His food contains more energy than he needs for his activity in a day and so this extra energy is stored in fat.

**b** heart disease or high blood pressure, but also diabetes (Type 2)

**c** Cut down on the amount he eats. By cutting out foods that contain the most fats and carbohydrates since these contain a lot of energy (for example, the boiled sweets, chocolate, ice cream and cake).

**d** exercise more

**e** He doesn't eat enough food. His food does not contain enough energy for his activity in a day.

**f** any two of: protein, a wide range of vitamins and minerals. Protein and a named vitamin, such as vitamin C which is only present in small quantities in this diet.

**g** A deficiency disease. A higher-level answer would make reference to particular deficiency diseases (e.g. kwashiorkor due to lack of protein and scurvy due to lack of vitamin C).

**h** Rickets because there is milk in his diet and milk is a good source of calcium.

**2 a** The recommended amount of a nutrient needed per day.

**b** 34 sprouts

**c** night blindness/problems seeing in dim light

### 8Ac-8 Diabetes and diet

**1 a** by eating too much (fatty and/or sugary food)

**b** lack of exercise and getting older

**c** the graph shows that as obesity rates have increased so have the rates of Type 2 diabetes.

**2** When the pancreas was removed the urine contained sugars.

**3** Topic sentence should be short, state the main point of the paragraph and be engaging. Supporting sentences should describe the findings of each doctor/scientist. The summary sentence should restate the main point, linking it back to the supporting sentences. For example:

It took thousands of years from the first clues about the cause of diabetes until the discovery of insulin. In about 1500 BC an Indian doctor, called Susruta, knew that diabetic urine was sweet. Matthew Dobson then showed in 1776 that diabetic urine contained sugar. Just over a hundred years later, Oscar Minkowski linked diabetes to a problem with the pancreas. Then in 1921 Banting and Best finally isolated insulin from the pancreas. Today we understand the role of insulin on blood sugar levels and we use insulin to control diabetes.

**4** The glucose goes into the blood, insulin is produced but the cells don't respond to it and so glucose stays in the blood. OR the glucose goes into the blood, but very little insulin is produced and so only a small amount of glucose is taken into the cells.

**5** They can cause blood glucose levels to rise quickly.

**6** There is so much glucose in the blood that it gets into the urine. OR The body puts it in the urine to get rid of it.

**7** Exercise increases the rate of respiration and so increases the rate at which glucose is taken out of the blood to provide energy. If there is less glucose in the blood, then less insulin will be needed.

### 8Ad Digestion

#### Student Book

#### 1: 8Ad Digestion

**1 a** breaks large/insoluble food molecules down into smaller ones

**b** many food molecules are too big for the body to use

**2** flow chart showing organs in the correct order and a brief summary of the function for each:

mouth (chews food and adds saliva), gullet/food-pipe/oesophagus (takes food to stomach), stomach (adds acid and digestive juices, churns food), small intestine (adds more digestive juices and absorbs food), large intestine (removes water from undigested food), rectum (stores faeces), anus (egests faeces)

**3** ingestion is the taking of food into the mouth/gut; egestion is expelling undigested food from the anus/gut

4 The muscles in the wall of the gut behind a piece of food contract and squeeze the food along.

5 benefit – they can digest some foods that the body can't; drawback – they can give you wind, some of them are harmful

6 a They contain enzymes, which break up big molecules into smaller ones.

b Scissors cut through paper and can make a large piece of paper into many smaller pieces of paper. Enzymes act in a similar way, turning large molecules into many smaller ones.

### Activity Pack

#### 8Ad-1 Digestion

1 The breakdown of food into smaller soluble substances is called – digestion.

Large molecules such as starch and fats are broken down into smaller ones by – enzymes.

Large molecules need to be broken down so that they can be – absorbed.

Food is pushed through the gut by the contraction of – muscles.

The food is churned up and mixed with acid in the – stomach.

Food that cannot be digested has water removed in the – large intestine.

After food is broken down it is taken into the body in the – small intestine.

The intestines hold about 1 kg of microorganisms called – bacteria.

When undigested food is pushed out through the anus it is said to be – egested.

The tube that carries food into the stomach is called the – oesophagus.

2 The drawing on the right should show six separate squares.

#### 8Ad-5 Digestive system parts

rectum – picture 6 – Faeces are stored here.

salivary glands – picture 8 – They produce a digestive juice.

anus – picture 7 – Egestion occurs here.

oesophagus – picture 5 – Food is pushed down this tube into the stomach.

mouth – picture 4 – The food is ground up by hard surfaces and mixed with a digestive juice.

stomach – picture 1 – This organ churns up food with enzymes and acid.

large intestine – picture 3 – Water is taken out of undigested food.

small intestine – picture 2 – Most digestion occurs here. Small molecules are absorbed.

#### 8Ad-7 Human digestion

1 i mouth; ii gullet; iii stomach; iv small intestine; v large intestine; vi rectum; vii anus

2 Digestion starts in the mouth. During digestion, digestive juices are added to the food and these contain enzymes that break the food down into smaller pieces.

3 Credit should be given for using complex and/or compound sentences with appropriate conjunctions. Credit should also be given for using scientific words such as: digest, molecule, absorption, small intestine. A good explanation will include the fact that food molecules are too big to be absorbed into the body in the small intestine and so they need to be broken down into smaller pieces.

4 a one of: some of them make vitamins; they help to digest food that we cannot

b some can make us ill

5 a one of: teeth in the mouth break up food into smaller pieces; food is mixed with saliva in order to start digesting it; food is mixed with saliva in order to make it easier to swallow

b one of: food is digested by enzymes in the small intestine; small molecules/pieces of food are absorbed into the body/blood in the small intestine

#### 8Ad-8 Enzymes and digestion

1 a mouth, gullet/foodpipe/oesophagus, stomach, small intestine, large intestine, rectum, anus

b small intestine (absorption of food), anus (egestion), mouth (ingestion)

2 a in the mouth

b small intestine – more different enzymes are found there

c Bread – ticks in mouth, gullet and small intestine

Butter – ticks in small intestine

Celery – mainly fibre, so either no ticks or one tick in the small intestine

Ham – ticks in stomach and small intestine

d pH 1–3 because the stomach contains strong acid.

3 For example: Muscles in the wall of the gut behind the food contract, and this squeezes the food forward inside the gut.

4 Credit should be given for: the enzyme in the diagram being labelled 'amylase', the diagram showing the lines between the hexagons being cut by the enzyme, the enzyme looking the same after it has finished its job.

#### 8Ad-9 Enzyme action

1 a Enzymes break down large molecules into smaller ones.

**b** Large molecules cannot be absorbed into the blood/body by the small intestine. OR The body cannot use large molecules.

**2 a** It shows that large molecules are split into smaller ones; it shows that the enzymes don't get used up; it shows that enzymes change shape as they work; it shows that links/bonds are broken in the molecules by enzymes.

**b** It doesn't show that the enzyme only works on a specific molecule.

**3 a** It shows that large molecules are split into smaller ones; it shows that the enzymes don't get used up; it shows that the enzyme works on a specific molecule.

**b** It doesn't show that enzymes change shape as they work; it doesn't show that the links/bonds are broken.

**4** Each enzyme will only work on a specific type of molecule.

**5 a** The spanner model works better to explain this. The action of heat on the spanner will change its shape slightly, so there will be an optimum temperature for each spanner.

**b** *Students' model* should take account of:

- enzymes do not get used up as they carry out their tasks
- enzymes change shape as they work
- each enzyme only works on one particular type of molecule
- digestive enzymes break links (bonds) between atoms in larger molecules
- digestive enzymes change shape with temperature.

## 8Ae Absorption

### Student Book

#### 1: 8Ae Surface area

**1**  $100 \times 45 = 4500 \text{ m}^2$

**2**  $2 \times (10 \times 15) = 300 \mu\text{m}^2$ ;  $2 \times (10 \times 20) = 400 \mu\text{m}^2$ ;  
 $2 \times (15 \times 20) = 600 \mu\text{m}^2$

$300 + 400 + 600 = 1300 \mu\text{m}^2$

**3 a**  $2 \times (8 \times 4) = 64 \text{ cm}^2$ ;  $2 \times (8 \times 6) = 96 \text{ cm}^2$ ;  $2 \times (4 \times 6) = 48 \text{ cm}^2$

$64 + 96 + 48 = 208 \text{ cm}^2$

**b**  $2 \times (4 \times 4) = 32 \text{ cm}^2$ ;  $2 \times (4 \times 6) = 48 \text{ cm}^2$ ;  $2 \times (4 \times 6) = 48 \text{ cm}^2$

For each block  $32 + 48 + 48 = 128 \text{ cm}^2$  but we have two blocks now, so the total of both is  $2 \times 128 = 256 \text{ cm}^2$ .

**4** The granules have a greater surface area for the water to reach the sugar and dissolve it.

**5** The smaller the food pieces are, the greater surface area they have and there is a larger area

over which enzymes can break down the food. This means that smaller pieces of food will be digested faster; teeth help in this process by grinding up food into smaller pieces.

**6 a**  $216/216 = 1$

**b**  $54/27 = 2$

## 2: 8Ae Absorption

**1 a** small intestine

**b** the sugars/glucose (not the enzyme or starch), because they are small enough to be absorbed

**2** sugars (glucose), because the enzymes break down the starch into sugars which are then small enough to diffuse through the Visking tubing

**3 a** to release energy from food

**b** plasma carries glucose; red blood cells carry oxygen

**4** the overall movement of particles from an area where there are a lot of particles to an area where there are fewer particles until a balance is reached

**5** Molecules move in all directions, so by chance some will move in one direction and others will move in the opposite direction.

**6** Small soluble molecules can pass through the wall of the small intestine. So, there is an overall movement of these soluble molecules through the wall of the small intestine into the blood because there are more soluble molecules in the small intestine than there are in the blood. Insoluble molecules are too big to go through the wall of the small intestine.

**7** It is long and so has a large surface area. Its surface area is increased by folds, villi and microvilli. The walls of the villi are only one cell thick, making it easier for molecules to diffuse.

**8 a** Fewer digestive enzymes are released into the small intestine.

**b** Fewer of the insoluble food molecules will be digested into soluble ones that can be absorbed.

**c** They will digest less food, due to less digestive enzymes; the villi shrink in size and so are not able to absorb as many of the nutrients as before.

**9** The calculation does not take into account the effects of the folds, the villi or the microvilli.

## 3: 8Ae Packaging and the law

**1 a** to add weight to their products/make their products sound the best so they can sell more

**b** to add weight to the health message and make their products sound as though they can be eaten and not cause weight gain

**2 a** fat, carbohydrates (sugars), salt, protein

**b** fats store energy and provide insulation, carbohydrates provide energy, salt is needed for health, protein is needed for growth and repair



**c** Only the ones which cause the most problems for health if overeaten are included.

**3** Bacteria can make useful substances (e.g. vitamins) and can help digest foods but some can also cause diseases.

**4** flow chart showing starch being digested by enzymes into glucose, which is soluble and so can easily diffuse through the wall of the small intestine and into the blood plasma; cells take it out of the blood plasma

### Activity Pack

#### 8Ae-1 Absorption

**1 a** inside the small intestine

**b** blood

**c**

Substance	Inside tubing at start	Inside tubing after 30 min	Outside tubing at start	Outside tubing after 30 min
enzymes	✓	✓		
starch	✓	✓		
sugars		✓		✓
water	✓	✓	✓	✓

**2** large surface area and wall is only one cell thick

**3** plasma

**4** Diagram completed to show that there are an equal number of small food molecules (white circles) and water molecules on each side but that the grey squares have stayed where they are.

#### 8Ae-4 The small intestine

**1 a** absorption

**b** squares drawn around the two types of smaller circles

**c** They are small enough to fit through the wall of the small intestine (villi).

**d** diffusion

**e** plasma

**2 a** to release energy

**b** glucose

**3 a** one of: by having a folded wall, by having microvilli

**b** They can't absorb digested nutrients so quickly and so may not absorb enough, which may result in malnutrition or a deficiency disorder.

#### 8Ae-5 Calculating surface area

**1**  $2 \times (8 \times 4) = 64 \text{ cm}^2$ ;  $2 \times (6 \times 4) = 48 \text{ cm}^2$ ;  $2 \times (6 \times 8) = 96 \text{ cm}^2$ . So,  $96 + 48 + 64 = 208 \text{ cm}^2$ .

**2** 24

**3**  $6 \times (2 \times 2) = 24 \text{ cm}^2$

**4**  $24 \times 24 = 576 \text{ cm}^2$

**5** The smaller the food pieces are, the greater surface area they have and there is a larger area over which enzymes can break down the food. This means that smaller pieces of food will be digested faster and teeth help in this process by grinding up food into smaller pieces.

**6 a**  $0.51 \times 20 \times 20 = 204 \text{ m}^2$

**b** A larger surface area allows more space for digested nutrients to be absorbed and so digested nutrients are absorbed more quickly.

**c** The small intestine wall is folded, which also increases the surface area.

**d**  $21/6.5 = 3.2$

So, the elephant's small intestine is more than three times longer than a human's.

$3.2 \times 204 = 653 \text{ m}^2$  (to the nearest  $\text{m}^2$ )

**e** Assumed that elephants also have villi and microvilli to increase their surface area, and their small intestine is of a similar width.

#### 8Ae-6 Absorbing digested food

**1 a** X

**b** It has a greater surface area of absorbent fibres.

**2 a** small intestine **b** villus **c** capillary **d** microvillus **e** starch molecule **f** glucose molecule

**3** It is a long, thin tube so has a large surface area. Its surface area is increased firstly by folds and then by villi. The villi themselves are covered in microvilli that greatly increase the surface area further. The walls of the villi are only one cell thick, making it easier for molecules to diffuse through and there are many blood vessels to absorb the molecules.

**4 a** It will increase.

**b** Molecules are randomly moving. Some will move into the blood. There will be an overall movement of particles from where there are more of them (the small intestine) to where there are fewer of them (the blood). Until there is a balance between them.

**c** The wall of the small intestine is very thin (one cell thick) and has a very large surface area.

**d** If the soluble products of digestion are removed then the blood will always have fewer molecules than the small intestine. As there will never be a balance, the small molecules will continue to diffuse out of the small intestine.

#### 8Ae-7 More digestive enzymes

**1 a** starch, maltose, glucose

**b** 2 – salivary amylase, pancreatic amylase and maltase

**2** Labelled diagram to show enzymes cutting up a protein into smaller units (peptides) and then a different enzyme cutting up the peptides into

## Plants and their reproduction

amino acids, which are then absorbed in the small intestine.

**3 a** Molecules are randomly moving. Some will move into the blood. There will be an overall movement of particles from where there are more of them (the small intestine) to where there are fewer of them (the blood). This continues until there is a balance between them.

A better answer will explain how the flowing of the blood helps to maintain the imbalance and so the overall diffusion of soluble molecules from the small intestine into the blood will be maintained.

**b** It has a large surface area caused by having folds, villi and microvilli. It also has very thin walls and many blood vessels.

**4 a** pH from 6–8 or 9. It needs to neutralise the highly acidic stomach contents, but a pH of over about 9 may be dangerous.

**b** Answer should explain that bile forms an emulsion in which the fat/lipid droplets are broken down into smaller droplets. This allows a greater surface area for enzymes (like steapsin) to act on and so the fat/lipid is broken down more quickly. This can be illustrated by calculating the surface area of the large cube in the diagram ( $150\text{mm}^2$ ) and comparing that value with the total surface area of the 125 smaller cubes that the large cube can be cut up into ( $750\text{mm}^2$ ).

### 8B Plants and their reproduction

#### 8Ba Classification and biodiversity

##### Student Book

##### 1: 8Ba Useful plants

**1** one of: animal, fungus, protoctist, prokaryote ('animal' is the expected answer)

**2** rough calculation of the value of something

**3 a** They transfer pollen from one flower to another.

**b** scent (given in text), flower colour (hinted at in the caption to photo A), nectar

**c** the pollen grain and the egg cell/two gametes/sex cells fuse

**d** one of: edible fruits, wind, fruits that stick to animals, explosions

**4** example of a scientific name: *Gossypium hirsutum*; examples of a common name: flax, cotton, indigo, lavender, willow, foxglove, maple, spruce, rape, rubber tree

##### 2: 8Ba Classification and biodiversity

**1 a** Animal cells have no cell wall and animals cannot make their own food.

**b** protoctists, prokaryotes, fungi

**2 a** they both have leaves, they both have roots, they both have xylem tissue (some students may include similarities from figure A, e.g. their cells have cell walls)

**b** conifers have cones, flowering plants have flowers; conifers have needle-shaped leaves, flowering plants have large, flat leaves

**3** Fungi have chitin in their cell walls, plants have cellulose. Fungi do not make their own food, plants do.

**4** *Helianthus annuus*

**5** Birds and reptiles both have backbones/are both vertebrates, they are both animals, they both lay eggs. Birds and reptiles are different because birds have feathers but reptiles have dry scales, and the eggs that they lay have different shells.

**6** Both words are in italics and the first word (genus) has a capital but the second word (species) does not. (Note: instead of writing a scientific name in italics, you can underline it instead.)

**7** tropical rainforest, many more species live there

**8** preserves ecosystems (since organisms depend on one another), preserves a source of undiscovered substances for human use, allows a habitat to recover faster if disaster strikes

#### 3: 8Ba Accuracy and estimates

**1 a** balance Z (the scientific balance)

**b** balance X (the bathroom scales), it has the fewest significant figures

**2**  $50 \div 5 = 10$ ,  $10 \times 24 = 240$  sweets

**3** The exact number of sweets has not been determined. We have assumed that there are 24 sweets in each 5 cm of the jar.

**4 a**  $250 \div 10 = 25$ ,  $25 \times 15 = 375$  plants

**b** The exact number of daisies has not been determined. We have assumed that there are 15 daisy plants in each  $10\text{m}^2$  of the lawn.

**c** You would get a more accurate estimate.

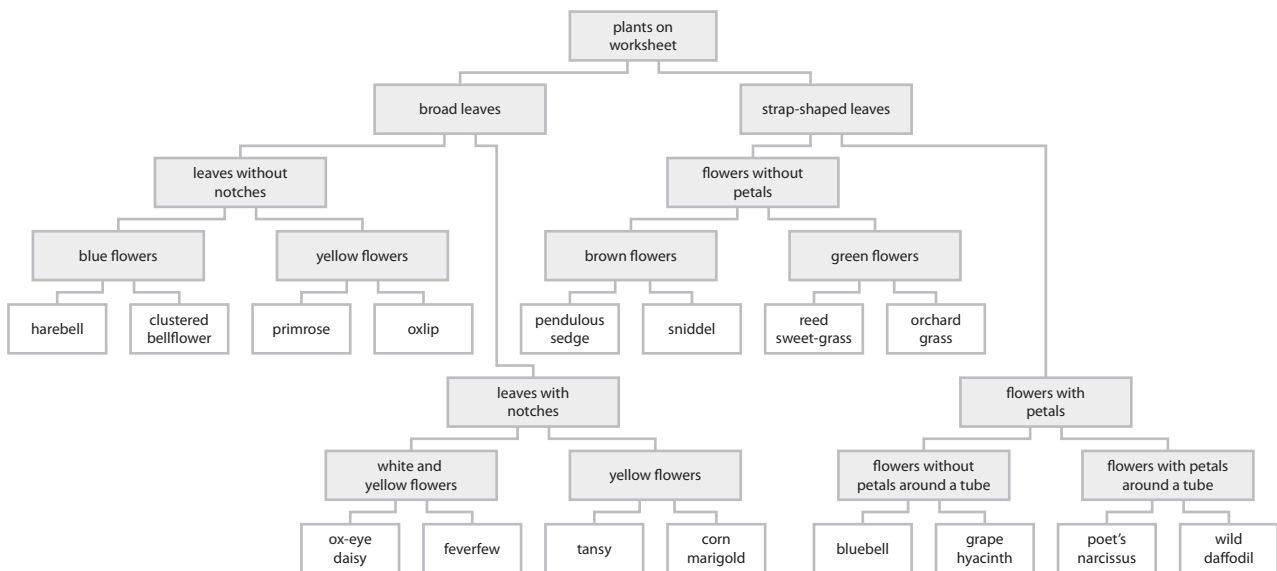
**d** It would take longer.

#### Activity Pack

##### 8Ba-1 Classification and biodiversity

1

Characteristics	Name of kingdom
make their own food (using photosynthesis)	plants
cells have a nucleus but no cell wall	animals
organisms only have one cell, which has a nucleus	protists/protoctists
cell walls contain chitin	fungi
cells do not have nuclei	prokaryotes



2

Characteristics	Name of plant group
do not have xylem tissue	mosses
make cones	conifers
have flowers	flowering plants
do not have flowers or cones	ferns or mosses

3 a *Monstera deliciosa*

b so that scientists all over the world know what plant someone is talking about

4 a X

b one of: we get useful products from organisms; organisms depend on one another; enriches our lives; more biodiverse areas are better at disaster recovery

**8Ba-4 Sorting plants**

A possible classification system is given below but there will be many variations on this.

**8Ba-5 Kingdoms and keys**

1 a X is common ash, Y is horse chestnut

b The leaves do not grow in opposite pairs along a stalk, the leaves do not have lobes, but they do have smooth edges.

c two trees (field maple, English oak)

2 a two of: animal; fungi; prokaryote (accept 'bacteria'); protist (or protoctist)

b one of: they can make their own food; their cells contain chloroplasts/chlorophyll; their cells have cell walls.

c classification

3 a conifers

b sensible suggestions, such as: shape of leaves; colour of flowers; shape of flowers

4 Rainforests have greater biodiversity because they contain the greater number of different species.

**8Ba-6 Paper quadrats**

1 Neatly drawn table, identifying each square sampled with a two-letter code (e.g. a g). There should be a column for the square codes. The numbers of the different species for each plant should be clearly shown. Extra credit should be awarded if space has been left to allow totals and/or means to be added.

2-4 Credit should be given for all working shown, even if the answers are incorrect.

5 a There are six thistle plants (followed by comparison to the student's estimate).

b by taking more samples

c It takes longer to do the analysis.

**8Ba-7 Biodiversity of species**

1 a animals, plants, fungi

b one of: plant cells have a nucleus/cell walls made of cellulose/organisms made of many cells/make their own food (using photosynthesis); or animal cells have a nucleus/no cell walls/organisms made of many cells/feed on other organisms; or fungi cells have a nucleus/cell walls contain chitin/organisms made of many cells/live on rotting organisms and their wastes

c controls the cell's activities

2 a animal kingdom

b sensible suggestion such as: they have feathers; have beaks; or they lay eggs with hard shells. 'They fly' is a less good suggestion because some mammals (e.g. bats) fly and some birds (e.g. penguins) don't.

c sensible suggestion such as: length of beak; or colour; or type of food they eat.

## Plants and their reproduction

**d** reed bunting and yellowhammer because the scientific name shows that they are in the same genus, which is the second to last group that you get to in the classification system.

**e** It allows scientists all over the world to know exactly which organism is being talked about.

**f** *Auriparus* (give extra credit for a capital at the start of the word, and the word being in italics).

**g** X, because it has a greater total number of birds, even though both areas have the same number of different species.

**h** one of: we get useful products from organisms; organisms depend on one another; enriches our lives; more biodiverse areas are better at disaster recovery

**8Ba-8 Monitoring biodiversity**

**1 a** *Glyceria* (give extra credit for a capital at the start of the word, and the word being in italics).

**b** It allows scientists all over the world to know exactly which organism is being talked about.

**2 a** *Students' own answers* based on observation of the three drawings (e.g. flower type).

**b** So that different species can be accurately identified. If you can't tell the difference between different species you cannot come up with an accurate number of the different species in an area.

**3 a** (award extra credit for showing working)

*Dactylis glomerata* Area A: 1267

*Carex pendula* Area A: 367

*Glyceria maxima* Area A: 2833

*Dactylis glomerata* Area B: 1500

*Carex pendula* Area B: 967

*Glyceria maxima* Area B: 767

**b** (award extra credit for showing working)

Area A = 0.0007

Area B = 0.0009

**c** Area B is more biodiverse because it has the greater biodiversity index.

**d** Take more species into account.

**e** To make sure that biodiversity is being preserved.

**8Bb Types of reproduction****Student Book****1: 8Bb Types of reproduction**

**1** two organisms/a male and a female/two parents

**2 a** plumcot

**b** because it is a hybrid and hybrids cannot reproduce/are not fertile

**3 a** one of: shape, size

**b** skin and flesh colour

**4** flower colour

**5 a** sperm cells

**b** egg cells

**6** Each sperm cell from a man contains slightly different instructions for characteristics and so does each egg cell from a woman. Therefore, all the offspring from two parents (apart from identical twins) have slightly different sets of instructions for characteristics and look slightly different.

**7 a** flowers/pollen grains and egg cells/gametes

**b** runners

**8** The tubers are produced by asexual reproduction and come from only one plant. The new plants will all have the characteristics of the parent plant.

**9 a** a plant is being grown from part of the parent plant/a new plant is produced using only one parent

**b** one of: it is quicker, you can be sure what the new plants are going to look like

**Activity Pack****8Bb-1 Types of reproduction**

**1 a** colour

**b** apricots and plums

**c** hybrid

**d** purple fruits

**e** one sensible suggestion, such as: size of fruit, shape of fruit, size of stone/pips, colour of flesh

**2** correct labels from left to right: sex cell; gamete; fertilisation; fertilised egg cell; growth

**3** Each time a parent produces a gamete cell it is different. So no two combinations of gametes will give identical results.

**4** sexually and asexually or using flowers and using runners

**5 a** asexual reproduction

**b** All its cells come from the original plant.

**8Bb-2 Variation and reproduction**

There are seven plants that are identical to Parent Y (A, C, D, G, J, K & M) so have been produced by asexual reproduction. There are seven plants that have been produced by sexual reproduction between X and Y (B, E, F, H, I, L & N). Award additional credit to students who have not included the two parents in either pile (since we cannot tell how they were produced).

**8Bb-3 Sexual and asexual reproduction**

**1 a** They are both the same type of plant.

**b** plant A

**c** It is exactly the same as all the other plants on the left. OR It is attached to the other plants by runners.

**d** inherited

2 a asexual reproduction

b a stem and leaf

3 sexual, gamete, fuse, fertilisation, fertilised, embryo, inherited

#### 8Bb-4 Plant variation

1 a the number of petals, number of spots on petals, number of leaves, flower width, plant height

b Continuous variation: flower width, plant height.

Discontinuous variation: number of petals, number of spots on petals, number of leaves.

2 inherited variation (accept inheritance or heredity)

3 They are all the same type of plants and can reproduce with one another to produce offspring that can also reproduce.

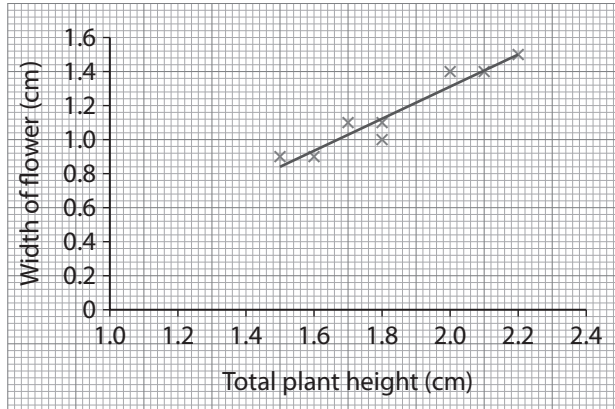
4 a

Plants	Total plant height (cm)	Flower width (cm)	Number of petals in flower	Number of spots on each petal	Number of leaves
Plant B	1.8	1.0	5	2	3
Plant E	2.0	1.4	7	2	3
Plant F	1.6	0.9	5	2	3
Plant H	1.8	1.1	7	1	2
Plant I	1.7	1.1	7	1	2
Plant L	2.1	1.4	7	1	2
Plant N	2.2	1.5	5	2	3
Parent X	1.5	0.9	7	2	3
Parent Y	2.2	1.5	5	1	2

(Note that plants A, C, D, G, J, K & M are identical to Plant Y.)

b

How the width of a flower depends on plant height



c Yes. As the height of the plant increases, so does the width of the flower. Award additional credit if students have described this as a positive correlation.

d see graph from part b

5 a *Students' own responses*, showing an understanding that sexual reproduction needs two parents (asexual reproduction needs only one) and that sexual reproduction produces variety (asexual reproduction does not).

b Students explain that, in sexual reproduction, a parent makes gametes that contain the instructions for characteristics but each gamete has a slightly different set of instructions. When

gametes fuse in fertilisation, the instructions are combined and so the offspring end up with different sets of instructions. (Students may add that, in asexual reproduction, all the cells come from one parent and so all contain the same instructions as the parent.)

#### 8Bb-5 Plant reproduction

1 a 3

b both trials

c second trial

d height

2 a red colour of fruits

b They are hybrids, so they are infertile (because they are hybrids).

c Take a cutting of a tayberry plant (e.g. stem, leaf) and plant it.

d They have come from exactly the same cells as the parent plant.

e two of: plumpness/size of fruits, colour of fruits, size/number of thorns.

f Students explain that, in sexual reproduction, a parent makes *gametes* that contain the instructions for *characteristics* but each gamete has a slightly different set of instructions. When gametes fuse in *fertilisation*, the instructions are combined and so the offspring end up with different sets of instructions.

**8Bb-6 Strawberries**

- 1 two parents
- 2 They use flowers to reproduce sexually and they use runners to reproduce asexually.
- 3 **a** They are made using plants from two different species.

**b** *F. virginiana* X *F. chiloensis*. Give additional credit if students have used italics for the scientific names.

4 **a** From *F. virginiana* they have inherited bright red colour of fruits, salt intolerance. From *F. chiloensis* they have inherited large fruits, ability to grow in full sunshine.

**b** Students explain that, in sexual reproduction, a parent makes *gametes* that contain the instructions for *characteristics* but each gamete has a slightly different set of instructions. When gametes fuse in *fertilisation*, the instructions are combined and so the offspring end up with different sets of instructions.

5 **a** *F. vesca* X *F. chiloensis*, *F. vesca* and *F. chiloensis*. Give additional credit if students have used italics for the scientific names.

**b** They cannot reproduce sexually.

**c** It can reproduce asexually, using runners.

**d** *F. vesca* X *F. chiloensis* because they are all identical. Sexual reproduction can still occur between different *F. vesca* and between different *F. chiloensis* plants, allowing variety. Some of those offspring may be more resistant to the disease.

**e** It is faster, or all the offspring will be suited to growing in that area (because it's the same area as where the parent is growing).

**8Bc Pollination****Student Book****1: 8Bc Pollination**

- 1 **a** stamen
  - b** anther, filament
- 2 Pollen is transferred from an anther to a stigma.
- 3 one of: nucleus, cytoplasm, cell surface membrane, mitochondria, cell wall
- 4 **a** to trap pollen grains
  - b** it is sticky
- 5 three from: flower is brightly coloured, flower has a scent, flower produces nectar, flower has large and sticky pollen grains, flower has a sticky stigma
- 6 Photo H because the pollen grains are bigger and have spikes on them to stick to insects.
- 7 They are small and light so that they are easily carried by the wind.
- 8 **a** Pollen is transferred from the anthers of one plant to the stigma of another (of the same species).

**b** because cross-pollination means the offspring have a mixture of characteristics from two different plants

**8Bc: Air quality (STEM)**

1 Pollen carries male sex cells/gametes to stigma so they can fertilise the egg cell/ female gamete and make seed.

2 Different plants produce different amounts of pollen at different times of year; in regions with seasons, most plants release pollen in the summer.

3 **a** People who suffer from hayfever or asthma only need general information on how much pollen there is in the air.

**b** It is important that pollen levels are kept below a set limit so that microchips are not damaged.

4 = 0.134 grains/cm<sup>3</sup>

5 **a** = 0.12 g/cm<sup>3</sup>

**b** = 0.075 g/cm<sup>3</sup>, so the solution in part a is more concentrated.

6 Any suitable answer that indicates the method will not give an accurate value. For example:

- This method doesn't capture all the pollen in a sample of air, only the grains that happen to touch the paper.
- This method only gives a count over a long period of time and the pollen levels need to be continuously monitored (regular samples) so that people can be alerted.

**Activity Pack****8Bc-1 Pollination**

1 **a** style – supports the stigma; ovule – contains the female gamete; stigma – receives pollen; anther – makes pollen grains

**b** Insects – because it does not have feathery stigmas like a wind-pollinated plant would have. There are other possible answers including the fact that it has petals or that its male and female parts are sheltered from the wind by petals.

2 **a** insects

**b** to provide food for bees

3 pollen grain

4 produce pollen

5 To prevent self-pollination. The wind blows the pollen off the flowers at the top and away from the female flowers below.

**8Bc-5 Inside a flower**

4 The sepals protect the flower in bud.

**8Bc-6 Flowers**

1 **a** Drawing of a cross-section through the flower, clearly showing three stamens in the centres of three petals and surrounding a central carpel, in which the ovary is wider than the stigma.

**b** correct labels

**c** stigma

**2 a** Plant X is pollinated by the wind. Plant Y is pollinated by insects.

**b**

Plant	X	Y
produces lots of light pollen	✓	
produces nectar		✓
produces a scent		✓
produces large, spikey pollen		✓

### 8Bc-7 *Hibiscus* flowers

**1 a** W stigma, X style, Y anther, Z filament

**b** to collect/receive pollen

**c** It has a brush-like structure to collect pollen off visiting insects.

**2 a** To attract animals to pollinate them, or to protect the parts inside.

**b** They produce scent, they are brightly coloured.

**c** Scientists were trying to establish how the size and presence of petals influences the attraction of insects to *Hibiscus* flowers.

**d** Petals are essential for attracting insects, and the bigger the flower, the more insects visited.

**e** *Bombus* preferred *Hibiscus* but *Ptilothrix* preferred a different type of flower. Or There were more *Bombus* than *Ptilothrix* in the area.

**f** They were attracted by the nectar. (Not scent, because the petals produce scent.)

**g** Pollen B is from *Hibiscus*. It is large and spiky, like pollen grains from other insect-pollinated plants. It has spikes that allow it to stick to the outer coverings of visiting animals.

**3** The male gamete is found inside the pollen grain and the female gamete is found inside the ovule.

**4** To stop pollen falling onto the stigmas from the anthers to prevent self-pollination.

**5** It means that there should be some varieties that can cope with a change in conditions, such as a disease, increased rainfall and decrease in temperatures.

### 8Bc-8 Pollinators and pollination

**1 a** to attract pollinators

**b** There are no pollinators for red campions around at night.

**c** The amount of sugar in male flowers is greater than that in female flowers in the afternoon, until between 5 pm and 7 pm when it suddenly falls and there is an increase in the amount of sugar in the female flowers at the same time.

**d** During the day, more insects are attracted to the male flowers because there is more nectar/

sugar available. This means that they get a lot of pollen on them. Then later in the afternoon, the plants need to make sure that the pollen that has been taken from the male flowers gets to the female flowers and so the male flowers become less attractive by producing less nectar and the female flowers become more attractive by producing more nectar.

**2 a** self-pollination

**b** In all but one case, insect pollination creates pods with more seeds in them. It is the seeds that are wanted because they contain the oil.

**c** sensible suggestions include: that it was too small/the wrong shape to rub against the stigma to transfer the pollen; or that the insect's covering did not pick up much pollen in the first place

**d** Both of the *Apis* species (*Apis dorsata* and *Apis florea*) because although they cause fewer seeds to form in pods than *Halictus* species, they are more active in the mornings when the plant produces most of its pollen and they also visit more flowers and spends less time transferring pollen.

### 8Bd Fertilisation and dispersal

#### Student Book

#### 1: 8Bd Fertilisation and dispersal

**1 a** A pollen grain grows a pollen tube down to the ovule, in which the egg cell is found. The male gamete is carried in the pollen tube to the egg cell in the ovule.

**b** fertilised egg cell or zygote

**c** fertilisation

**2** eight cells

**3** an embryo

**4** food store

**5** ovary

**6 a** Cocklebur fruits have hooks that trap the fruits in animal fur and so animals carry the fruits away.

**b** Dandelion fruits float in the wind, carrying the seeds away from the parent.

**c** Coconut fruits float on water and carry the seeds to new places by water currents.

**d** Himalayan balsam spreads its seeds using fruits that explode and fling the seeds away from the parent plant.

**7 a** The fruits are eaten and when the seeds are egested from the animal they will be in a different place.

**b** seed coat

**c** to stop the seeds being digested in the digestive system

**8** so that the new plants are not in competition with the parents and so that the plant species can spread to new areas

**Activity Pack****8Bd-1 Fertilisation and seed dispersal**

**1** 1 pollen release, 2 pollination, 3 pollen tube growth, 4 fertilisation, 5 embryo development, 6 seed dispersal

**2** cell division

**3** **a** eaten by animals (strawberry); **b** wind (sycamore maple); **c** wind (dandelion); **d** explosion (hairy bittercress)

**4** tiny root – absorbs water; tiny shoot – grows leaves; food store – an energy source; seed coat – protects the seed. Label lines also need to be drawn to the correct places on the diagram.

**5** so that the new plants do not compete with the parents

**8Bd-5 Comparing reproduction**

Humans: The male gamete can swim. The male gamete is found in a liquid called semen. Fertilisation occurs inside an oviduct.

Flowering plants: The male gamete is found in a pollen grain. Pollination occurs before fertilisation. The embryo contains a tiny root. Fertilisation occurs inside an ovule. Requires a pollinator. It only happens at a certain time of year.

Both: Two gametes fuse. The zygote uses cell division to become an embryo. Male and female gametes are required. The egg cell is the female gamete. The offspring show variation between one another. The egg cell has a cell membrane. The nuclei from the male and female gametes fuse. The male gamete has a nucleus. A fertilised egg cell (or zygote) is formed.

**8Bd-7 Making and dispersing seeds**

**1** four of: seed coat, food store, tiny shoot and/or embryo, tiny root and/or embryo

**2** **a** wind      **b** explosion      **c** animal fur  
**d** eaten

**3** **a** pollen tube drawn down the style and into the ovule in the ovary

**b** correctly labelled diagram

**4** **a** in the pollen grain

**b** egg cell

**c** fertilisation

**5** cell division

**8Bd-8 Comparing sexual reproduction**

Similarities may include: requires a male and female; produces variety; mixes characteristics; involves gametes; produces embryos.

Differences may include: in humans it usually requires people finding and getting close to one another (this does not happen in plants); the structures of the male gametes are different; the plant male gamete is not mobile.

See also the answers to Worksheet 8Bd-5.

**8Bd-9 Seed dispersal**

**1** **a** The filaments and anthers have been removed to prevent self-pollination; a plastic bag is used to cover the flower head to stop other pollinators pollinating the plant.

**b** The *pollen grain* grows a pollen tube from the *stigma* and down through the *style* into an *ovule* in an *ovary*. Award additional credit for the use of words in italics.

**c** The *nucleus* from the *male gamete* fuses with the nucleus from the *egg cell*. Award additional credit for the use of words in italics.

**d** small local bee

**e** suggestions might include: it was able to carry more pollen; it was of a better size/shape to rub against the stigma; it spent longer visiting the flowers

**f** The results for *Osmia* because this is the result that contains the fewest readings used to calculate the mean. Some students may have included *Xylocopa* here, which should also be seen as correct since both these results contain many fewer repeat readings than the others.

**2** **a** Animals eating it and then moving away from the parent before dispersing the seeds; it has fleshy fruit and a bright red colour.

**b** Flesh is from the ovary, seed is from the ovule, embryo is from the zygote/fertilised egg cell, tuft is the remains of the style/stigma.

**c** So that offspring do not compete with their parents and/or so that a plant species can spread to a new area.

**d** Major parts with functions.

Tiny root to absorb water; tiny shoot to support leaves; food store to provide energy; seed coat to protect the seed. Award extra credit for answers presented as paragraphs, demonstrating good overall structure together with unity, coherence, cohesion and order. For example, the order could be to look at the different parts of the seed starting in the centre and working outwards.

**8Bd-10 Evaluating seed dispersal**

Award extra credit for answers written as paragraphs, if students have been asked to do this.

**1** **a** *Baccaurea racemosa* is dispersed by animals, which move off in all directions scattering fruits and seeds as they go, either discarding them or egesting seeds in their faeces.

*Shorea leprosula* has seeds with wings that flutter. A lot of the seeds land quite close to the parents (as shown by the clumps) but if there is a wind in a certain direction they can be moved further away. There is evidence on the map of lines, possibly showing the direction of the wind.



*Neobalanocarpus heimii* has fruits that fall to the ground and are then disturbed by animals (or by rolling down slopes), as shown by the more regular shaped circular concentrations of fruits, formed by fruits dropping in a regular fashion from all around the tree.

*Croton argyратus* has seeds that are expelled by the forces unleashed in a drying seed pod. The seeds do not travel very far.

**b** Students make an argument for one of the types of dispersal being best (for example *Baccaurea racemosa* because the seeds get carried a long way and in an even distribution. Or *Croton argyратus* because a lot of the seeds land fairly near the parent, where conditions for its growth are likely to be good and it doesn't waste seeds landing up in unsuitable areas).

**c** Large fruits taken from the plant by animals as these had the largest clusters.

**d** Any habitat in which there are few animals or a habitat in which there is a lot of wind/water.

**2 a** The *pollen grain* grows a pollen tube from the *stigma* and down through the *style* into an *ovule* in an *ovary*. The *nucleus* from the *male gamete fuses* with the nucleus from the *egg cell*. Award additional credit for the use of words in italics.

**b** Suggestions could include that the fused gametes do not form a cell that can survive, or that the zygote cannot divide. However, the male gamete has entered the ovule and so fruit formation is triggered.

## 8Be Germination and growth

### Student Book

#### 1: 8Be Germination and growth

- when a seed starts to grow
- at least three of the following and in this order: the seed absorbs water, the root emerges, the shoot emerges, the first leaves open
- a** oxygen, glucose  
**b** carbon dioxide, water, energy
- water, oxygen, warmth
- to ensure that at least some fruits survive and carry the seeds away from the parent
- The cells in the embryo use cell division.  
The energy for this process comes from respiration.  
The glucose for respiration comes from the food store in the seed.
- The food store is being used up.
- a, b** oxygen (for respiration), carbon dioxide (for photosynthesis)

**9 a, b** carbon dioxide (for photosynthesis), light (for photosynthesis), mineral salts (for healthy growth)

**10** Plants release oxygen from photosynthesis, which animals depend on for respiration. Animals produce carbon dioxide when they breathe out, which plants depend on for photosynthesis.

**11** There are fewer pollinators and so some plants may not produce as much fruit or seeds as they used to.

#### 2: 8Be Animals using plants

**1** Humans, woodpecker finches, insects, bowerbirds, crested rats, flower mantises are in the animal kingdom. Cacti and arrow poison trees are in the plant kingdom.

**2** so that scientists know exactly what organism is being talked about: there is less chance of confusion

**3** *Lophiomys* (award additional credit if a student has used italics)

**4** flower (for sexual reproduction), tuber (for asexual reproduction), fruit (for seed dispersal), leaf (for making food/photosynthesis)

**5** Insects come to collect nectar/pollen from the flowers.

**6** by animals eating it; because it has flesh and can be safely eaten when it is ripe

**7** The arrow poison tree, bees and humans are all interdependent. The tree relies on bees that visit the flowers and so pollinate them. In turn, the bees rely on the tree for nectar, which they collect for food. Humans rely on the tree for poisons for the arrows, so that they can hunt animals and have meat to eat. Humans also collect and eat arrow poison tree fruit. This helps the tree by spreading its seeds. Humans may collect honey from the bees. Humans will make sure that the trees are not damaged and so the bees will always have a source of its nectar.

(Give additional credit for paragraphs that have a sound overall structure and good levels of unity, cohesion, coherence and order.)

#### Activity Pack

##### 8Be-1 Germination and growth

- a** A seed starts to grow.  
**b** root  
**c** water, oxygen, warmth  
**d** One of: Water is needed to allow chemical reactions, such as respiration, to occur. Oxygen is needed for respiration. Warmth is needed because chemical reactions, such as respiration, do not happen very quickly when it is cold.
- The raw materials for photosynthesis are *carbon dioxide* and *water*. The sugar made by photosynthesis is called *glucose*. *Oxygen* gas is also produced. Photosynthesis needs energy transferred by *light* to make it happen.

## Breathing and respiration

- 3 a C b A c respiration d glucose  
 4 a for food/nectar/pollen to eat  
 b for pollination  
 c less seeds/fruits due to less pollination.

**8Be-6 Growing from seed**

- 1 1 – flowering – The plant makes flowers.  
 2 – pollination – Pollen grains land on a stigma.  
 3 – fertilisation – The male gamete joins with the egg cell.  
 4 – seed dispersal – Fruits are carried away from the parent plant.  
 5 – germination – The seed starts to grow a tiny shoot and root.  
 6 – mature plant – The plant is old enough to have flowers.
- 2 oxygen, warmth, water
- 3 The function of part X is to provide raw materials/glucose for respiration (food store). The function of part Y is to protect the seed (seed coat).
- 4 carbon dioxide, water (*not* energy)
- 5 It needs light for photosynthesis. Photosynthesis is used to make the plant's food.

**8Be-7 New plants from seeds**

- 1 a March  
 b 3 months (it flowers in June)  
 c Seedlings may appear and be killed off by cold/frost; if the seedlings did survive and flower, there would be no pollinators to pollinate the flowers.  
 d root  
 e anchors the seedlings and absorbs water  
 f water and oxygen (*not* warmth because that isn't a substance)  
 g Water to allow chemical reactions to occur (or to allow cells to swell); oxygen for respiration.  
 h the food store in the seed
- 2 a It has reduced their populations because they depend on flowers for nectar/pollen to eat.  
 b made it more difficult for some crops, such as fruit trees, to be pollinated and produce fruit because there are fewer pollinators
- 3 glucose + oxygen → carbon dioxide + water  
 water + carbon dioxide → oxygen + glucose
- 4 a the seed coat  
 b Water soaks into it slowly and softens it.  
 c The seeds will last through the winter so when they germinate conditions will be right for good growth of the seedlings.  
 d They depend on one another. Bumblebees depend on wild primrose flowers for food (nectar/pollen) and the flowers depend on the bumblebees for pollination.

**8Be-8 Germination and photosynthesis**

- 1 a starch  
 b Using iodine solution. A blue-black colour indicates the presence of starch.  
 c Negative result. The soda lime absorbs the carbon dioxide and so the leaf cannot photosynthesise.
- 2 a Shaded area is only the green central area of the leaf, which should have a straight edge across the top of it where the foil was.  
 b Photosynthesis requires light and chlorophyll. There is no chlorophyll in the white parts of the leaf. Light cannot reach the parts of the leaf covered by the foil.  
 c chloroplasts
- 3 a testa protects the seed; cotyledon is the food store; radicle absorbs water and becomes the root, anchoring the seedling; plumule grows into a shoot to support the leaves  
 b It's the radicle that absorbs water for the embryo to start to grow and develop and so it is closest to the place where water enters the seed.
- 4 a Red light promoted germination at the end of the sequence, whereas far red light at the end of the sequence inhibited germination.

b If only far red light is reaching the seeds then there must be plants above them, shading the seeds. If the seeds grew they may not get enough light and would be in competition with the other plants. Therefore, seeds will germinate only when there is nothing that will stop them from growing well above/near them.

**8C Breathing and respiration****8Ca Aerobic respiration****Student Book****1: 8Ca Water sports and breathing**

- 1 a oxygen  
 b respiration; aerobic respiration  
 c cells; mitochondria  
 d blood; red blood cells
- 2 carbon dioxide
- 3 a mouth/nose, trachea/windpipe, bronchi, bronchioles, lungs  
 b diaphragm or muscles between ribs
- 4 a the number of breaths taken in a minute  
 b They both increase.  
 c More oxygen is needed by cells, therefore more air needs to be taken into the lungs so that more oxygen can be taken into the blood; the oxygen needs to be supplied to the cell more quickly by the blood so the blood must be pumped faster.

5 to remove the lactic acid from their bodies; may include mention of EPOC or the oxygen debt, although this isn't covered until 8Ce.

## 2: 8Ca Aerobic respiration

1 a The amount of oxygen in his blood is lower than it should be.

b oxygen

c His organs may become damaged.

2 finding evidence to support or not support an idea

3 Candles go out and mice are killed if you remove air.

Burning candles and living mice both need something from the air (and this may involve similar processes).

4 a The animal/candle died/went out after the water level had risen a small way up the beaker. If all of the air could be used by the animal/candle, the water level would have risen much further/to the top.

b The water level stopped rising at the same level in each case.

5 a beaker X because the peas are respiring (and this process releases energy, some of which is transferred by heating); accept answers that refer to releasing 'heat energy'

b beaker X because the peas are respiring (and this process produces carbon dioxide)

6 a Both processes produce carbon dioxide, produce water, release energy and use oxygen.

b one of: burning transfers some energy as light, respiration is a series of reactions, respiration is more controlled

7 a oxygen + glucose  $\rightarrow$  carbon dioxide + water

b good model, one from: you can see the reactants and products clearly, it is simple to understand; poor model, one from: it doesn't tell you anything about the energy released, it doesn't show you that a whole series of reactions is occurring

## Activity Pack

### 8Ca-1 Aerobic respiration

1 a drawing of candle with no flame

b Candles need air to burn.

c The snail will die.

2 a draw in the water level higher than in the diagram on left

b Burning only uses up a part of the air.

3 a reactants: glucose, oxygen; products: carbon dioxide, water

b energy

### 8Ca-3 Combustion and respiration

*Statements about both:*

glucose can be used as a fuel

glucose + oxygen  $\rightarrow$  water + carbon dioxide

the energy released is transferred by heating

the products of the reaction are oxides

makes things get warmer

energy is released

produces a gas

can be modelled using a word equation

is useful on camping expeditions

oxygen is used up

*Combustion only:*

metals can be used as a fuel

some energy released is transferred by light

wood can be used as a fuel

energy is released quickly

*Aerobic respiration only:*

happens in living cells

energy is released slowly

*Neither:*

happens in dead cells

produces a solid

### 8Ca-4 O2POW

1 Oxygen is a vital element needed by your body.

Oxygen is also a key substance used in a process that keeps your body warm.

This is because oxygen allows your cells to release energy.

Your cells can't use glucose sugar without oxygen.

2 a When your body has plenty of oxygen for aerobic respiration, the only product is harmless water.

b When your body has plenty of oxygen for aerobic respiration, the only products are water and carbon dioxide. (Note that energy should not be included here because it is not a product of the reaction.)

3 We get oxygen into our bodies using our lungs and not through the digestive system.

4 *Students' own adverts.* Possible health claims for 'fresh air' could include 'Contains oxygen', 'Contains the same percentage of oxygen that your lungs are adapted for', 'Contains very little carbon dioxide'.

### 8Ca-5 Ideas about respiration

1 a Heat is produced by respiration.

b The carbon dioxide we breathe out is made by respiration.

c Respiration happens in all living cells.

## Breathing and respiration

2 glucose

3 a carbon dioxide, water

b It will die.

c The oxygen will run out (or the carbon dioxide will increase and poison the bird).

4 with/needng air/oxygen

### 8Ca-6 La vie est une fonction chimique

1 a combustion/burning and aerobic respiration

b Both processes release energy, which is transferred to the ice and increases its temperature, so causing it to melt. Many students will write something like 'heat is produced, which melts the ice'. Give credit for this sort of answer but encourage students to talk about 'energy being released' and this energy causing a temperature rise.

c Combustion and aerobic respiration were similar processes, or combustion has the same effect as aerobic respiration but takes less time.

d Since respiration is a chemical reaction, living things need to use a chemical reaction to stay alive.

2 a glucose + oxygen → carbon dioxide + water

b with/needng air/oxygen

3 a The higher you go, the less saturated your blood is with oxygen.

b two from: feels tired; feels short of breath (breathing rate increases); heartbeat (pulse rate) increases

c The climber would feel tired because his muscles cannot get enough oxygen for aerobic respiration and so don't work as well; feels short of breath because his muscles need more oxygen but there is less oxygen in the air; his pulse rate increases because the heart pumps faster to get what oxygen there is quickly from the lungs to the muscles.

d The oxygen saturation at those altitudes is very low and this may harm the climber, or prevent them from reaching the summit.

### 8Ca-7 Aerobic respiration and oximetry

1 a with/needng air/oxygen

b glucose + oxygen → carbon dioxide + water

c glucose → pyruvate + water

d Possible good points: it is easy to understand; it clearly shows what you start with and what you end with.

Possible poor points: it doesn't give any information about how the reaction(s) occur(s); it doesn't give any information about energy.

It is a useful model because it helps us to understand why aerobic respiration causes changes in an organism/an organism's surroundings, and we don't need to know how it happens.

2 a 4

b 50%

c drawing of five haemoglobin molecules to which 16 oxygen molecules are attached, with no more than four oxygen molecules on each haemoglobin

3 a It is likely to fall. A lower pH (i.e. more acidic solution) results in more oxygen leaving the haemoglobin molecules.

b suitable suggestions: temperature, time of day, restedness/level of activity of subject, room/place of testing, pulse oximeter used

c suitable reasons include: temperature will cause higher oxygen saturation readings because lower temperatures make it less likely that oxygen will leave haemoglobin molecules; time of day may affect temperature or amount of food eaten by subjects; more active subjects may be respiring more and so using more oxygen from their blood; the air in different rooms/places may contain more carbon dioxide depending on the number of people in the room; a different pulse oximeter may not be calibrated the same (or words to that effect) and so may give different readings.

### 8Cb Gas exchange system

#### Student Book

#### 1: 8Cb Gas exchange system

1 bellows – ribs cage/muscles/diaphragm; bladder – lung

2 They contract (breathing in) and relax (breathing out).

3 Label 1: The bellows are pushed together. Label 2: The air pressure inside the bellows is increased. Label 3: The pressure inside the bellows pushes air out of the bladder, which deflates. As it deflates the air pressure inside the bellows falls. It carries on falling until the pressure inside the bellows is the same as atmospheric pressure.

4 There are cells that produce mucus to trap dirt etc., and there are ciliated epithelial cells, which have cilia to sweep the dirty mucus away.

5 There is a movement of oxygen from the air in the lungs into the blood and a movement of carbon dioxide in the opposite direction.

6 a the overall movement of particles from an area where there are a lot of them to an area where there are fewer of them

b Molecules move in all directions, so by chance some will move in one direction and others will move in the opposite direction.

7 mouth/nose, trachea/windpipe, bronchus/bronchi, lungs

- 8** It would decrease the speed of gas exchange because there would be less area/room for the gas molecules to get from one side of the lung to the other.
- 9** The cilia do not work and so mucus builds up. This increases the distance through which gases have to move to pass between blood and air in the lungs and/or this reduces the amount of surface area for gas exchange, because some of it is blocked.

## 2: 8Cb Means and ranges

- 1 a** to check readings so that you can be more sure that they are correct
- b** *Students' own answers:* the bag, because it is really simple to do and doesn't need a lot of setting up; the computer, because it can take lots of measurements quickly and easily
- c** for the bag: it is not very accurate, it is time consuming to take lots of repeated readings; for the computer and spirometer: it is expensive, you have to learn the software to run it
- 2 a** Hitesh:  $30\text{ cm}^3$  before exercise,  $110\text{ cm}^3$  after exercise; Josie:  $50\text{ cm}^3$  before exercise,  $200\text{ cm}^3$  after exercise
- b** the results before exercise because they have a narrower range
- 3** Hitesh before exercise  $435\text{ cm}^3$ , Josie before exercise  $327.5\text{ cm}^3$  (a better answer would round this up to  $330\text{ cm}^3$  since all the figures in the table are given to only two significant figures); Hitesh after exercise  $1037.5\text{ cm}^3$  (a better answer would round this up to  $1040\text{ cm}^3$ ), Josie after exercise  $860\text{ cm}^3$
- 4** one that doesn't follow the same pattern as the others
- 5 a** any sensible suggestion, e.g. running on the spot, star jumps, stepping
- b** to take multiple repeat readings so that you can be more sure that the results are correct
- c** Suggestions are likely to be three or four times. The justification should include a weighing up between the amount of time that it takes to do a lot of repeats versus how concentrating on your breathing rate can change it and so it is difficult to get accurate values. By taking a lot of readings you are more likely to get an accurate value for the reading.
- d** Add up each set of repeated figures and divide by the number of repeat readings.
- 6** Pulse and breathing rate will increase after exercise.

## Activity Pack

### 8Cb-1 The gas exchange system

- 1** correctly labelled diagram
- 2** breathing – using muscles to expand and deflate the lungs  
ventilation – air moving into and out of the lungs

- respiration – a chemical process that happens in cells  
alveolus – a small pocket in the lungs  
gas exchange – oxygen and carbon dioxide diffusing in the lungs
- 3** correct order (top to bottom) 5, 3, 4, 6, 2, 1
- 4** They are constantly moving.
- 5** so that gas exchange happens quickly

### 8Cb-5 Mouth-to-mouth resuscitation

- 1** Correctly arranged information. The sentences should read:
- Step A** – *Place the person face upwards on a solid, flat surface. To open the airways, tilt the head backwards by placing one hand on the forehead and gently lifting up the neck.*
- Step B** – *Support the back of the neck and open the mouth and check that there is nothing blocking the back of the mouth. You may need to remove anything that is blocking the windpipe or pull the tongue out of the way.*
- Step C** – *Hold the nose, take a deep breath, open your mouth and place it onto the person's lips. Breathe out gently but hard enough to get the person's chest to rise.*
- Step D** – *Remove your mouth and look to see that the person's chest is falling, while listening for air coming out of the lungs. Repeat these last two steps every 5 seconds until medical help arrives or breathing re-starts.*
- 2** The cells need oxygen for aerobic respiration and will die without it.
- 3** They are causing air to flow into and out of the person's lungs. (Air flow is ventilation.)
- 4** make the trachea/windpipe as wide as possible
- 5** Too strong a breath can damage the delicate parts of lungs, especially in a young child.
- 6** Air from the person doing the resuscitation is at higher pressure than atmospheric pressure and so leaves the person and goes into the injured person. The air in the injured person is now at higher pressure than atmospheric pressure and so the lungs expand. When the person doing the resuscitation stops breathing out, the injured person's lungs deflate again because the elastic walls of the lungs squash the air, putting it at higher pressure than atmospheric pressure and so air flows out of the lungs.
- 7 a** Gas exchange will be reduced because there is less fresh air (containing more oxygen) getting into the lungs because of the narrower tubes. The widening of the capillaries will squash the alveoli and so reduce their surface area, which will also reduce gas exchange.

- b** anaphylaxis

## Breathing and respiration

8 The adult's mouth is placed to cover both the mouth and nose.

**8Cb-6 Breathing, ventilation and respiration**

1 a ventilation

b mouth/nose, trachea/windpipe, bronchus/bronchi, lungs

2 respiration; aerobic respiration

3

	Do the ribs move in or out?	Does the diaphragm move up or down?	Does air in the trachea contain more or less carbon dioxide?
Inhaling	out	down	less
Exhaling	in	up	more

4 a As the cord is pulled, it pulls down the rubber sheet and this makes the space inside the jar bigger and so air flows into the balloons and they get bigger. As the cord is pulled, it pulls down the rubber sheet and so lowers the pressure inside the jar. Atmospheric pressure is now greater than this pressure and so air flows into the balloons and they expand.

5 alveoli

6 a gas exchange

b Particles are always moving, so naturally move into places where there are fewer of them.

**8Cb-7 Lungs and gas exchange**

1 a i diaphragm ii lungs iii trachea/windpipe

b Students working in the *Developing* progression band may not talk in terms of pressure (e.g. as the cord is pulled, it pulls down the rubber sheet and this makes the space inside the jar bigger and so air flows into the balloons and they get bigger), whereas a better answer (*Securing* progression band) will be in terms of pressure (e.g. when the rubber sheet is pulled down, the pressure inside the jar is reduced. Air rushes into the balloons to balance the pressure inside and outside the balloons. When the rubber sheet is let go, the pressure inside the jar is increased. Air flows out of the balloons until the pressure inside the balloons is equal to the pressure outside them).

c Breathing is the movement of the muscles (to increase/decrease the volume of the lungs), ventilation is the flowing of air.

2 a cilia

b sweep mucus containing trapped dirt away from the lungs (and to the top of the gullet to be swallowed).

c diagram B

d The cilia are inactive.

3 The capillary walls are thin and so are the walls of the alveoli, and so there is not far for particles to

travel (speeding up gas exchange). Also the alveoli give the lungs a large surface area (also speeding up gas exchange). Give credit for using scientific terms (such as alveoli, capillaries, surface area). Some students may also answer in terms of blood flow and ventilation maintaining the diffusion gradients of oxygen and carbon dioxide but students are not expected to know this (see Worksheet 8Cb-8).

**8Cb-8 Gas exchange rates**

1 The overall movement of particles from a place where there are more of them to a place where there are fewer of them due to the natural movement of particles.

2 a X – you move down the concentration gradient from left to right.

Y – you move down the concentration gradient from the bottom to the top.

Z – you move down the concentration gradient from right to left. Answers may also be in terms of going up the concentration gradient.

b Z, X, Y

3 is for correctly identifying alveoli, air sac, capillaries.

would consider that the capillary walls are thin and so are the walls of the alveoli, and so there is not far for particles to travel (speeding up gas exchange). Also the alveoli give the lungs a large surface area (also speeding up gas exchange).

is for talking in terms of the concentration gradient being maintained. With a continuous supply of blood replacing the newly oxygenated blood in the capillaries, the concentration gradient of oxygen is maintained and kept steep (between blood and the air in the lungs). With a continuous supply of air replacing the newly de-oxygenated air in the capillaries, the concentration gradient of carbon dioxide is maintained and kept steep (between blood and the air in the lungs).

**8Cc Getting oxygen****Student Book****1: 8Cc Getting oxygen**

1 no because they are a dark brown-red colour

2 a carbon dioxide (accept water vapour)

b aerobic respiration (try to ensure that students use this full terminology)

c mitochondria

d It diffuses out of the cell and into a capillary, where it dissolves in the blood plasma. In the lungs, it diffuses out of the capillary and into an alveolus/air sac, from where breathing movements then move it out of the lungs and into the surrounding air.

The answer will talk in terms of 'moving'.

The answer will mention diffusion (although the term does not need to be explained).

**3** in the blood

The answer will state that it is dissolved in the blood plasma.

**4 a** During exercise, more energy is needed therefore more aerobic respiration needs to occur, which needs more oxygen. The swimmer breathes faster to get more oxygen into the blood.

**b** During exercise, more energy is needed and increased blood flow will deliver more oxygen to the muscle cells.

**5** Tar coats the alveoli making diffusion of oxygen into the blood slower; smoke irritates the lungs and can cause the alveoli to break down, reducing surface area; carbon monoxide stops red blood cells carrying oxygen; smoke and heat cause the cilia to stop working and mucus builds up which can cover some of the surfaces used for gas exchange.

**6 a** X

because the cavities are much bigger resulting from the alveoli breaking down

**b** They would have a higher breathing rate because there is less surface area in the lung when someone has emphysema, so there is less area over which oxygen can diffuse and less oxygen gets into the blood. With less oxygen getting into the blood in each breath, the person needs to breathe faster in order to make sure that enough oxygen gets into the blood.

The answer will mention the need to maintain a steep concentration gradient (the steeper the concentration gradient, the faster diffusion occurs and by cycling air through the lungs more quickly the percentage of oxygen in the lungs is always maintained at a higher level than with slower breathing).

## 2: 8Cc Epidemiology (STEM)

**1 a** Yes, the two variables change together in the same way.

**b** No, the graph can only show a correlation not a cause; more information is needed to show a causal link.

**c** Ice cream sales and shark attacks both increase with increasing temperature; this could suggest that more people go to the seaside on hot days, where they are more likely to eat ice cream and more likely to go into the sea where they are attacked by sharks.

**2** As smoking index increases (people smoking more), the number of deaths from lung cancer increases.

**3** Smoking more increases the amount of substances from tobacco smoke taken into the lungs. This increases the chance that some lungs

cells will be affected by the substances and become cancerous.

**4** Vital capacity should show some correlations with some factors, for example: adult males, on average, have a larger vital capacity than adult females; vital capacity increases from childhood to adult height in adult males, for example, may show a correlation with vital capacity, but other factors have an effect (such as fitness, playing a wind or brass instrument) so this correlation may not be seen.

## Activity Pack

### 8Cc-1 Getting enough oxygen

**1 a** All three factors will go up.

**b** She needs more oxygen because aerobic respiration is happening faster.

**2 a** red blood cell

**b** to carry oxygen

**c** bright red

**d** dark brownish red

**e** carbon monoxide

**f** tar or nicotine or 'particles' (do not accept 'heat')

**3** aerobic respiration

**4 a** emphysema

**b** There is less surface area.

**5** They die.

### 8Cc-5 Gas exchange and circulation 2

**1 a** circles only drawn inside blood vessels

**b** Circles nearer to the entry of the blood are coloured in brown and those nearer to the exit of the blood are coloured in red.

**2 a** Arrows of appropriate colour for oxygen going from the alveolus to the inside of the blood vessel.

**b** Arrows of appropriate colour for carbon dioxide going from the inside of the blood vessel to the alveolus.

**3** plasma

**4** Circles nearer to the entry of the blood (on the left) are coloured in red and those nearer to the exit of the blood are coloured in brown.

**5 a** Arrows of appropriate colour for oxygen going from a capillary to the tissue. Award extra credit for arrows that start in a red blood cell and end clearly inside a tissue cell.

**b** Arrows of appropriate colour for glucose going from a capillary to the tissue. Award extra credit for arrows that start in the plasma of the blood and end clearly inside a tissue cell.

**c** Arrows of appropriate colour for carbon dioxide going from the tissue into a capillary. Award extra credit for arrows that start in a tissue cell and end clearly in the blood plasma.

## Breathing and respiration

**6 a** The blood vessel leaving the lungs should be coloured (e.g. bright red) to show oxygenated blood and the blood vessel going to the lungs should be coloured (e.g. brown) to show deoxygenated blood. Elsewhere, the blood coming from the heart towards the body is oxygenated and the blood leaving the capillaries before returning to the heart is deoxygenated. Award extra credit if there is an attempt to show a gradual deoxygenation of the blood as it moves through the capillaries.

**b W** – high oxygen because the blood has just gone through the lungs and picked up oxygen

**X** – high oxygen because the blood is returning from the lungs where it picked up oxygen

**Y** – high oxygen because the blood is still in an artery and has not been through any capillaries yet

**Z** – low oxygen because the blood has just been through capillaries where tissue fluid has leaked out taking oxygen to be used up by the cells for aerobic respiration.

**c** correctly labelled diagram

**7 a** The heart pumps faster so moving blood faster through the system.

**b** The cells are respiring more. So, the cells need more oxygen. Oxygen is carried by the blood. So, the heart pumps blood faster to supply more oxygen.

**8 a** Any way in which the surface area of the lungs is decreased (e.g. emphysema) or the flow of air into and out of the lungs is diminished (e.g. asthma attack).

**b i** explains that their blood contains less oxygen and so has to be pumped faster to get enough oxygen to the cells.

will mention concentration gradients and explain that blood needs to be moved on faster in order to maintain a steeper concentration gradient.

**ii** there is less of the oxygen in each breath getting into the blood and so more breaths are needed to get enough oxygen into the blood.

the air needs to be cycled faster in order to maintain a steeper concentration gradient.

**8Cc-6 Poisons**

1

Condition	Cause	Symptoms	Treatment
hypercapnia (too much carbon dioxide in the blood)	lung disease	breathing very quickly	breathing in 100% oxygen
carbon monoxide poisoning	breathing in poisonous gas	parts of the skin go bright red due to the poison sticking to red blood cells and turning them bright red	breathing in 100% oxygen
hydrogen cyanide poisoning	breathing in poisonous gas	skin goes pink due to high oxygen concentration in blood	injecting a chemical that sticks to the poison and makes it harmless
blue-baby syndrome	too many chemicals called nitrates in drinking water	the skin turns a bluish colour since the blood cells break apart and cannot carry oxygen	in severe cases a blood transfusion (extra blood) is given

**2** Hydrogen cyanide and carbon monoxide poisoning. Students may have included blue-baby syndrome if they make the reasoned point that someone could have been giving the baby water containing excess nitrates on purpose.

**8Cc-7 Capillaries and respiration**

**1 a** it increases/goes up

**b** it increases/goes up

**c** He needs to release more energy using aerobic respiration.

**d** blood vessel; capillary

**e** tissue fluid

**f** oxygen, glucose

**g** arrow drawn from the end of the dashed arrow back to a capillary

**2 a** A reduction in internal surface area of the lungs, or an increase in the distance over which diffusion occurs (e.g. by covering surfaces with a film).

**b** A reduction in the surface area from emphysema or the loss of a lung. An increase in distance over which diffusion occurs (e.g. mucus from asthma or lung infection, tar coating from cigarette smoke).

**3 a** tar or nicotine

**b** It stops red blood cells carrying oxygen.



**8Cc-8 Reducing and increasing gas exchange****1 a i Y ii X iii Z**

**b** The more active she is, the more energy she needs. Energy is released by aerobic respiration. Aerobic respiration requires oxygen. A faster pulse rate delivers more blood carrying oxygen to the muscles.

**2** Oxygen from red blood cells dissolves in the plasma. The plasma leaks out of capillaries, carrying oxygen and glucose. The oxygen and glucose diffuse into cells. The oxygen and glucose are used up in aerobic respiration, and carbon dioxide is produced. This is carried in the tissue fluid back to a capillary.

**3 a** Nicotine reduces the blood flow.

**b** The more nicotine in the cigarette, the more the blood flow in the capillaries is slowed.

**c** it narrows them

**d** They may not run so fast because less blood would get to their muscle cells and so less oxygen would get to their muscle cells (to be used in aerobic respiration).

**e** Tar coats the lungs and so makes diffusion of gases/gas exchange more difficult, so less oxygen enters the blood. Carbon monoxide stops red blood cells carrying oxygen, so less oxygen can be carried by the blood.

**f** aerobic respiration (do not accept respiration)

**8Cc-9 Coronary heart disease**

**1** Oxygen leaves red blood cells and dissolves in the plasma. Plasma leaks out of the capillaries, forming tissue fluid. Oxygen diffuses from the tissue fluid into the heart muscle cells.

**2 a** Doing exercise lowers the risk of developing CHD.

**b** Exercise reduces the amount of fatty substances in the blood and so there is a lower risk of plaques forming. Exercise increases lung volume meaning that there is more air in every breath and so more oxygen gets into the blood. Exercise increases heart volume and so more blood is pumped around the circulatory system with each beat. All of these increase the amount of oxygen that can get to heart muscle cells.

**3 a** The heart muscles work harder and so respire more and so need more oxygen. The pain starts as the cells start to become short of oxygen.

**b** The pain is likely to start at lower intensities of exercise if the amount of oxygen in the blood is already lower. This can be caused by smoking in various ways:

tar coating the lungs slows down diffusion of oxygen into the blood

carbon monoxide reduces the amount of oxygen that the red blood cells can carry

irritation of the lungs can damage the air sacs/alveoli, reducing the surface area over which oxygen can diffuse

heat from cigarettes causes cilia to stop working, so mucus builds up and coats the surfaces of the lungs leading to slow diffusion of oxygen

In addition, nicotine makes the build up of plaques more likely, causing arteries to become narrower and reducing the flow of blood to the heart muscles.

**8Cd Comparing gas exchange****Student Book****1: 8Cd Comparing gas exchange**

**1 a** They have an organ full of blood (note that this is an adaptation of the spleen of an elephant seal).

**b** The blood in the organ contains oxygen which can then be pumped around the body when needed, while the animal is diving.

**2** It will last longer: Allan is doing less exercise so his muscles will be respiring less and he will use less oxygen.

**3** Nitrogen remains the same because nitrogen is not used in aerobic respiration. Oxygen levels are lower in exhaled air because oxygen diffuses out of the lungs and into the blood where it is carried to cells for respiration. Carbon dioxide levels are higher in exhaled air because carbon dioxide produced by respiration diffuses from the blood and into the air in the lungs. Water vapour levels are higher because the surfaces of the lungs are damp and the water evaporates from them. The temperature is higher in exhaled air because the body is warmed by aerobic respiration and the temperature of the lungs warms the air inside them.

**4 a** tube X

**b** It has gone milky/cloudy.

**c** Tube X will go yellow because exhaled breath contains a lot of carbon dioxide and this lowers the pH and makes the indicator turn yellow. (Tube Y will also go yellow after a while, as it absorbs the small amounts of carbon dioxide in the air that is bubbling through it.)

**5 a** oxygen, glucose (sugar)

**b** oxygen diffuses into the leaves through the stomata/oxygen is made by photosynthesis; plants make their own glucose (sugar)

**6** Fish are respiring and producing carbon dioxide, an acidic gas. The carbon dioxide diffuses into the water in the fish's gills.

**7** similarities include:

oxygen diffuses into the blood

## Breathing and respiration

carbon dioxide diffuses out of the blood, the surfaces where gas exchange takes place are covered in water, the organs used for gas exchange have very large surface areas

differences include:

mammals exchange gases with the air but fish exchange gases with water

the fluid from which gases are exchanged flows into and out of the lungs in the same tubes but there is a one-direction flow of water across gills

### Activity Pack

#### 8Cd-1 Comparing gas exchange

- All ticked apart from 'fire'.
- It went from clear and colourless to cloudy/milky.
  - Sasha's breath contained carbon dioxide.
- The temperature increases.
  - Energy is released into the surroundings by respiration.
- Arrows showing movement of carbon dioxide out of the leaf and movement of oxygen into the leaf.
  - stomata (accept 'stoma')
- water
  - gills

#### 8Cd-6 Respiration card sort

*Statements that apply only to animals:* Lungs excrete carbon dioxide. Respiration occurs in heart tissue. Gas exchange can happen in gills.

*Statements that apply only to plants:* Respiration happens in leaf cells. Gas exchange happens using stomata. Respiration happens in root cells.

*Statements that apply to both plants and animals:* Respiration releases energy from glucose. Aerobic respiration occurs in mitochondria. Cells die if they do not get enough oxygen. Oxygen can be taken from air or water. Water is a product of respiration. One product of respiration turns limewater cloudy. Respiration uses up a sugar. Gas exchange occurs through diffusion. Respiration makes the temperature go up.

*Statements that apply to neither:* Respiration only occurs when it is dark. The reactants in aerobic respiration include water. Respiration produces an alkaline gas.

#### 8Cd-7 Respiration in plants and animals

- oxygen
- oxygen
- carbon dioxide
- carbon dioxide
- all cells
- limewater
- A – yellow, B – yellow, C – yellow, D – pink

#### 8Cd-8 Differences in gas exchange

- The temperature in A will rise because the cells in the peas are respiring. The temperature will not rise in B as all the cells in the peas will be dead.
  - The gas from A will turn limewater milky because the peas in A are alive and respiring. The gas from B will not produce any effect in the limewater.
  - Use an indicator (such as hydrogen carbonate or bromothymol blue) to test for acidity in the gases. The gas from A will be more acidic due to additional carbon dioxide from respiration. Alternatively, students might suggest burning candles in the different gases. The candle will burn for less time in flask A because some of the oxygen will have been used up in respiration.
- The higher the temperature, the more often the operculum opens and closes.
  - It would appear from the experiment that warmer water must contain less oxygen. Fish need to pump warmer water faster over their gills in order to get the same amount of oxygen as they would in colder water.

- They do not have a mechanism to pump water and so must swim to create a flow of water over their gills.

- Since gas exchange happens through their skins as well, they don't have so large a surface area in their lungs.

- All the cells are living and so need to respire.
  - Gases produced by respiration diffuse out of a leaf through the stomata.

#### 8Cd-9 Efficient gas exchange

- one of: they both have a large surface area; they both have a rich supply of blood; they both are moist to allow gases to dissolve; they both have short distances for diffusion to occur; they both use concentration gradients

- one of: lungs have pockets but gills have projections; lungs expand and contract but gills do not; lungs extract the oxygen from air, gills extract it from water

- Oxygen from the air needs to dissolve in water in order to get into the blood and so frogs must keep their skin moist for it to exchange gases to obtain oxygen.

- The gill filaments collapse and stick together, reducing the surface area for gas exchange.
- so that gas exchange can occur when they are exposed to air or when submerged by the tide

- When the two volumes of blood are mixed, the resulting oxygen percentage has equal contributions from the lungs and from the gills. If the mixed blood is 53% and the blood from the

lungs is 61% (8% higher), then the blood from the gills must be 8% lower; 45%.

**c** The lungs are more efficient.

**d** three of: the gills collapse in air, the gills have less surface area, the gills maintain a lower concentration gradient, the distance gases have to travel is greater for the gills

**4 a** Gills, because they have the greatest surface area.

**b** one of: there is a greater concentration gradient between the blood and the air in pouch X, there is less of a distance for gases to travel into and out of the blood in pouch X. (It is this last explanation that has been shown to be most likely.)

**c** It cannot obtain all the oxygen it needs using its gills.

### 8Ce Anaerobic respiration

#### Student Book

##### 1: 8Ce Anaerobic respiration

**1** carbon dioxide and water vapour.

**2** The more they move, the more energy they need and the more of their oxygen reserves will be used up.

**3** aerobic respiration and anaerobic respiration

**4 a** It cannot be done for a long time./It requires more energy than can be supplied by aerobic respiration./It builds up EPOC/an oxygen debt.

**b** Anaerobic respiration makes muscles become tired quickly./Anaerobic respiration uses up glucose faster than aerobic respiration and so runs out of glucose in the muscles quickly.

**5** *Students' own answers*, containing the following – similarities:

they both use glucose, they are both used during strenuous exercise, they both release energy differences:

anaerobic respiration produces lactic acid but aerobic respiration does not, anaerobic respiration makes the muscles become tired quickly

aerobic respiration occurs in mitochondria but anaerobic respiration occurs in the cytoplasm, anaerobic respiration releases less energy than aerobic respiration Anaerobic respiration leads to the formation of less ATP than aerobic respiration.

**6** It is transported in the blood to the liver where it is turned back into glucose.

**7 a** to get extra oxygen into the body

**b** to get oxygen to cells/the liver faster

**8** lactic acid being turned into glucose in the liver requires additional energy from aerobic respiration; replenishing oxygen stores in blood and muscles; additional aerobic respiration required to operate

rib muscles and diaphragm at a faster rate (faster breathing rate); additional aerobic respiration required to operate heart muscles at a faster rate (faster pulse rate)

### 2: 8Ce Fitness training

**1 a** aerobic respiration

**b** glucose and oxygen

**c** it turns limewater milky

**d** anaerobic respiration

**2** attached to the ribs, in the diaphragm

**3** It diffuses into the blood and is carried on red blood cells to the capillaries where it dissolves in the blood plasma.

It is then carried out of the capillaries as tissue fluid and diffuses into cells.

**4** oxygen is need for aerobic respiration; nicotine can cause the arteries to narrow, reducing blood flow; tar can coat the lungs, reducing gas exchange carbon monoxide prevents the blood carrying as much oxygen; tar can irritate the lungs and cause coughing, which, over time, can cause the air sacs to collapse and so reduce gas exchange; smoke stops cilia from working, which means that an athlete may be more prone to lung infections that disrupt training; non-working cilia mean that mucus can coat the lung surfaces reducing surface area for gas exchange

**5 a** Before exercise there is a steady pulse as the heart pumps blood containing enough oxygen so that all cells can respire aerobically. When exercise starts, the pulse rate increases to supply more oxygen to the cells because they are respiring faster.

The pulse rate increases to increase the rate at which lactic acid is removed from muscle cells. After exercise, the pulse rate starts to drop since not as much oxygen is needed by the cells because they are working less hard. However, it remains above resting level for a while in order to replenish oxygen stores and provide oxygen for additional aerobic respiration.

**b** Their pulse rate returns to normal faster after exercise than when less fit and their pulse rate is not as high while they are exercising.

**c** Regular exercise causes the heart muscle to increase in strength and so it pumps out more blood with each beat./Regular exercise causes the breathing muscles to increase in strength.

Increase in strength of the heart muscles means that the heart does not need to pump so fast to supply enough oxygen./ Increase in strength of the breathing muscles means that the lungs become bigger and can exchange more oxygen.

**Activity Pack****8Ce-1 Anaerobic respiration**

- 1 **a** carbon dioxide  
**b** the girl sprinting  
**c** She is doing the most strenuous exercise and so is respiring more and so is producing more carbon dioxide.
- 2 **a** lactic acid  
**b** doing hard exercise, sprinting, holding your breath for a very long time, when there is a lot of carbon monoxide in the blood  
**c** both aerobic and anaerobic  
**d** All cells always respire aerobically. They respire anaerobically as well if aerobic respiration cannot meet the energy needs of the body.
- 3 lactic acid in cell → lactic acid in blood → lactic acid in liver → converted to glucose
- 4 in blood, in muscles

**8Ce-3 Comparing respiration**

1 *Aerobic respiration only*: Produces carbon dioxide; Requires oxygen; Water is a product; Occurs in mitochondria.

*Anaerobic respiration only*: Causes muscles to become tired quickly; Produces lactic acid; Produces a substance that is broken down by the liver; Is a main cause of EPOC; Can be switched on suddenly.

*Both aerobic and anaerobic respiration*: releases energy from glucose; occurs in muscle cells; increases as hardness of exercise increases; produces an acidic substance.

*Neither aerobic nor anaerobic respiration*: produces oxygen; requires lactic acid; requires water as a reactant; carbon monoxide is a product; uses up blood.

**8Ce-4 Changing ideas about anaerobic respiration**

*The cards are already in the correct order. Scientist 1: A – F. Scientist 2: G – L*

A&G – observation

B&H – scientific question

C&I – hypothesis

D&J – prediction

E&K – experiment

F&L – results

**8Ce-5 Aerobic and anaerobic respiration**

1

	<b>Aerobic respiration</b>	<b>Anaerobic respiration</b>
Releases energy?	✓	✓
Needs glucose?	✓	✓
Needs oxygen?	✓	×
Produces a gas?	✓	×
One product is acidic?	✓	✓

2 **a** It goes up.

**b** More energy is needed by muscles at higher speeds, so more respiration needs to happen, which requires more oxygen to reach cells.

**c** 18 km/h

**d** The lactic acid line on the graph is higher for this value than the others.

**e** Not enough energy can be released by aerobic respiration alone.

**f** If this aerobic respiration stopped, then the muscles would not have enough energy.

**8Ce-6 Maggot and human respiration**

1 two from: one needs oxygen and the other does not; aerobic respiration occurs in mitochondria but aerobic respiration occurs in the cytoplasm; anaerobic respiration releases less energy than aerobic respiration; anaerobic respiration produces lactic acid but aerobic respiration does not; anaerobic respiration makes the muscles become tired quickly

2 **a** at rest, or low activity

**b** during strenuous exercise

**c** never

**d** if the cell is dead

3 It makes the muscles become tired quickly.

4 **a** glucose → lactic acid

**b** liver

**c** carried in the blood

5 **a** To the left – because the maggots are using up oxygen for aerobic respiration and the gas that they produce is being removed by the soda lime, so reducing the volume of gas in the flask.

**b** It gradually decreased for both sets of maggots.

**c** There was less and less oxygen available and so aerobic respiration slowed down.

**d** To ensure a fair test. The maggots in set A were being agitated by being transferred to a new flask so those in set B had to be agitated too.

**e** As the amount of oxygen was reduced in the flask, the maggots used anaerobic respiration. When given fresh air (containing more oxygen) the maggots showed EPOC, using up more oxygen than originally in order to replace oxygen stores and to provide additional oxygen for additional aerobic respiration required to convert/remove lactic acid.

**8Ce-7 Cellular respiration**

1 **a** 40 km/h

**b** To start with, the horse is going faster and faster but its energy needs can mainly be supplied by aerobic respiration, showing a steady increase in the rate of glucose use. After the anaerobic

threshold, the energy needed can no longer be supplied by just aerobic respiration and so anaerobic respiration is also used. This does not release so much energy from each gram of glucose and so glucose use rapidly increases.

**c** It needs extra glucose because aerobic respiration is still required to release more energy than before. This is due to the extra energy needed to move the lungs (faster breathing rate) and heart (faster pulse rate). The faster rates are because additional oxygen needs to get to the liver to help turn lactic acid back into glucose, and to replenish the store of oxygen in the muscles and blood.

**2** X – the cells are respiring and so using up glucose and so the concentration of glucose decreases; Y – the cells are using anaerobic respiration (they have no mitochondria for aerobic respiration) and are producing lactic acid, so it gradually increases in concentration; Z – the cells are not using aerobic respiration (they have no mitochondria for aerobic respiration) and so the levels of carbon dioxide do not increase

**3** IAA stops both aerobic and anaerobic respiration. Cyanide only stops aerobic respiration.

## 8D Unicellular organisms

### 8Da Unicellular or multicellular

#### Student Book

#### 1: 8Da The Black Death

**1 a** movement, growth, reproduction, sensitivity, respiration, excretion, nutrition

**b** tiny organisms/an organism that you need a microscope to see

**2** any three of: fungi, plants, animals, protoctists

**3** They decomposed.

**4** any sensible answer, e.g. baking, brewing

**5** to get enough raw materials/or to take waste away

**6** anaerobic respiration because oxygen would be hard to get

#### 2: 8Da Unicellular or multicellular

**1** movement – locomotor system; reproduction – reproductive system; sensitivity – nervous system; growth – locomotor system; respiration – gas exchange system, circulatory system; excretion – urinary system; nutrition – digestive system

**2** They are made of a lot of cells.

**3** (aerobic) respiration

**4** diffusion

**5 a** circulatory system

**b** There are so many cells that it would take too long for materials to diffuse through all the cells to get to every cell.

**6 a** one of humans, birds, pigs, horses, dogs or other mammal

**b** it replicates inside a cell and causes the cell to burst

**7** unicellular – it is a prokaryote because it has no mitochondria and all prokaryotes are unicellular

**8** protoctists, plants

**9** They do not carry out any of the life processes on their own, so they are not living organisms.

### 3: 8Da Tackling diseases (STEM)

**1** Any sensible answer. *Yersinia pestis* causing plague, was given on the previous page. Accept answers such as 'chicken pox caused by a virus/chicken pox virus'.

**2** One sensible suggestion, such as: easy to transport, would give a quicker identification of the pathogen, easy for everyone to use (not just microbiologists).

**3** Fluid (coughed up) from the lungs.

**4** Many bacteria have become resistant to it.

**5 a** To stop their animals getting diseases (which could kill them cost them or cost more money to treat).

**b** It allows more bacteria to become resistant.

**6** A development of something that has already been invented.

**7** To come up with new antibiotics to kill bacteria that have become resistant to existing antibiotics.

**8** Measles is caused by a virus (and antibiotics don't affect viruses).

**9** Vaccinated people will not get the disease so there will be fewer infected people who can spread the disease.

### Activity Pack

#### 8Da-1 Unicellular and multicellular

**1 a** growth

**b** movement

**c** excretion

**2** all organisms

**3 a** made of one cell

**b** bacteria – unicellular; humans – multicellular; plants – multicellular; yeasts – unicellular; prokaryotes – unicellular

**4 a** Arrows show particles X diffusing throughout, and into the cell.

**b** diffuse, materials, organisms, tissues, systems

**5** nucleus, mitochondria

#### 8Da-3 Diffusion and cells

Suggested order of the diagrams is W, Z, X, Y.

Suggested links (but students may have used the diagrams and sentences in other ways):

## Unicellular organisms

W Particles are in a constant state of motion.

Z The particles diffuse through the water.

X The particles diffuse into the cells.

Y The particles take longer to diffuse into cells surrounded by other cells.

So, cells in tissues need a system to supply them with raw materials.

Diffusion may not allow bigger cells to get enough raw materials.

The particles take longer to diffuse evenly inside bigger cells.

So, cells in most organisms are small rather than big.

### 8Da-4 Microorganisms

1

Life process	Meaning
movement	being able to move all or a part of itself
reproduction	producing more living things like itself
sensitivity	sensing and reacting to things around it
growth	increasing in size
respiration	using a chemical reaction to release energy
excretion	getting rid of waste materials that it makes
nutrition	needing food

2 unicellular: bacteria, yeast; multicellular: cat, daffodil, mouse, oak tree

3 plants, protocists, animals, fungi, prokaryotes

4 The particles are in a constant state of motion and so spread out evenly. This means that there is an overall movement of particles from areas in which there are many to areas in which there are fewer.

5 a circulatory system

b It would take too long to diffuse.

### 8Da-5 Unicellular vs multicellular

1 a The number of cells (a unicellular organism is made of one cell and a multicellular organism is made of many cells).

b movement, reproduction, sensitivity, growth, respiration, excretion, nutrition

2 a diffusion

b The particles are constantly moving and so spread out evenly. This means that there is an overall movement of particles from areas in which there are many to areas in which there are fewer.

c It is smaller and so has a greater surface area.

d Diffusion will not allow the cell to take in enough of the raw material to supply the whole cell.

e Diffusion would not be fast enough to allow raw materials like glucose to move from the small intestine to all cells in the body.

3 a prokaryotes

b plants

c protocists

d prokaryotes

e animals

4 They can only 'live' when inside another living cell. Or, on their own they do not carry out all the life processes.

### 8Da-6 Surface area: volume ratios

1 a As the sphere gets bigger, the volume increases at a faster rate than the surface area.

b As they get bigger, they have more volume and so need more raw materials but the surface area does not increase enough to be able to supply the additional raw materials. Some students may have also talked about getting rid of waste (or both taking in raw materials and getting rid of waste).

2 a

Radius (mm)	Surface area:volume ratio
1	3.25
2	1.47
3	1.00
4	0.75
5	0.60
6	0.50

b so that they can take a lot of raw materials – enough to supply the whole cell

3 Low ratio. The higher the ratio, the more heat the organism will lose to its surroundings. In cold habitats, animals need to conserve heat.

4 On cold days we curl up, making our surface area:volume ratios smaller so that we lose less heat to the surroundings. We do the opposite on hot days.

5 a 0.12 (This is a ratio and so should not have units.)

b Possibilities include that it has a very slow rate of respiration/growth and so only needs a very slow supply of raw materials. Or it may have ways of moving the cytoplasm ensuring that raw materials are quickly transported from the outer parts of the cell to all parts of the cell.

c nucleus, mitochondria, chloroplasts

### 8Db Microscopic fungi

#### Student Book

#### 1: 8Db Microscopic fungi

1 Microscopes were not good enough until then to be able to see the organisms.

- 2 a budding  
b because it has exactly the same DNA as its parent bud and that daughter cell can then bud.
- 3 carbon dioxide
- 4 If there is air then there is oxygen and this means that the yeast will use aerobic respiration. Aerobic respiration releases more carbon dioxide and so will make the bread rise further/faster.
- 5 mitochondria
- 6 ethanol (alcohol)
- 7 anaerobic respiration/fermentation
- 8 aerobic respiration because it is more efficient
- 9 a warmth, food (sugar, glucose), moisture  
b Food/sugar/glucose because it takes a long time for water to evaporate at the temperatures at which yeast grow, and heat is produced when cells respire so their surroundings will be warm.

### Activity Pack

#### 8Db-1 Microscopic fungi

- 1 a white loaf and baguette circled  
b They have bubbles in them caused by carbon dioxide from yeast respiration.  
c any sensible example (e.g. soy sauce, foods made with yeast)
- 2 tube 4
- 3 a Y  
b It does not use oxygen.  
c When there is no oxygen, but there is water and the temperature is suitably warm.  
d X: glucose + oxygen → carbon dioxide + water  
Y: glucose → carbon dioxide + ethanol
- 4 a budding b limiting factor

#### 8Db-6 Using yeast

- 1 a The higher the temperature the greater the volume increase.  
b Respiration is faster at higher temperatures (and so more carbon dioxide is produced at higher temperatures, which increases the volume of the dough).  
c Dough B rises more than dough A at higher temperatures.  
d Dough B contains more *sugar* and so there is more *respiration* occurring, which means that more *carbon dioxide* is produced.  
e Dough C volume increases more than dough A at all temperatures.  
f Dough C contains more yeast and so there is more respiration occurring, which means that more carbon dioxide is produced.

- 2 a 1st equation: water; 2nd equation: ethanol  
b fermentation  
c To get more oxygen into the dough. Aerobic respiration produces more carbon dioxide than anaerobic respiration.

#### 8Db-7 Making bread

- 1 a flour, sugar, water and yeast (NB: sugar is not often added, a simplification has been made here to aid understanding. See Background information.)  
b folding and squashing the dough  
c To get air trapped inside it. The yeast cells use the oxygen in aerobic respiration.
- 2 It cuts the dough into loaf-sized pieces.
- 3 fungus
- 4 a aerobic respiration  
b glucose + oxygen → carbon dioxide + water
- 5 Reactions occur faster when it is warmer and so respiration occurs faster, producing more carbon dioxide.
- 6 a an oven  
b They are killed.
- 7 *Students' own questions.*

#### 8Db-9 Populations

- 1 Drawing of budding. Labels should mention the terms 'parent cell' and 'bud'.
- 2 lag phase: 0–3 days; log phase: 4–8/9 days; stationary phase: 10–11 days; death phase: 11–14 days.
- 3 a The death rate is the same as the reproduction rate.  
b The amount of food (sugar). It is not oxygen, as the yeast is fermenting.
- 4 a ethanol  
b Bubble air through the mixture so that aerobic respiration occurs, which does not produce ethanol/alcohol.
- 5 1000 cells per day.
- 6 a stationary and death phases  
b log phase
- 7 a two from: contraception, (epidemic) diseases, drought, famine, natural disaster, legal restrictions, war etc.  
b There will be so many people that food/resources will start to run out, or overcrowding will spread disease at faster rates and lead to more conflict.

#### 8Dc Bacteria

##### Student Book

#### 1: 8Dc Bacteria

- 1 tuberculosis
- 2 the beige/brown/larger cells – because you can see their budding scars or because they are much bigger than the blue-coloured, smaller bacteria

## Unicellular organisms

3 e.g.

	budding	binary fission
asexual	✓	✓
creates two cells	✓	✓
creates cells of the same size	✗	✓

The enzymes (needed to break down substances and make new substances) work more slowly at lower temperatures.

5 an S-shaped curve, similar to that shown for yeast (Figure E on the Microscopic Fungi spread in the Student Book); award additional credit for correctly labelled axes and a title

6 a anaerobic respiration

b lactic acid

c It makes it sour and thickens it.

7 photo A – *Lactobacillus delbrueckii*; photo B – *Salmonella typhimurium*; drawing D – *Vibrio cholerae*; photo E – *Streptococcus pyogenes*

8 cell wall – for support and protection; flagellum – for movement; cytoplasm – for cell reactions, including respiration; cell membrane – to control what comes into and goes out of the cell; chromosome – contains the information to control the cell; students are not expected to know the function of the slimy layer, which can be used to help movement, protect the cell and help it to attach to surfaces

9

	human aerobic	human anaerobic	bacterial anaerobic	yeast aerobic	yeast anaerobic
releases energy	✓	✓	✓	✓	✓
requires oxygen	✓			✓	
produces carbon dioxide	✓			✓	
produces lactic acid		✓	✓		
requires glucose	✓	✓	✓	✓	✓

(Students who have not covered Unit 8C at this point are unlikely to have included anaerobic respiration in humans.)

**2: 8Dc Pie charts**

1 a the causes of death in two time periods

b It dropped from one year to the next.

c more – the blue sector covers more than half of the circle

d more – the blue sector covers more than three-quarters of the circle

2 The pie chart should look like the one using the 1855 data. The angles are: diseases 212°; wounds 130°; other causes 18°.

3 b (a would be best plotted on a line graph and c would be best plotted on a scatter graph)

**Activity Pack****8Dc-1 Bacteria**

1 glucose

2 a glucose → lactic acid

b It does not require oxygen.

3 a

	Bacteria	Yeast
asexual	✓	✓
binary fission	✓	
budding		✓

b Enzymes work faster when it is warmer.

4 They make it sour.

5 soft cell wall – helps support and protect the cell; flagellum – moves the cell; cytoplasm – where respiration occurs; chromosome – contains the information to control the cell

**8Dc-5 Bacterial pie charts**

1 a firmicutes

b actinobacteria

c It increased (by about three times).

2 Two pie charts using the following data:

Bacterium	Degrees for yoghurt X	Degrees for yoghurt Y
<i>Bifidobacterium lactis</i>	72	99
<i>Lactobacillus acidophilus</i>	108	72
<i>Lactobacillus bulgaricus</i>	36	81
<i>Streptococcus thermophilus</i>	144	108
Totals	360	360

3 Q (P is best plotted on a bar chart and R on a scatter graph).

**8Dc-6 Bacterial cell model**

Refer to diagram D in 8Dc of the Student Book.

**8Dc-7 Bacterial questions**

1 glucose, moisture, warmth

2 a Respiration that does not need oxygen.

b lactic acid

3 It gets thicker.

4 a *Coccus*

b *Salmonella*

c *Streptococcus*

d *Spirillum*



5 a swim/move

b one of: soft cell wall – for support and protection; cytoplasm – for cell reactions, including respiration; cell membrane – to control what comes into and goes out of the cell; chromosome – contains the information to control the cell

8Dc-8 Yoghurt and bacteria

1 a warmth, moisture, sugar/glucose/nutrients

b Bacteria grow faster when it is warmer because the enzymes that make new substances work faster at higher temperatures.

c anaerobic respiration by microorganisms

d lowers the pH, thickens it, reduces the amount of carbohydrate

e Lactic acid lowers the pH. The lowered pH causes proteins to clump together to thicken the milk. Respiration reduces the amount of carbohydrate.

2 a They do not have flagellae.

b (circular) chromosome

c controls the cell

d cytoplasm

e Drawing should show one bacterium splitting into two equally, and then each of those bacteria growing. If students have included the circular chromosome, make sure that it is a similar size in all the cells.

8Dc-9 Bacterial cell walls

1 anaerobic respiration

2 protection and support

3 to control what goes into and out of the cell

4 a It is permeable to crystal violet because this substance can get into the cytoplasm of the cells.

b It is permeable to iodine because this substance can get into the cytoplasm of the cells.

c It is not permeable to CVI because this layer has to be removed using ethanol to wash the CVI out of Gram-negative bacteria.

5 Y because it has an outer membrane (and thin cell wall).

6 *Escherichia coli* and *Pseudomonas aeruginosa* – colourless cells; *Staphylococcus aureus* – purple cells

7 to make it easier to see the cells of Gram-negative bacteria

8 It allows hospitals to do a test to help work out what bacterium might be infecting a patient and so work out how best to treat the patient.

8Dd Protoctists

Student Book

1: 8Dd Protoctists

1 a mitochondria

b

	A <i>Amoeba</i>	B <i>Paramecium</i>	C alga
nucleus	✓	✓	✓
cell surface membrane	✓	✓	✓
cytoplasm	✓	✓	✓
storage vacuoles	✓	✓	✓
cilia	✗	✓	✗
flagella	✗	✗	✓
mitochondria	✓	✓	✓
cell wall	✗	✓	✓
pseudopods	✓	✗	✗
eyespot	✗	✗	✓

c Amoeba get nutrition by surrounding smaller organisms; paramecium feed using their cilia to sweep smaller organisms into a ‘mouth’; algae use photosynthesis to make their own food.

2 Student’s drawing should show one *Amoeba* cell splitting into two equally and then each of those cells growing. If a nucleus is included, it should be a similar size in all the cells.

3 Photosynthesis traps energy which is then stored in plants. Eating plants is how animals get their energy.

4 a carbon dioxide, water

b glucose

5 a two from: warmth, moisture, glucose/nutrients, oxygen

b light (for photosynthesis)

6 a mussel b beetle

c The date palm uses light from the sun to make glucose by photosynthesis. The beetle gets this energy when it eats the palm.

d Energy is lost in the droppings of an organism and through respiration.

7 The pyramid shape is because there is a large mass of date palm, which feeds a smaller mass (even though larger number) of domino beetles. This mass of beetles feeds an even smaller mass of vipers, which feeds an even smaller mass of eagle owls.

8 A pyramid of biomass shows energy flow because it shows the energy decreasing at each level. It is not easy to see energy flow by looking at the pyramid if numbers in E.

9 They had eaten fish containing a large amount of toxin. The toxin was produced by photosynthetic protists and because the toxin is not broken down, it moves through the organisms in a food chain, becoming more and more concentrated.

Activity Pack

8Dd-1 Protoctists

1 a moisture, warmth, oxygen

b carbon dioxide, light

## Unicellular organisms

2

	<i>Amoeba</i>	<i>Paramecium</i>	alga
cell surface membrane	✓	✓	✓
cell wall	✓	✓	✓
cilia		✓	
flagella			✓
mitochondria	✓	✓	✓
pseudopods	✓		

3 a molecule that contains carbon atoms joined together

4 to get more light for photosynthesis

5 a carnivore: stickleback; consumer: water flea and stickleback; herbivore: water flea; producer: algae

b stickleback

c the Sun

d in wastes and respiration (for moving)

**8Dd-4 Protoctist cell model**

Refer to diagram D the Bacteria spread of the Student Book for labelling of a similar protoctist.

**8Dd-6 Algae and others**

1 a protoctists

b temperature

c The higher the *temperature*, the *more/faster* the algae grew.

d EITHER oxygen for aerobic respiration OR carbon dioxide for photosynthesis

e chlorophyll/chloroplasts

f for photosynthesis, to make their own food

2 The answer can be presented as either a food chain or a pyramid of numbers.

algae → pond snail → minnow → grey heron

3 X uses a flagellum, Y uses cilia, Z uses pseudopods

**8Dd-7 The protoctists**

1 a They feed on other organisms/they do not make their own food.

b two of: oxygen, warmth, minerals

c using cilia

d *Paramecium* (award additional credit if the word is italicised or underlined)

e As the population of *Paramecium* increases it provides more food for the *Didinium* and so their population can then increase.

f Too many *Paramecium* are being eaten and so their population starts to fall.

g With fewer *Paramecium*, the food source for the *Didinium* population becomes a limiting factor and the population starts to fall.

h chloroplast

i three of: soft cell wall – for support and protection; cytoplasm – for cell reactions, including respiration; cell membrane – to control what comes into and goes out of the cell; nucleus – contains the information to control the cell; vacuole(s) – for storing substances

j The answer can be presented as either a food chain or a pyramid of numbers.

*Chlamydomonas* → *Paramecium* → *Didinium*

2 a The *Chlamydomonas* move towards the light because more light allows faster photosynthesis.

b three from: light, carbon dioxide, water, warmth

c Energy from the Sun is transferred by light to a chloroplast in a *Chlamydomonas* cell, chlorophyll traps the energy and uses it to help make glucose, which stores the energy in the cell.

d carbon dioxide + water → glucose + oxygen

**8Dd-8 Toxins and eutrophication**

1 a The more light they can get, the faster they will photosynthesise.

b flagellae

c Energy from the Sun is transferred by light to a chloroplast in a *Gambierdiscus toxicus* cell, chlorophyll traps the energy and uses it to help make glucose, which stores the energy in the cell.

d The answer can be presented as either a food chain or a pyramid of numbers.

*Gambierdiscus* → small fish → large fish → humans

e The poison from *Gambierdiscus* does not break down so stays in the bodies of the small fish. The large fish eat many small fish and so get many doses of poison. The large fish contain enough of the poison to poison humans.

2 a Photosynthesis produces oxygen, which fish need for (aerobic) respiration.

b The respiration of many bacteria uses up all the oxygen in the lake, so not leaving enough for the fish to respire.

c [Topic sentence] Using too much fertiliser can kill fish in ponds and lakes. [Supporting sentences in chronological order] Fertilisers contain substances that help plants and algae grow well. When these substances wash out of farmland into bodies of water, the algae and plants in the water grow very quickly. Eventually there is so much algae that they block the light getting to water plants. These then die. The large amount of dead plant material encourages the growth of bacteria, and these use up the oxygen in the water. This can mean that fish are not able to get enough oxygen from the water for respiration. [Summary sentence] This sequence of events, caused by fertiliser getting into bodies of water, causes the fish to die.

**8De Decomposers and carbon****Student Book****1: 8De Decomposers and carbon**

- 1 an organism that breaks down dead organisms and animal wastes
- 2 wood
- 3 They break down the bodies of dead things and so remove them. They recycle nutrients, making them available for other organisms.
- 4 **a** enzymes  
**b** The molecules in their food are too big/insoluble to absorb.  
**c** absorption
- 5 gases produced by the respiration of microorganism decomposers:  
carbon dioxide  
methane/hydrogen
- 6 **a** Respiration releases energy, some of which makes the compost heap increase in temperature.  
**b** Bacteria produce lactic acid when they respire anaerobically. (Carbon dioxide from aerobic expiration is also acidic.)
- 7 yeast
- 8 list of organic compounds (e.g. carbohydrate, protein, fat, glucose, starch); carbon dioxide does not contain a chain of carbons and so is not organic
- 9 diagram to show how respiration and photosynthesis are the reverse of one another
- 10 We are burning more fossil fuels. We have cut down forests that remove carbon dioxide from the atmosphere.

**2: 8De Black Death hypotheses**

- 1 **a** bacteria are prokaryotes, humans are animals  
**b** prokaryotes are unicellular, animals are multicellular  
prokaryotes do not have a nucleus but a circular chromosome; prokaryote cells have cell walls but animal cells do not; prokaryote cells do not contain mitochondria but animal cells do
- 2 **a** Microorganisms decompose the softer tissues.  
**b** They break down the bodies of dead things and so remove them. They recycle nutrients, making them available for other organisms.  
**c** any sensible suggestion, e.g. fewer microbes can reach the dead bodies from the air, there is less oxygen underground for use by aerobic decomposers, the temperature is lower, there is less access for detritivores
- 3 Algae need light to survive (for photosynthesis).

- 4 because it does not have a flagellum (or cilia)
- 5 *Student's drawing* should show one bacterium splitting into two equally and then each of those bacteria growing. If students have included the circular chromosome, it should be a similar size in all the cells.
- 6 **a** controls the cell  
**b** nucleus
- 7 S-shaped growth curve drawn and labelled in a similar fashion to that shown in diagram E of the Microscopic fungi spread of the Student Book

**Activity Pack****8De-1 Decomposers and carbon**

- 1 **a** all the organisms living in an area  
**b** light
- 2 protoctists
- 3 1 Enzymes are released; 2 Large organic molecules are broken down; 3 Small organic molecules are absorbed.
- 4 glucose, proteins
- 5 They break down the bodies of dead things and so remove them. They recycle nutrients, making them available for other organisms.
- 6 1 decay; 2 respiration; 3 feeding;  
4 photosynthesis; 5 burning or combustion

**8De-3 The carbon cycle**

See diagram in the Student Book.

**8De-4 The importance of decomposers**

- 1 An *ecosystem* is made up of a *community* (all the different *species* of organism) and physical *environmental* factors (e.g. wind, *temperature*). *Microorganisms* are an important part of an ecosystem because they are *decomposers*; they break down dead organisms and animal wastes in a process called *decay*. This means that *carbon* and nutrients can be recycled and used again by other organisms.
- 2 two of: fungi, prokaryotes, protoctists.
- 3 Names of two organic compounds (e.g. carbohydrate, protein, fat, glucose, starch). (Carbon dioxide does not contain a chain of carbons and so is not organic.)
- 4 clockwise from the top: combustion, respiration (or decay), photosynthesis, respiration (or decay)

**8De-5 Natural recycling**

- 1 **a** glucose  
**b** name of one organic compound apart from glucose (e.g. carbohydrate, protein, fat, starch). (Carbon dioxide does not contain a chain of carbons and so is not organic.)
- 2 fungi, prokaryotes, protoctists

## Combustion

- 3 photosynthesis
- 4 See Diagram C on the Decomposers and carbon spread of the Student Book.
- 5 See Diagram F on the Decomposers and carbon spread? of the Student Book.
- 6 any two from: burning plants/fossil fuels releases more carbon dioxide into the air; removal of trees decreases the amount of carbon trapped; more people on Earth respire more, releasing more carbon dioxide
- 7 plant more trees/plants; stop burning fossil fuels
- 8 They break down the bodies of dead things and so remove them. They recycle nutrients, making them available for other organisms.

### 8De-6 Decomposers and food

**a** Microorganisms grow/reproduce more slowly when it is cold. The enzymes in microorganisms do not work very quickly when it is cold, so the decay process is stopped or slowed right down.

**b** The heating kills the decomposers. Further bacteria are not able to enter the container because it sealed. Decay is stopped.

**c** The low pH kills some microorganisms. It also prevents enzymes working. Decay is stopped.

**d** Microorganisms need moisture. Substances cannot move around inside microorganism cells if they are dry. Decay is slowed right down.

**e** Many of the microorganisms are killed. So there are less microorganisms and decay will happen more slowly.

**f** The salt causes water to leave the microorganisms, by osmosis. Substances cannot move around inside microorganism cells if they are too dry. Decay is slowed right down.

**g** Many decomposers need oxygen. If there is no oxygen decay will be slowed.

**h** The sugar causes water to leave the microorganisms, by osmosis. Substances cannot move around inside microorganism cells if they are too dry. Decay is slowed right down.

**i** Many decomposers need oxygen. If there is no oxygen decay will be slowed.

## 8E Combustion

### 8Ea Burning fuels

#### Student Book

#### 1: 8Ea Engines

- 1 burning
- 2 Energy is transferred to the wheels so the car moves: without a source of energy, the car cannot move.
- 3 any two suitable fuels, e.g. wood, coal, petrol, hydrogen, biofuel (do not accept 'steam' as it is not a fuel)

- 4 Fuel is burnt to release energy, which is transferred to the wheels to make them go round.
- 5 When the fuels are burnt they release substances that cause pollution.
- 6 Both burn fuels to transfer energy. In external combustion, the energy is transferred to steam outside the engine in the boiler. The steam passes into the engine and there transfers energy to parts of the vehicle so that movement occurs. In internal combustion, the energy is transferred from the fuel inside the engine during combustion directly to parts of the vehicle so they can move.

### 2: 8Ea Burning fuels

- 1 a substance that contains stored energy that can be transferred (e.g. by heating) to make things happen
- 2 water
- 3 a spark or flame that transferred energy to the fuel
- 4 any three from: heat, light, sound, movement
- 5 It contains substances formed from carbon and hydrogen that store energy which can be usefully transferred to do work.
- 6 carbon + oxygen → carbon dioxide
- 7 coal (hydrocarbon) + oxygen → carbon dioxide + water
- 8 Limewater goes cloudy.
- 9 Blue (dry) cobalt chloride paper turns pink in the presence of water; white (anhydrous) copper sulfate turns blue in the presence of water.
- 10 Hydrogen is a fuel.

When it is in contact with oxygen (in the air), the flame from the splint causes the hydrogen to react with the oxygen, producing flames.

The flames continue after the splint is removed and will last until all the hydrogen has reacted. Then the flame goes out.

### Activity Pack

#### 8Ea-1 Burning fuels

- 1 burning, or to burn
- 2 oxygen
- 3 water
- 4 hydrogen + oxygen → water
- 5 **a** hydrogen or oxygen      **b** water
- 6 carbon + oxygen → carbon dioxide
- 7 A substance that contains only carbon and hydrogen.
- 8 hydrocarbon + oxygen → water + carbon dioxide

#### 8Ea-2 Burning a fuel

- 1 To draw the products of the combustion reaction through the equipment.

- 2 It rises.
- 3 It turns pink, because water is present.
- 4 It goes cloudy, because carbon dioxide is present.
- 5 hydrocarbon + oxygen → carbon dioxide + water
- 6 The rise in temperature shows energy is transferred by heating, and the brightness of the flame shows energy is transferred by light.

### 8Ea-3 Combustion questions

- 1 a combustion      b fossil  
c hydrocarbon
- 2 a reactant    b product
- 3 carbon dioxide
- 4 a water  
b carbon dioxide  
c temperature rises  
d Energy is released by the burning fuel, which causes the air in the flask to heat up.

### 8Ea-4 Methane explosion

- 1 a burning  
b It contains only carbon and hydrogen.  
c oxygen from the air  
d water and carbon dioxide  
e Limewater test for carbon dioxide: limewater turns from clear to cloudy when the gas is bubbled through it.

Cobalt chloride paper test for water: blue paper turns pink when it touches water.

- f methane + oxygen → carbon dioxide + water
- g Energy was released, transferred as heat and light in the flames and as sound in the explosion.
- h The reaction needs energy to start it, such as by a spark or a flame.

- 2 When methane burns energy is transferred causing the surroundings to heat up. We can use this energy transfer usefully to make other things happen, for example heating water to produce steam or driving an engine to turn a motor.
- 3 Energy is transferred from the hydrogen fuel as electricity. The hydrogen then combines with oxygen to form water.

### 8Ea-5 Combustion engines

- 1 a Fuel is burnt inside the engine.  
b A steam engine burns fuel to produce steam. The steam enters the engine to cause movement. So a steam engine is an external combustion engine.
- 2 As the combustion chamber is outside the engine, this makes it much heavier. A smaller engine means that the energy released from

combustion can make the vehicle go faster. Also, as the energy from combustion is transferred directly to the pistons, less is likely to be wasted by transfer to other parts of the surroundings.

- 3 As the fuel ignites it forms gases that heat up and expand rapidly. This expansion produces a force on the top of the piston, pushing it down.
- 4 The combustion reaction releases energy, some of which is transferred to the engine causing it to get hot. If the engine gets too hot, it could stop working (as the metal expands) or oil around the engine could get hot enough to start combusting.
- 5 a Without one of the reactants (fuel) the reaction cannot happen.

b Combustion reactions need an initial input of energy to begin. The spark needs to provide enough energy to make the fuel/air mix start reacting.

c Water doesn't combust, so this reduces the amount of fuel in the fuel/air mix. As a result, the reaction won't happen as forcefully.

d Air entering the mix will change the proportions of oxygen and fuel, which will affect how well they react together.

- 6 The rocket engine does not use oxygen from air, but from an oxidising agent. This is needed because the engine needs much more oxygen than can be supplied from the air as it travels through the atmosphere, and beyond the atmosphere there is no oxygen at all. There are no moving parts in the rocket engine, which means less energy is transferred wastefully and the engine is more efficient. The fuel may be solid. This means it would take up less space than a liquid or gas, so the rocket can be smaller.

### 8Eb Oxidation

#### Student Book

#### 1: 8Eb Oxidation

- 1 a carbon dioxide    b oxidation
- 2



(The exact arrangement of atoms in the right-hand molecule is not essential, as long as one carbon and two oxygens are together.)

- 3 a magnesium + oxygen → magnesium oxide  
b iron + oxygen → iron oxide  
c copper + oxygen → copper oxide
- 4 mainly as light (bright white flame), a little as heating of the surroundings and as sound
- 5 a It is an oxidation reaction because magnesium reacts with oxygen. It is also a combustion reaction as the magnesium burns.

**b** mass is conserved during a reaction, therefore:

$$\begin{aligned} \text{mass of oxygen} &= \text{mass of magnesium oxide} - \\ &\quad \text{mass of magnesium} \\ &= 4.0 - 2.4 = 1.6 \text{ g} \end{aligned}$$

**6** Explanation should include: mass is not lost; petrol is a hydrocarbon and so combines with oxygen (a gas) to produce carbon dioxide (another gas) and water (released as water vapour, a gas); if all the gases are contained, then the mass of petrol and oxygen will equal the mass of carbon dioxide and water produced.

### Activity Pack

#### 8Eb-1 Oxidation

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

**e** The total mass of hydrogen and oxygen is the same as the mass of water.

**2 a** magnesium oxide

**b** copper oxide

**c** oxidation

**3** from the air

#### 8Eb-2 Changing mass

**4** The mass of magnesium oxide is greater than the mass of magnesium.

**5** The gain in mass of the magnesium oxide is the mass of oxygen that reacted with the magnesium during the oxidation reaction.

#### 8Eb-3 Phlogiston

**1 a** wood  $\rightarrow$  phlogisticated air + calx

**b** wood + oxygen  $\rightarrow$  carbon dioxide + ash

**c** Phlogiston theory suggests that the loss of mass after combustion is due to the loss of phlogiston to the air. Oxygen theory suggests that the loss of mass is due to the production of carbon dioxide gas.

**2 a** metal  $\rightarrow$  phlogisticated air + calx

**b** metal + oxygen  $\rightarrow$  metal oxide

**c** Phlogiston theory suggests that the gain of mass after combustion is because phlogiston has a negative mass, so mass will go up when it is lost by combustion. Oxygen theory suggests that the gain of mass is from the mass of the oxygen it reacts with.

#### 8Eb-4 Metal reactions

**1** The very bright flame shows that energy is released.

**2** oxidation

**3** oxygen

**4** magnesium + oxygen  $\rightarrow$  magnesium oxide

**5** copper + oxygen  $\rightarrow$  copper oxide

**6** The same as the mass of copper added to the mass of oxygen.

#### 8Eb-5 Mass in reactions

**1 a** oxygen

**b** oxidation

**c** Light is given out, which shows the release of energy in a chemical reaction.

**d** magnesium + oxygen  $\rightarrow$  magnesium oxide

lead + oxygen  $\rightarrow$  lead oxide

potassium + oxygen  $\rightarrow$  potassium oxide

**2 a** zinc oxide

**b** The mass of zinc oxide is greater than the mass of the zinc it was formed from.

**c** The mass of zinc has reacted with a mass of oxygen, which means the mass of zinc oxide must be greater than the mass of zinc.

**3 a** The mass decreases over time.

**b** As the hydrocarbon fuel burns it forms carbon dioxide and water. The products are both gases, and so mix with the air. This causes an apparent loss in mass during the combustion reaction.

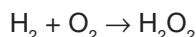
#### 8Eb-6 Formula equations

**1** one carbon atom, two oxygen atoms

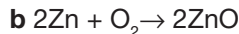
**2 a** same number of atoms in products as in reactants

**b** Nothing is gained or lost during the reaction, so the mass stays the same.

**3** hydrogen + oxygen  $\rightarrow$  hydrogen peroxide



**4 a**  $\text{S} + \text{O}_2 \rightarrow \text{SO}_2$



#### 8Eb-7 Ideas old and new

**1** Idea 2: If there is no air in the container there is no oxygen. When something burns it combines with oxygen, so if there is no oxygen then burning cannot happen.

Idea 3: A substance will burn until it has used up all the oxygen in the container. When there is no oxygen left, burning stops.

Idea 4: 'Mercury calx' is mercury oxide; 'dephlogisticated air' is oxygen.

mercury oxide  $\rightarrow$  mercury + oxygen

**2**  $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$

**3** The phlogiston theory can explain why substances lose mass when they burn, because substances give off phlogiston. It could also explain why air that has had something like a candle burnt in it has a greater mass than at the start, due to the extra mass of the phlogiston. However, it cannot explain how hydrogen burns but the product has a greater mass (the theory says that hydrogen should release its phlogiston to the dephlogisticated air).

**4** Since the theory cannot explain all the observations it is no longer believed to be correct.

**8Ec Fire safety****Student Book****1: 8Ec Fire safety**

- 1** It is a reaction in which energy is transferred to the surroundings so that they get hotter.
- 2** fuel, oxygen, heat
- 3** The grass in the burnt area was the fuel. As there is no grass left, there is no fuel to keep the fire burning.
- 4** flammable – these substances will catch fire very easily (are fuels), oxidising – these substances release oxygen (promotes fire), explosive – exposure to fire might cause these substances to explode (thus spreading the fire)
- 5** **a** heat **b** oxygen
- 6** Water will turn to gas explosively, spreading droplets of burning oil and so spreading the fire.
- 7** The carbon dioxide smothers the fire, excluding oxygen. Oxygen is one of the three factors needed for fire, so the fire is put out.
- 8** **a** an extinguisher that does not contain water or water-based liquid (e.g. powder or carbon dioxide) as water will evaporate explosively, spreading the fire

**b** A water extinguisher will cool the wood and paper, removing heat.

**c** A foam or powder extinguisher will exclude oxygen, and so put out the fire. Carbon dioxide could also be used if the fire is on a flat surface, otherwise the gas will flow away from the fire.

**2: 8Ec Fair testing**

- 1** independent – volume of fuel, dependent – time taken; the time taken depends on the volume of fuel.
- 2** **a** Different fuels may burn at different rates (changing the dependent variable).
- b** any sensible answer, e.g. the dish in which the fuel is burnt (different sizes will contain different amounts of oxygen), how the fuels are set alight (one method may supply more energy, which may make the fuel burn faster to start with)
- 3** **a** the amount of reactant  
**b** the amount of MMT  
**c** the temperature
- 4** independent – height of flame above surface, dependent – time until flame goes out
- 5** e.g. ‘Does the height of the flame above the base of the container affect the time it takes for the flame to go out?’
- 6** **a** (suggestions) **b** (explanations) **c** (descriptions of controls).

**a–c** any two suggestions that would affect time for flame to go out, e.g. size of container (affects

how much oxygen is available to react with fuel – control by using the same size container in each test), type of candle (may change the fuel, so changing the rate of reaction – control by using same type of light/candle), length of wick (affects how quickly the fuel reaches the point where combustion is taking place – control by trimming the wicks of the lights/candles so that they are the same length), length of time candle was burning before it was placed in the container (affect how much wax has melted and is able to travel up the wick to the point of combustion – control by allowing the lights/candles to burn for the same length of time before covering with the containers)

**Activity Pack****8Ec-1 The fire triangle**

**Oxygen:** the gas in air that is needed for things to burn; taken away if you smother a fire with a fire blanket

**Heat:** a water extinguisher cools the fire and takes this away; energy needed to start a fire

**Fuel:** a substance that contains a store of energy; cutting down trees in a forest takes this away

**8Ec-2 Candle height**

**1** **a** size of container, type of fuel used to make tea light, size of tea light, length of time tea light has already been burning (affects size of pool of liquid fuel at base of wick), length of wick

**b** In all cases, make sure identical apparatus used, and that the tea lights have the same size pool of melted fuel at the base of the wick.

**2** Results should show that tea lights nearer the top of the container go out first.

**3** Combustion of the hydrocarbon in the fuel produces carbon dioxide. Although carbon dioxide is a gas that is heavier than air, it is also hot and so collects at the top of the container. This excludes oxygen, so the nearer the flame is to the top of the container, the quicker it will be surrounded by carbon dioxide and so go out.

**4** Answer along the lines of: all other variables that could have affected the time were controlled.

**8Ec-3 Comparing fuels**

**1** independent – type of fuel, dependent – increase in temperature of water in a given time

**2** The more energy released per gram of fuel, the greater the increase in temperature of the water in a given time.

**3** **i** The greater the mass of water, the more energy that needs to be transferred to it to increase it to a particular temperature. Therefore, it needs to be controlled by using the same mass of water each time.

**ii** The volume of the beaker will only affect how much energy is transferred to the water if the beakers have different base areas. The wider the base, the more energy is likely to be transferred to the beaker and water rather than to the surrounding air. So the beakers should have identical base areas.

**iii/iv** Answer will depend on method used. If a fixed mass of fuel is burnt then time will vary. If a fixed temperature increase is used, then time is the dependent variable, and the mass of fuel is irrelevant as long as there is more than enough fuel to cause the required increase in temperature.

**v** The greater the height of the beaker above the flame, the greater the proportion of energy that will be transferred to the surrounding air rather than to the beaker and the water it contains. So the height of beaker above the flame should be the same in each test.

**4** Any suitable suggestion with an explanation about how it should be controlled. For example, all or no beakers should be stirred so that energy transfer through the water and to the surroundings is the same.

#### 8Ec-4 Fire extinguishers

**1** bands should be:

water: no band (coloured red as rest of extinguisher)

carbon dioxide: black

powder: blue

foam: cream/yellow

#### 8Ec-5 Fire safety

**1 a** Explosive, dangerous because a fire could cause the substance to explode which can cause harm and damage.

**b** Flammable, dangerous because the substance can easily burn, causing a fire or making an existing fire worse.

**2** chip pan fire: damp cloth; oxygen (and heat)

plane fuel fire: foam extinguisher; oxygen

electrical: carbon dioxide extinguisher; oxygen

forest: water or cut down trees; heat or fuel

#### 8Ec-6 The Great Fire of London

**1** accidentally, in a bakery

**2 a** an oven **b** wooden houses (mainly) **c** strong easterly winds

**3** The wood provided the fuel for the fire and the houses were very close together so the fire could spread from one to the other very easily.

**4** there was no running water supply; too far from the river; not enough water pumps; fire spread too quickly

**5** No. Houses are further apart, there is running water and a professional fire brigade and most properties are not wooden.

**6** to leave bigger gaps between buildings/wider streets and have better water supplies

**7** Fire breaks aim to contain a forest fire as the fire cannot spread because there is no fuel to burn in the gaps.

**8** Whole rows of houses were blown up. They hoped to escape the fire and keep their belongings and homes.

**9** Flames show energy is given out, and spreading fire means new material is combusted by the energy given out by the initial fire.

#### 8Ec-7 Energy in fuels

**1 a** The reaction releases energy, usually heating the surroundings.

**b** One way to stop a fire is to reduce the temperature around the fire so that the combustion reaction stops.

**2 a** Energy released from the fuel burning in the lamp is transferred to the beaker and water, so raising their temperature. The change in temperature is measured by the thermometer.

**b** Not all of the energy released by the combustion reaction is transferred to the water. Some may be transferred to the air and surroundings.

**c** If the proportion of energy transferred to the air and surroundings is different for the different fuels, then the results will not be reliable and it will not be a fair test.

**3** volume of water must be the same each time; thermometer used to measure temperature change should be the same each time as different thermometers may read differently; height of beaker above the flame should be the same, as more of the energy released will be transferred to the beaker the closer the beaker is to the flame; other equipment must be identical, e.g. use of safety gauze, as different materials (and different amounts of the same material) may absorb different amounts of energy and so change the proportion of energy released being transferred to the water; shape of beaker must be the same as a larger area will intercept more of the energy released than a smaller area

**4** mass of fuel burnt for each alcohol is: methanol 0.48 g; ethanol 0.41 g; propanol 0.39 g; butanol 0.27 g; pentanol 0.26 g; hexanol 0.25 g

**5** Hexanol releases the most energy per gram of fuel because this had the smallest mass that raised the temperature of the water by 30 °C.

**6 a** Hexanol and pentanol are more than five times the price of propanol and butanol, and more than



10 times the price of ethanol and methanol, so methanol is the cheapest.

**b** any suitable suggestions, such as: how easy it would be to refuel with each fuel; pollution caused by each fuel; any problems with containing fuel; fire hazards; affect of fuel on engine

**8Ed Air pollution**

**Student Book**

**1: 8Ed Air pollution**

**1** soot (carbon), carbon monoxide, carbon dioxide

**2** Incomplete combustion is occurring: some of the carbon in the diesel fuel is not reacting with oxygen in the engine.

**3** sulfur + oxygen → sulfur dioxide

**4 a** any suitable answer, e.g. nitrogen oxide (nitrogen monoxide) or nitrogen dioxide

figure a



figure b



**b** nitrogen and oxygen from the air react together in the hot temperature inside the engine

**5** a substance that harms the environment or living things

**6** small particles of soot

**7 a** Fossil fuels contain substances that react with oxygen to produce polluting gases. For example, carbon monoxide is formed by the incomplete combustion of carbon in the fuels, and nitrogen and oxygen from the air react together to form nitrogen oxides. Carbon monoxide is poisonous and nitrogen oxides can cause acid rain. Vehicles that burn diesel fuel also release soot particles, which can trigger asthma in some people.

**b** Catalytic converters cause carbon monoxide to react with more oxygen to form carbon dioxide, which is not poisonous; catalytic converters also break down nitrogen oxides to nitrogen and oxygen, which are not pollutants. Particles in diesel exhausts are removed from the gases as they pass through a filter.

**8 a** a rain that is more acid than usual because it contains dissolved sulfur dioxide and nitrogen oxides

**b** Sulfur is removed from the smoke before it leaves the chimneys.

**Activity Pack**

**8Ed-1 Air pollution**

**1 a** carbon dioxide, water

**b** carbon monoxide, soot (carbon)

**c** sulfur dioxide

**d** nitrogen oxides

**2** carbon dioxide – probably causing global warming and climate change

carbon monoxide – poisonous, will kill if too much is breathed in

soot particles – coat the lining of the lungs when breathed in and can trigger asthma

sulfur dioxide and nitrogen oxides – acidic, dissolve in water droplets in clouds and cause acid rain

**3 a** neutralisation

**b** filters

**c** oxygen, carbon dioxide

**d** nitrogen and oxygen

**8Ed-2 Measuring pollution**

**2 b** The site where most particles were collected had the most pollution.

**c** nearest to the greatest source of particulate pollution

**3 a** so that particles were only collected at the site

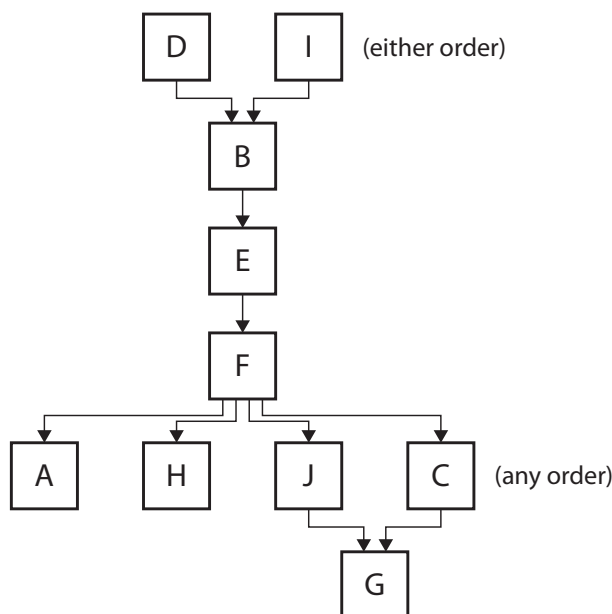
**b** To avoid adding particles from your fingers. OR To change the surface so that it is less sticky.

**c** Rain drops collect particles, so this would increase the amount of particles that stuck to the card and may mean that the comparison of results from different sites may not be reliable as it may have rained more at one site than others.

**4** to make the test fair

**8Ed-4 Acid rain**

**1**



**8Ed-5 Pollution by non-metal oxides**

- 1 sulfur dioxide, carbon dioxide
- 2 A substance that can cause harm to the environment and living things.
- 3 any suitable suggestions, such as: combustion of fossil fuels
- 4 **a** sulfur + oxygen
  - b** It is more acidic than normal rain, and the acid can damage living things and make soil and water more acidic than is usual.
  - c** The amount of sulfur dioxide in the air has decreased greatly over the past 30 years. So less acid rain is being formed.
- 5 **a** When only part of the substance reacts with oxygen during combustion
  - b** It is poisonous and can kill.
  - c** When breathed in, it coats the linings of the lungs and causes damage. It can also trigger asthma.

**8Ed-6 Sources of air pollution**

- 1 **a** hydrocarbon + oxygen → carbon dioxide + water
  - b** hydrocarbon + oxygen → carbon dioxide + carbon monoxide + carbon (soot) + water
  - c** There is not enough oxygen for all the carbon to react to form carbon dioxide.
- 2 **a** sulfur + oxygen → sulfur dioxide
  - b** nitrogen + oxygen → nitrogen oxides
  - c** Incomplete combustion produces carbon monoxide and soot, which are both pollutants.
- 3 **a** Acidic gases sulfur dioxide and nitrogen oxides, released into the air from burning fossil fuels, dissolve in water droplets in clouds to form acid rain.
  - b** When the rain falls, the acid makes the soil and water more acidic than normal. This can harm the organisms living there.
- 4 Nitrogen oxides, because the largest segment in this pie chart is for road vehicles.
- 5 The segment for road vehicles would have been larger than it is now (although it could have been the same if the other sources were also producing more sulfur dioxide then).
- 6 **a** energy generation
  - b** Removing the sulfur from the gas emissions from power stations and related sources (process known as scrubbing).
- 7 Catalytic converters cause nitrogen oxides to be broken down to nitrogen and oxygen, which are not pollutants. They also convert

carbon monoxide to carbon dioxide, which is not poisonous. However, carbon dioxide is a pollutant because it is linked to global warming and climate change. (Sulfur dioxide is no longer a problem because of ultra-low sulfur fuels.)

**8** Using fuels that don't contain nitrogen, such as methane or hydrogen, as this would eliminate nitrogen oxides emissions. Making sure carbon is fully burnt in the car engine so that carbon monoxide and soot are not produced. Only using a fuel or energy source (e.g. battery) that doesn't contain carbon will eliminate carbon dioxide emissions.

**8Ed-7 Flue gas desulfurisation**

- 1 sulfur + oxygen → sulfur dioxide
- 2 The liquid was acidic because it contained sulfuric acid. This would have increased the acidity of the river which could harm organisms living in it.
- 3 **a** Because people would be less affected as the pollution created would not create smog in the cities.
  - b** This only moves the problem from where it is obvious. Winds can move acidified water droplets in clouds to other places before they fall as acid rain. The acid rain can cause pollution where it falls.
- 4 Possible to break them down to nitrogen + oxygen using a catalyst (like in the catalytic converter on car exhausts).
- 5 The dark colour of smoke is caused by particulates and soot in the gases, due to the incomplete combustion of fossil fuels. The particulates could be removed by filtering.
- 6 Both treatments use calcium carbonate. The wet treatment is more effective at removing sulfur dioxide from the gases (90% removed compared with dry, which removes about 75%), but the wet treatment is more expensive to set up and run than the dry treatment.
- 7 For smaller production processes, the wet treatment would be too expensive, but using the dry treatment makes a big difference in sulfur dioxide emissions. Large production processes can afford to use the wet treatment and remove a greater proportion of sulfur dioxide.

**8Ee Global warming****Student Book****1: 8Ee Global warming**

- 1 the Sun

**2** the warming of the Earth's surface as a result of the trapping of energy from the Sun by greenhouse gases in the atmosphere

**3** Carbon dioxide is a greenhouse gas that absorbs some of the energy emitted by Earth and transfers it back to the Earth's surface.

**4 a** the present time

**b** about 130 000 years ago

**5** The temperature changes were caused by natural factors such as the tilting of the Earth's axis and the amount of energy transferred from the Sun to the Earth.

**6** The emission of carbon dioxide increased gradually from 1900 to about 1950 and then more rapidly from then to now.

In 1900, only about 2000 million tonnes of carbon dioxide were released each year. This value rose gradually to about 5000 million tonnes in 1950, at a rate of about 60 million tonnes each year. Since then, the rate of release has increased more rapidly to about 460 million tonnes each year so that by 2008 around 320 000 million tonnes were released.

**7** The graph suggests that around 1950 there was a sudden increase in activities that released carbon dioxide. This may have been due to an increase in a particular activity (e.g. building with concrete) or to the increase in industrialisation of large countries such as China, India and Brazil.

**8** an increase in the greenhouse effect, resulting in an increase in the Earth's surface temperature

**9** melting icecaps and glaciers; changing climate resulting in changed weather patterns; rising sea levels

**10** We release carbon dioxide when we burn fossil fuels for energy (e.g. for heating and cooking, to generate electricity, to run vehicles). As we burn more and more fossil fuels, increasing amounts of carbon dioxide are released into the air. As carbon dioxide is a greenhouse gas, it absorbs energy radiated from the warm Earth's surface and transfers it back to the surface. More carbon dioxide in the air will increase this effect, so the Earth will get warmer.

### **2: 8Ee Carbon footprints (STEM)**

**1** The 'carbon footprint' of a business is a measure of the amount of carbon dioxide released into the atmosphere as a result of all its activities.

**2 a** There is a positive correlation between the amount of carbon dioxide in the atmosphere and the global temperature. Carbon dioxide levels

and global temperature have both been increasing significantly during the last 100 years.

**b** between 1860 to 1900

**c** The steady rise was probably due to increased use of fossil fuels (in industry and transport).

**3 a** Walking to school would reduce your carbon footprint.

**b** Reusing materials would reduce your carbon footprint.

**c** Turning electrical appliances off when not in use would reduce your carbon footprint.

**d** Using tap water instead of bottled water would reduce your carbon footprint.

**4** The 'Recycling used materials' box is a different colour as this activity reduces the carbon footprint (the other boxes increase the carbon footprint).

**5** An advantage of using hydrogen-fuelled trucks is that it reduces the company's carbon footprint. A disadvantage is that the engines would need to be converted, or that hydrogen is less available. (Other answers are possible.)

**6 a** 71 550 kg of CO<sub>2</sub> per year

**b** 30% (to the nearest 1%)

### **3: 8Ee Reducing pollution**

**1** advantage – pollution from the car is less, disadvantage – pollution still occurs in power stations when they make electricity, cars don't perform as well as conventional cars

**2** advantage – burning hydrogen fuel does not release carbon dioxide, disadvantage – making hydrogen fuel is uneconomical, cars don't perform as well as conventional cars

**3 a** saves fuel

**b** lowers pollution

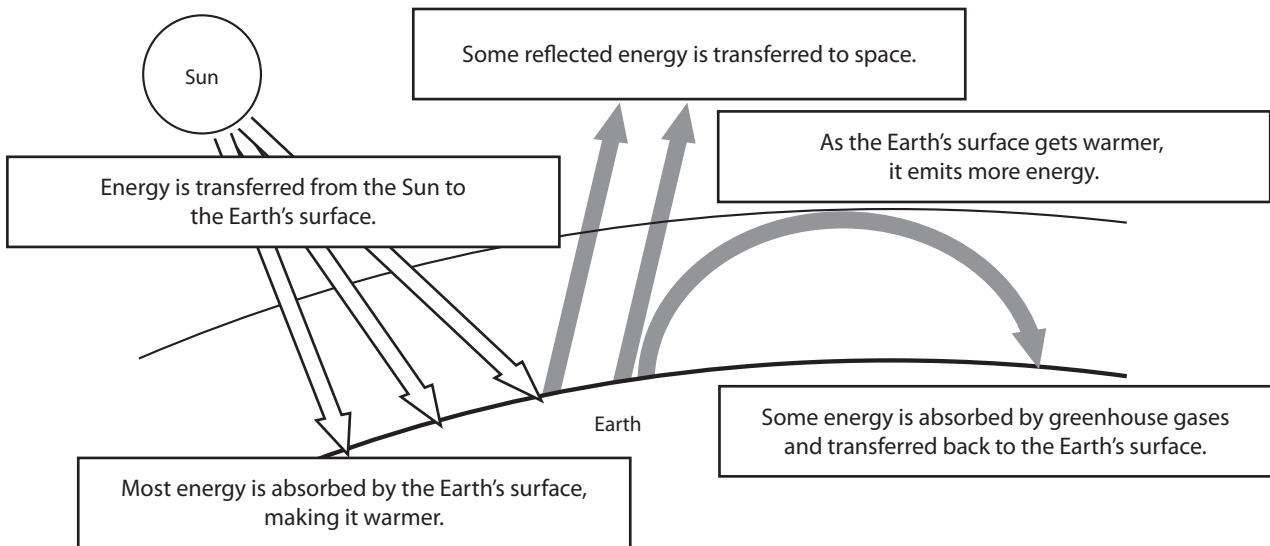
**4** Road tax encourages use of less-polluting vehicles.

Annual tests remove cars that are emitting too much pollution.

Congestion charges dissuade people from driving in areas where there are lots of people travelling around and so lower pollution levels.

Fuel prices encourage people to use less polluting forms of transport (e.g. walking, cycling, public transport).

Travel restriction lowers pollution in areas where there are lots of people travelling around and encourages people to use less polluting forms of transport (e.g. sharing cars).



### Worksheet 8Ee-1, Question 1

#### Activity Pack

##### 8Ee-1 Global warming

1 See figure at top of page.

2 Natural causes of changes in the Earth's temperature include ... the amount of energy transferred from the Sun to the Earth, and the tilt of the Earth's axis.

Global warming is caused by ... an increase in the greenhouse effect because there are more greenhouse gases in the atmosphere.

Greenhouse gases include ... carbon dioxide and other gases.

Global emissions of carbon dioxide have increased over the past 200 years because ... there has been an increase in the burning of fossil fuels.

The largest sources of carbon dioxide emissions are ... transport and electricity generation from power stations.

##### 8Ee-2 Climate change modelling

1 'Difficulties in predicting climate change.'

2 & 3 *Students' own answers.*

##### 8Ee-4 Carbon dioxide emissions

1 Labelled sources should include: exhaust emissions from burning fossil fuels (petrol, diesel or LPG) in vehicle engines and trains; exhaust emissions from burning fossil fuel in aircraft engines; smoke from burning fossil fuels in power stations; industrial processes; and for heating homes.

2 Vehicles and trains: use electricity as energy source, or fuel such as hydrogen that does not produce carbon dioxide on combustion.

Power stations: use non-carbon fuel such as nuclear energy source, or replace with renewable energy supplies from wind, Sun, water, etc. Alternatively, capture carbon from emissions and store it in a form that prevents release of carbon dioxide.

Industry: use electricity generated from non-fossil fuel source or capture and store carbon from emissions.

Homes/buildings: use electricity generated from non-fossil fuel source, or make them more efficient so they use less energy.

Aircraft: more fuel-efficient engines, or the development of carbon-less fuel that can be carried on long-distance flights.

##### 8Ee-5 Which car?

1 a diesel car

b diesel car

c diesel car

d Because it can travel further on the same amount of fuel.

2 a An increase in the Earth's temperature as a result of extra greenhouse gases/carbon dioxide in the atmosphere.

b any suitable answer, such as: climate change, increase in storms, drought, flooding

c Diesel car because it burns less fuel, so releases less carbon dioxide.

3 a Since no fossil fuel is burnt, no carbon dioxide is released.

b Even though the car releases no carbon dioxide, the power station releases carbon dioxide as it produces electricity.

##### 8Ee-6 Climate change

1 a increasing levels of greenhouse gases/carbon dioxide in atmosphere

**b** It will affect weather patterns, which could lead to floods, droughts and food shortages. It could also cause the icecaps to melt, which would cause sea levels to rise and some low-lying countries could be permanently flooded.

**2 a** Gases in the atmosphere trapping some of the Sun's energy.

**b** No, without any greenhouse effect the Earth would be much colder than it is now.

**3** burning more fossil fuels and cutting down forests

**4 a** about 280 ppm

**b** approx.  $-0.3^{\circ}\text{C}$

**c** about 1980

**d** It is rising fast.

**e** It has been slowly rising.

**f** It will rise at a much faster rate, by about  $4.5^{\circ}\text{C}$ .

**g** As the level of carbon dioxide has risen, the average global temperature has risen similarly.

**h** Not strong evidence as the graphs are on different time scales and provide too little detail.

**5 a** Answers should include factors such as the amount of energy reaching the Earth from the Sun; the amount of carbon dioxide and other greenhouse gases in the air; how much energy is reflected by the Earth; how much is absorbed by the atmosphere; etc. Accept any sensible suggestions.

**b** There is a lot of different information needed by the models, and scientists do not have accurate data for all the inputs. Also, the climate is very complex, and might be modelled in different ways. Accept any other sensible suggestions.

### 8Ee-7 Global warming evidence

**1 a** The graph shows that the pattern of change of temperature is very similar to the pattern of change of carbon dioxide.

**b** The greenhouse effect is how gases in the air, including carbon dioxide, absorb energy emitted from a warm Earth surface and re-emit it back to the surface, so keeping the Earth warm. If the amount of greenhouse gases/carbon dioxide increases in the atmosphere, then this effect will be increased, causing global warming.

**c** Two other possible interpretations are that (1) an increase in temperature as a result of something else causing carbon dioxide concentration to increase, or (2) some other factor is changing and causing both temperature and carbon dioxide to change in the same way.

**2 a** Fossils and rocks .../A number of different studies ...

The Sun could be .../The link between solar ...

More than 31 000 scientists .../ Over 97% of published ...

Computer models are not .../Computer models do show ...

**b** Responses may vary but should give suitable reasons for decisions, such as: a larger number of studies/scientists/models support the view that human activity is causing global warming, while the arguments against are more limited, have less support and therefore are not as strong.

### 8Ee-8 Whose responsibility?

**1** Industry needs energy from burning fossil fuels, either as part of industrial processes or as a result of generating electricity for use in industrial processes.

**2 a** China and India are developing their economies, which developed countries have already done. If China and India have to control emissions then their rate of development may slow, making it more difficult for their economies to catch up with those of developed countries.

**b** If developing countries do not control or reduce carbon emissions, then anything that developed countries do will have less of an effect on controlling global warming. Also if developed countries reduce emissions further, to make up for developing countries, then that could damage their own economies.

**3** Carbon emission reduction can be achieved in many ways. If a country is forced to generate electricity only from sources that release little carbon dioxide, some countries will have to spend more for their energy than others, which is considered unfair.

**4** Answers will depend on students' own views. Suitable examples are:

**a** Draft laws that make it illegal to release large amounts of carbon dioxide; increase taxes on fuels/processes that release large amounts of carbon dioxide; reduce taxes on fuels/processes that release no carbon dioxide.

**b** Actively research new methods and processes that reduce carbon dioxide emissions without making the products more expensive.

**c** Change lifestyle in ways that reduce carbon dioxide emissions, for instance by choosing electric cars; walking/cycling more; re-use and recycle rather than throw away; lobby industry and government to reduce emissions.

**d** If people prefer a lifestyle that results in higher carbon dioxide emissions, this will jeopardise the chances of achieving national targets. Education is one way to tackle this. Taxation is another.

## 8F The periodic table

### 8Fa Dalton's atomic model

#### Student Book

#### 1: 8Fa Fireworks

- 1 a new substance is formed
- 2 An element is a simple substance that cannot be broken down into anything simpler. A compound can be broken down into simpler substances.

An element contains only one kind of atom while a compound contains different kinds of atoms joined together.

- 3 a carbon + oxygen → carbon monoxide/carbon dioxide

sulfur + oxygen → sulfur oxide/sulfur dioxide

aluminium + oxygen → aluminium oxide

**b** combustion or oxidation reactions

**c** air

- 4 The energy given out and gases released produce the explosion.

#### 2: 8Fa Dalton's atomic model

- 1 Democritus thought that substances were made up of tiny particles (called atoms) which had different sizes and shapes and so different properties.
- 2 In ice the particles are close together and vibrate while fixed in position. In water the particles are close together but can move past each other. In steam the particles are far apart and move freely in all directions.
- 3 The atoms in an element are all identical and each element has its own type of atom.
- 4 Democritus just thought up his answers while Dalton carried out experiments (then thought about what the results meant).
- 5 There are many different ways in which this table could be presented. Students should include only four properties.

Property	Metal	Non-metal
shiny when polished	Yes	No
conducts	Yes	No
brittle	No	Yes
malleable	Yes	No
ductile	Yes	No
melting pt.	Usually high	Usually low

- 6 melting point and boiling point

- 7 a freezing (crystallising, solidifying)

**b** any three from: melting – changing from solid to liquid; sublimating – changing from solid to gas; condensing – changing from gas to liquid; evaporating – changing from liquid to gas

8 a



**b** any IUPAC symbol, e.g. C – carbon, Cl – chlorine, Pb – lead

**c** so scientists can communicate with each other, even if they speak different languages

#### Activity Pack

##### 8Fa-1 Dalton's atomic model

- 1 a compounds b atoms c destroyed d elements e new
- 2 a molecules and element b molecules and compound
- 3 brown colour, high melting point, good conductor of heat and strong
- 4 carbon – C; chlorine – Cl; oxygen – O; nitrogen – N

##### 8Fa-2 Atoms, symbols and equations

- 1 correct colours for atoms
- 2 missing words: atoms; created; same; number; different; fixed
- 4 a carbon C b potassium K
- 5 a iron + oxygen → iron oxide  
b silver + oxygen → silver oxide  
c tin + chlorine → tin chloride

##### 8Fa-3 Properties and change

- 1 Electricity can pass through iron ... because it is a conductor of electricity.

Elements are substances ... that contain only one kind of atom.

Sulfur will turn from a liquid into a gas ... at its boiling point.

The symbols of iron and sulfur ... are Fe and S.

Iron and sulfur are examples ... of elements.

Iron is used make bridges ... because it is strong.

Iron sulfide is a solid at room temperature ... as its melting point is high.

Iron sulfide is a compound ... because it contains different atoms joined together.

Compounds are different from the elements they are made from ... in terms of their properties.

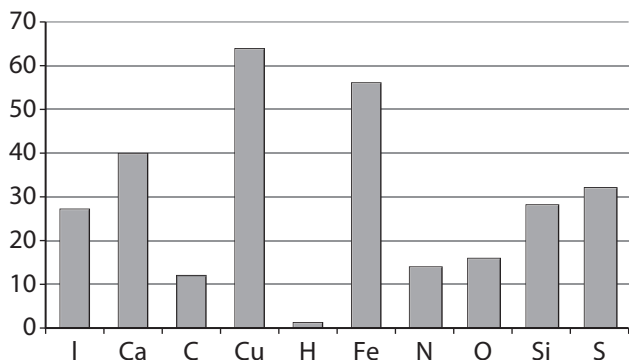
All substance are made up ... of tiny particles called atoms.

- 2 a A chemical property describes how a substance reacts with other substances. A physical property describes a substance on its own.

**b** He said that different elements had different properties because their atoms were different.

**8Fa-4 Comparing atoms**

1



2 Copper

3 40

4 a sulfur b nitrogen

5 1g

6 a 16g b 4g

**8Fa-5 Modelling matter**

1 atoms

2 A set number of atoms joined together.

3 solids, good conductors of heat and good conductors of electricity

4 The atoms of elements are all the same (all have the same size and mass).

5 Compounds contain atoms of different elements joined together.

6 calcium + oxygen → calcium oxide

7 Al; C; Ca; Na

8 O; F; H; I

9 Si; Ar; Ne; Ca

**8Fa-6 Ideas about matter and chemical change**

1 a They contained different kinds of atoms (different shapes and sizes).

b The atoms changed shape and size.

2 Aristotle thought there were four elements and that different substances contained different amounts of the four elements.

3 melting point; boiling point; flexibility; strength

4 Lavoisier and Dalton carried out experiments.

5 a copper oxide + hydrogen → copper + water

b silver carbonate → silver + oxygen + carbon dioxide

6 three of: copper oxide; water; carbon dioxide; silver carbonate

7 All the atoms in an element are the same while compounds contain different types of atoms.

8 a He would have said that atoms don't change to form new materials. New substances were formed when different atoms joined together.

b Correct: all matter was made up of atoms (the atoms in an element were all the same). Wrong: atoms could change to make new substances.

**8Fa-7 Calculating relative atomic masses**

1 The mass of a carbon atom is 12 times the mass of a hydrogen atom.

2 a Because different elements contain different atoms.

b Because all the atoms in a reacting element had to join to the same number of atoms of another element.

3 a 7g b 7

4 17

5 32

**8Fb Chemical properties****Student Book****1: 8Fb Chemical properties**

1 a gas being produced (bubbles forming in a test tube), energy being released (light being emitted)

2 chemical properties: flammable (it burns), reacts with water; physical properties: solid, conducts electricity, shiny when polished

3 5g

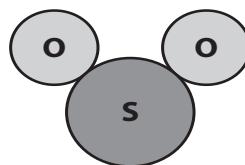
4 a 30g b 5g

5 a 1:1 b 1:1

6 a CO b CuO

7 three

8



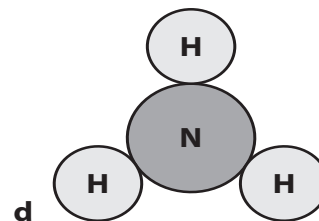
a



b



c



d

9 a HF b  $\text{PCl}_3$ **Activity Pack****8Fb-1 Elements and their symbols**

1 a compounds b new

2 In chemical changes ... a new substance is always formed.

In a physical change ... no new substances are formed.

Changes of state ... are examples of physical changes.

## The periodic table

3 1:2

4 **b** Melting point and boiling point – physical property**c** Conduction of electricity – physical property**d** pH of solution – chemical property5 **a** NO<sub>2</sub> **b** PH<sub>3</sub>**8Fb-3 Chemical and physical change**

1 chemical changes: iron rusting; frying an egg; lighting a match; carbon burning

physical changes: ice melting; dissolving sugar; water evaporating; water freezing; cutting up wood

2 In physical changes, no new substances are formed. New substances are formed in chemical changes.

3 When carbon reacts with oxygen the carbon atoms are broken apart and the oxygen atoms are broken apart and then the carbon atoms are joined to the oxygen atoms.

**8Fb-6 Types of change**

1 A chemical change always forms a new substance. A physical change involves a substance on its own.

2 physical; chemical; chemical; chemical; physical; physical

3 *Students' own answers*, such as:**a** burning gas fire **b** frying an egg

4 carbon + oxygen → carbon dioxide

5 flammability, reaction with water and pH

**8Fb-7 Formulae and masses**

1 i, iii, iv and vi

2 iii is phosphorus chloride and vi is hydrogen chloride

3 i is water as it contains two small atoms joined onto one larger atom

4 Only in a chemical change are new substances formed.

5 During a reaction no atoms are lost or gained so the mass of the products is the same as the mass of the reactants (as the same atoms are in them).

6 13.2g

7 **a** 24g **b** calcium + bromine → calcium bromide8 **a** 15g **b** 36g9 **a** methane + oxygen → water + carbon dioxide**b** The atoms are split apart and (rearranged) joined together in a different way to make the new substances (products).**8Fb-8 Chemical formulae**1 CaS 2 Li<sub>3</sub>N 3 MgF<sub>2</sub> 4 CCl<sub>4</sub> 5 PH<sub>3</sub> 6 Li<sub>3</sub>P 7 Na<sub>2</sub>S 8 CaO 9 CO<sub>2</sub> 10 BP 11 AlN 12 SiC**8Fc Mendeleev's table****Student Book****1: 8Fc Mendeleev's table**1 **a** any one of: good conductors of heat, good conductors of electricity, flexible**b** any one of: poor conductors of heat, poor conductors of electricity2 **a** lithium + water → lithium hydroxide + hydrogen**b** copper + chlorine → copper chloride3 **a** oxygen – O, fluorine – F, chlorine – Cl (or any other three examples)**b** the masses of atoms4 **a** react with metals forming solid compounds**b** react with water forming hydrogen (and an alkaline solution/solution of metal hydroxide)**c** very unreactive5 **a** increasing mass of their atoms**b** similar chemical properties**c** increasing atomic number/number of protons in their atoms**2: 8Fc Anomalous results**1 **a** because they are very different from the pattern of the other results in the graph and table**b** 34 – 12 = 22 s**c** It will reduce the range (to 6 s for the rocket fuse burn times).2 **a** The anomalous result is 29 s.**b** range with anomalous result = 14; range without anomalous result = 43 **a** It is very much higher than the rest of the results.**b** they heated longer than the other groups/they used less water than the other groups**c** i 26 °C ii 6 °C4 **a** group 6, change in mass 0.01 g**b** magnesium oxide has been lost as smoke**c** balance error when reading mass, the strip of magnesium used was not 10 cm, the magnesium was not clean/the magnesium did not burn completely**Activity Pack****8Fc-1 Mendeleev's table**1 **a** Mg **b** Cl **c** Ar **d** K

2 Elements in the same group ... have similar chemical properties.

Fluorine gas has similar chemical properties to ... bromine liquid.

Lithium metal is ... an alkali metal.



The group of elements that are very unreactive is ... the noble gases.

**3 a A b** valency of 2  
**8Fc-3 Groups in the periodic table**

1

Group 1	Group 2	Group 3							
			H						
Li				B	C	N	O	F	Ne
Na				Al	Si	P	S	Cl	Ar
K					Ge			Br	Kr
Rb					Sn			I	Xe

Alkali metal   
Halogen   
Noble gas

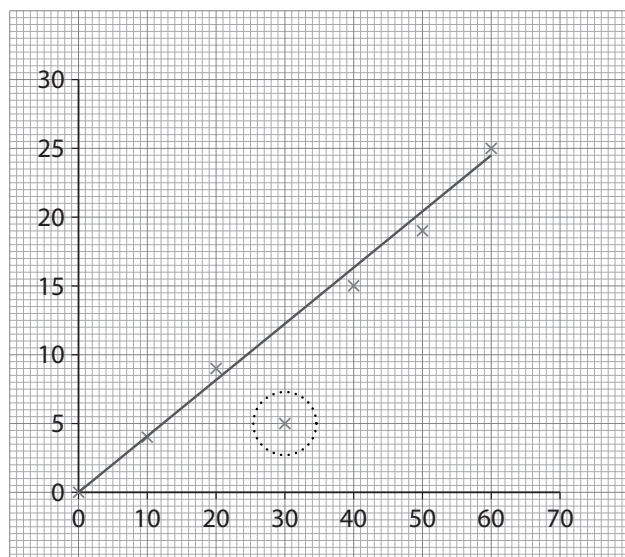
**2 Across:** 1 noble gases  
**Down:** 2 chlorine; 3 lithium; 4 halogens; 5 potassium

**8Fc-5 Anomalous result**

- 1 a 5.30m b Even when measured properly there will be some experimental error which means the results will be close but not exactly the same.
- c  $6.80 - 6.25 = 0.55 \text{ m}$
- d  $6.25 \text{ m} + 6.45 \text{ m} + 6.30 \text{ m} + 6.70 \text{ m} + 6.40 \text{ m} + 6.80 \text{ m} + 6.35 \text{ m} + 6.55 \text{ m} + 6.45 \text{ m} + 6.35 \text{ m} + 6.65 \text{ m} = 71.25 / 11 = 6.48 \text{ m}$
- e Because it is wrong and it will change the mean and make it less accurate.

f They could have forgotten to count in 1 metre lengths when measuring the room with the metre stick.

**2 a, b & d**



c The line of best fit is drawn by drawing a line so the data points each side of the line are equal.

d The anomalous result identified is well away from the best fit line.

e You should ignore anomalous results when drawing a line of best fit.

f Outlier.

g The length of the piece of magnesium used could have been shorter than recorded, etc.

**8Fc-6 Sorting elements**

- 1 a viii b i c iv d v and vi e vii f viii
- 2 a C, Ca, Co and Cu.
- b halogens, fluorine, chlorine and bromine
- 3 An unreactive element that does not form compounds easily – Noble gas
- An element that reacts quickly with water forming hydrogen gas – Alkali metal

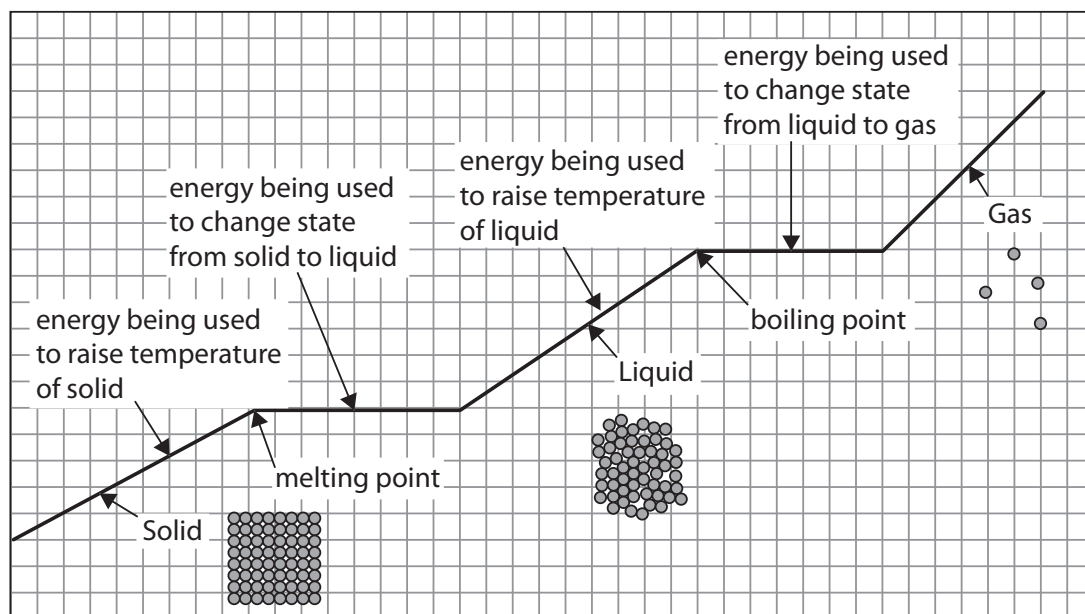
**8Fc-7 The first periodic table**

- 1 a i fluorine, chlorine, bromine and iodine ii halogens
- b i lithium, sodium, potassium, rubidium and caesium ii alkali metals iii copper, silver and osmium do not react with water like the alkali metals
- 2 a the masses of atoms (relative to hydrogen)
- b He knew that there were undiscovered elements that would fit into these places.
- c i The mass of its atoms came between zinc and germanium. ii Its properties would be like aluminium and boron as these elements are in the same group.

**8Fc-8 Predicting new elements**

- 1 That was all the known elements at that time.
- 2 The mass of their atoms (relative to hydrogen).
- 3 Most properties will be in between silicon and tin. Therefore semi-metal, in between a metal and a non-metal.
- Difficult to predict conductivity, so could be a poor or a good conductor.
- Relative atomic mass between 60 and 80 as masses get greater in increasing steps down the group.
- Melting point about 1000 °C, or at least less than 1410 °C, the melting point of silicon.
- Density between 4 and 6 g per cm<sup>3</sup>, between silicon and tin.
- GeO<sub>2</sub> (same as other compounds in the group).
- Solid, as both silicon and tin.
- 4 He switched a few elements around out of order with the masses of their atoms.
- 5 *Students' own answers*, but might be something ending in - ium.





Worksheet 8Fd-3, question 1

Non-metals: dull, low melting points, brittle (when solid), poor conductors of heat and electricity.

**8Fd-4 Looking for trends**

**1 a** Melting points decrease down the alkali metal group.

**b** Between 20 and 30 °C. Bar drawn on melting point chart to fit answer.

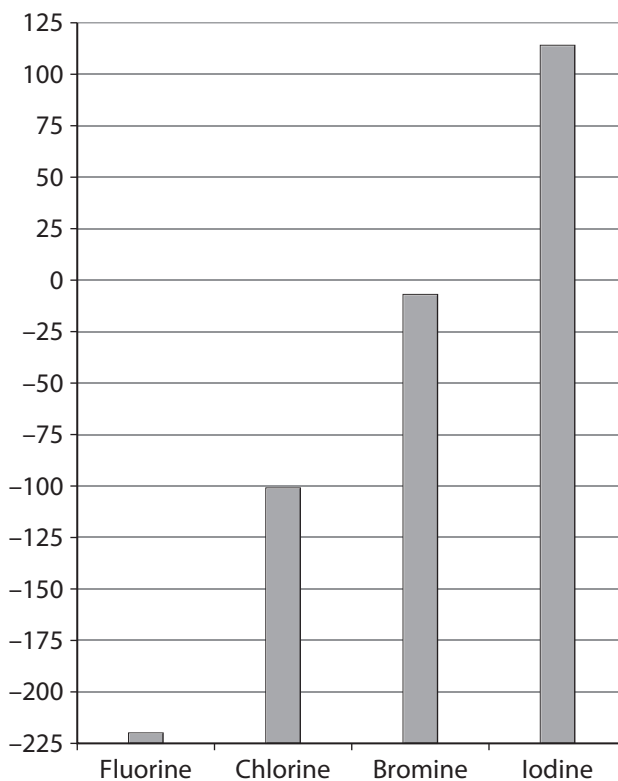
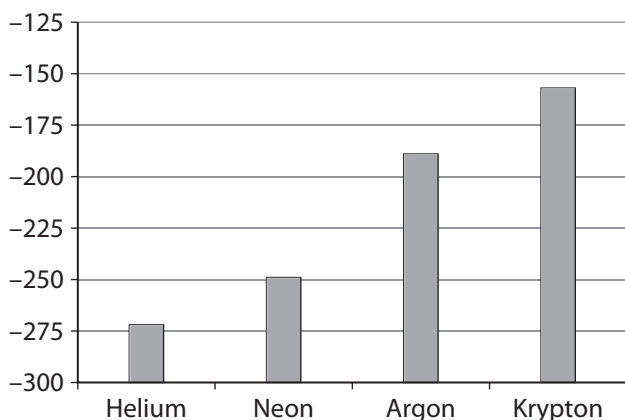
**c** Boiling points decrease down the alkali metal group.

**d** Between 600 and 700 °C. Bar drawn on boiling point chart to fit answer.

**e** Data book values: caesium melting point = 28 °C and boiling point = 671 °C, plus comments.

**f** All fit the trend, as they all decrease (in smaller steps each time) as you move down a period.

**2 a i & ii**



**b** Range for halogens is 334 °C. Range for noble gases is 115 °C.

**c** Melting points are increasing down each group.

**d i** Melting point astatine between 200 and 400 °C.

## The periodic table

**ii** Melting point xenon between  $-140$  and  $-100$  °C.

**e** Data book values: astatine melting point =  $302$  °C; xenon melting point =  $-112$  °C, plus comments.

**8Fd-5 Atomic sizes**

**1** diagrams of atomic sizes in periodic table order

**2 a** Size decreases across a period.

**b** Size increases down the groups.

**c** All results fit the trends as there is a steady increase down groups and a steady decrease across periods.

**3 a 6 b 5 000 000**

**8Fd-6 About properties**

**1 a** solid changes to liquid

**b** liquid changes to solid

**c** liquid changes to gas

**2 a** Element X is a non-metal due to its properties, for example being a non-conductor of electricity as all metals are conductors.

**b** Element Y is a metal due to its properties, for example being a conductor of heat electricity. All metals are conductors while most non-metals are non-conductors.

**c** Element Y.

**d** Element Y as it is a good conductor of heat.

**e i** X = solid and Y = solid **ii** X = liquid and Y = solid **iii** X = gas and Y = solid **iv** X = gas and Y = gas

**8Fd-7 Looking for trends**

**1 a** rising **b** solid **c** boiling

**d** The temperature doesn't rise as the energy added is used to free the particles in the solid to allow them to move over each other as the substance melts.

**2 a** fluorine, chlorine, bromine, iodine.

**b** The melting points decrease down the alkali metal group and increase down the noble gas group.

**c** Down group 6 the melting points generally increase except for polonium, which has a lower melting point than tellurium.

**d** melting point estimates: germanium between  $500$  and  $2000$  °C (between the melting points of silicon and tin); bromine between  $-50$  and  $+50$  °C (between the melting points of chlorine and iodine)

**8Fd-8 Tiny measurements**

**1** water molecule < virus < grain of salt < ant < small boy

**2 a 1 000 000 b 10 000 000 c 50 000 000**

**3 a** Rubidium (Rb) is the largest and helium (He) is the smallest.

**b** Atomic size increases down the groups.

**c** Atomic size decreases across the periods.

**d** See graph *Worksheet 8Fd-8, question 3d*, below.

**e i** germanium between  $0.272$  and  $0.228$  nm and magnesium  $0.236$ – $0.368$  nm

**ii** Estimates made by looking at the atomic sizes of elements above and below and on either side in the periodic table and choosing a value that fits the trends.

**f** It is described as periodic because the graph rises and falls regularly.

**8Fe Chemical trends****Student Book****1: 8Fe Chemical trends**

**1** three from: soft, low melting point, react quickly with oxygen (producing a metal oxide), react quickly with water (producing metal hydroxides and hydrogen)

**2 a** lithium fizzes/bubbles, sodium fizzes rapidly then melts into a ball, potassium bursts into flames

**b i** sodium + oxygen  $\rightarrow$  sodium oxide

**ii** potassium + water  $\rightarrow$  potassium hydroxide + hydrogen

**3 a** because they react quickly with air and water/ to keep out air and water

**b** lithium

**4 a** rubidium hydroxide and hydrogen

**b** e.g. an explosive reaction, burns very brightly, sparks

**5 a** photo B: sodium + oxygen  $\rightarrow$  sodium oxide; photo C: phosphorus + oxygen  $\rightarrow$  phosphorus oxide; photo D: sulfur + oxygen  $\rightarrow$  sulfur dioxide

**6** sodium oxide + water  $\rightarrow$  sodium hydroxide + hydrochloric acid  $\rightarrow$  sodium chloride + water

**7** From left to right across the periodic table the oxides become more acidic/form solutions with lower pH/become less alkaline.

**8 a** Add universal indicator and check the pH against the colour chart.

**b** Element X is on the right-hand side of the periodic table while element Y is on the left.

**9 a** It would burn brightly.

**b** Fluorine would be more reactive than chlorine as reactivity increases up the group of halogens.

**2: 8Fe Firework ban**

**1 a** hands and fingers

**b** burns

**c** rockets

**d i** Someone could pick up a spent sparkler that was still very hot.

ii Rockets could fall over when lit or go in the wrong direction and fly into people.

2 any five from: carbon – C, sulfur – S, iron – Fe, magnesium – Mg, aluminium – Al, lithium – Li, potassium – K, nitrogen – N, oxygen – O

3 a because they had similar chemical properties

b the alkali metals; their reactivity increases down the group

4 a carbon + oxygen → carbon dioxide  
sulfur + oxygen → sulfur dioxide

b the sulfur dioxide solution; oxides of elements get more acidic from left to right across the periodic table

### Activity Pack

#### 8Fe-1 Trends in chemical properties

1 Missing information: Li; sodium; 1; under oil; gas; sodium hydroxide + hydrogen; potassium; fire; water and hydrogen.

2 The reaction of zinc with oxygen ... produces zinc oxide.

When elements react with oxygen ... compounds called oxides form.

When an element burns in air ... it is reacting with oxygen.

The product of sulfur and oxygen ... is sulfur dioxide.

#### 8Fe-3 Chemical properties

1 a 1

b under oil

c oxygen → sodium oxide

d hydrogen

e they react with water

2 b

#### Making metal oxides

copper + oxygen → copper oxide

sodium + oxygen → sodium oxide

magnesium + oxygen → magnesium oxide

#### Making non-metal oxides

carbon + oxygen → carbon dioxide

sulfur + oxygen → sulfur dioxide

phosphorus + oxygen → phosphorus oxide

#### 8Fe-4 Trends and patterns

1 a drawings of lithium fizzing, sodium melting into a fizzing ball and potassium burning

b Caesium would burn brightly or explode as reactivity is increasing down the group.

2 a pH decreases from group 1 to 5, then rises again from 5 to 7.

b Metal oxides form alkaline (or neutral solutions), non-metal oxides form acidic (or neutral solutions) solutions.

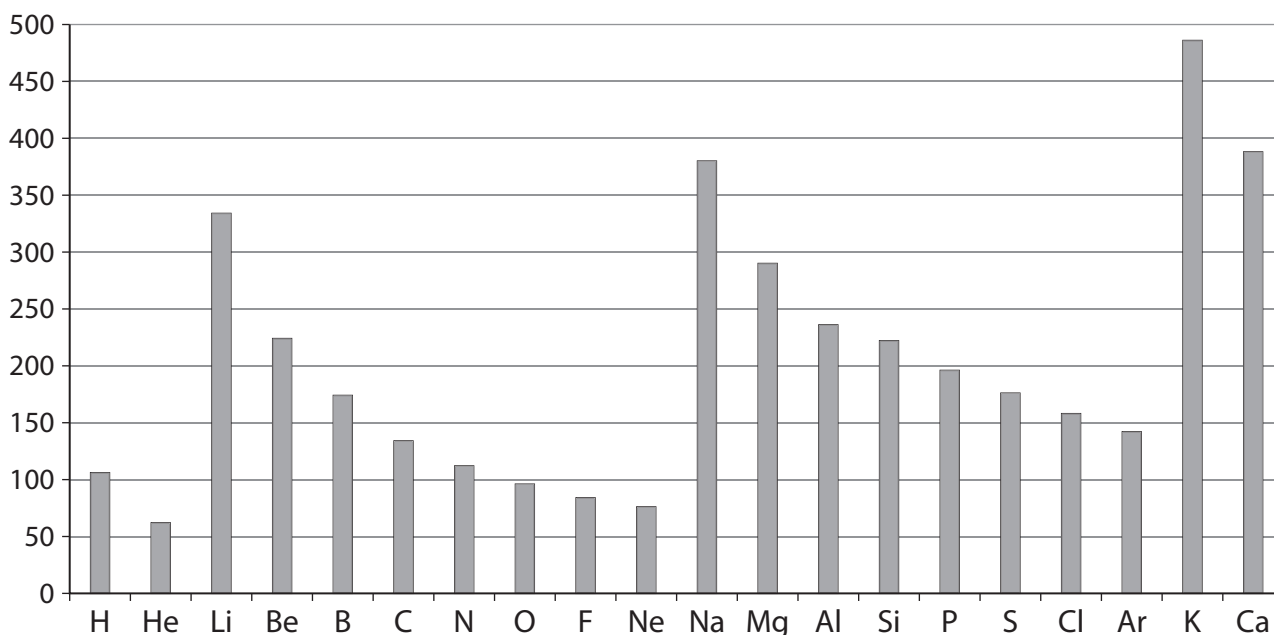
c Argon does not form compounds (it's a noble gas).

d Their oxides have a pH of 7, which is the same pH that would result if they were insoluble (as the pH of water is 7).

#### 8Fe-5 Atoms, molecules and lattices

1 b Data sheet figures:

sodium chloride melting point = 801 °C and boiling point = 1413 °C



Worksheet 8Fd-8, question 3d

## Metals and their uses

sulfur melting point = 113 °C and boiling point = 445 °C

water melting point = 0 °C and boiling point = 100 °C

magnesium oxide melting point = 2614 °C and boiling point = 2850 °C

carbon dioxide melting point = 801 °C and boiling point = 1413 °C

methane melting point = -183 °C and boiling point = -164 °C

carbon melting point = 3642 °C and boiling point = 3642 °C (sublimes)

copper melting point = 1083 °C and boiling point = 2567 °C

**c** Molecular structures: sulfur, water, methane and carbon dioxide.

Lattice structures: sodium chloride, carbon, copper metal and magnesium oxide.

**2** Molecular substances have fairly low melting points and boiling points. Lattice substances have high melting points and boiling points.

**8Fe-6 About chemical reactions**

**1 a** lithium + oxygen

**b** sodium oxide

**c** carbon

**d** sodium + water ... hydrogen

**2 Across:** 3 hydrogen **6** caesium **8** oxide

**9** potassium **11** and **7** down alkali metals

**Down:** **1** burn **2** and **4** down chemical reactions

**5** hydroxide **8** oil **10** water

**8Fe-7 The halogens of group 7**

**1 a i** between -200 and -250 °C **ii** burns **iii** Br<sub>2</sub> **iv** solid **v** MgI<sub>2</sub>

**b** group 7

**c i** magnesium + bromine → magnesium bromide

**ii** sodium + fluorine → sodium fluoride

**iii** magnesium + oxygen → magnesium oxide

**d** reactivity decreases

**e** Astatine formula = As<sub>2</sub>; melting point 200–400 °C and solid. Formula same as other halogens, melting point greater than iodine and solid state as melting points increasing down the group.

**2** The trend goes the opposite way, so the alkali metals get more reactive going down the group.

**3** Metal oxides: all solids; high melting point; alkaline solutions.

Non-metal oxides: can be gases; low melting point; acidic solutions.

**8Fe-8 Atoms, molecules and lattices**

**1** group 0

**2** They are very unreactive.

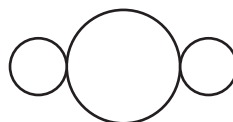
**3** Melting points and atomic sizes both increase going down the group.

**4** nanometres

**5** Melting point between -60 and -90 °C as the trend is decreasing down the group. Atomic size 0.10–0.20 nm as the trend is increasing down the group.

**6** XeF<sub>6</sub>

**7**



**8** Reactivity increases down the noble gas group.

**9** In terms of reactivity, helium doesn't form compounds, argon and neon compounds are rare; however, some compounds of krypton have been made and the xenon forms compounds most easily. Reactivity is increasing down the group.

**10** In air the filament would react with the oxygen, but it will not react with argon.

**11** Helium is safer as it will not burn, whereas hydrogen gas will burn readily with oxygen.

**12** Molecular structures have a set number of atoms joined together in small groups, e.g. xenon hexafluoride has molecules containing one xenon atom and six fluorine atoms.

Lattice structures have billions of atoms joined together with no set number being joined in the structure, e.g. sodium chloride lattice contains billions of sodium and billions of chlorine atoms joined together.

**8G Metals and their uses****8Ga Metal properties****Student Book****1: 8Ga Building up**

**1** At the time people didn't know how to make steel.

**2** It is strong and malleable.

**3** any appropriate answers, e.g. aluminium for windows, copper for pipes and wiring, lead for roof flashings and gutters

**4** too expensive/not enough available/not strong enough

**5** *Students' own answers*, e.g. advantage: doesn't use up a lot of land space; disadvantage: expensive/difficult to build

**2: 8Ga Metal properties**

**1** any four from: shiny, hard, strong, high density, high melting point, malleable, flexible, good conductors of heat and electricity

**2 a** Mercury is unusual because most metals are solids at room temperature.

**b** Carbon is unusual as most non-metals do not conduct electricity.

**3 a** It is a good conductor of electricity.

**b** Iron rusts/reacts with water.

**4** A physical property is what a substance looks like or does without reacting. A chemical property is what a substance does in chemical reactions.

**5 a i** sodium + oxygen → sodium oxide

**ii** magnesium + chlorine → magnesium chloride

**iii** silver + oxygen → silver oxide

**iv** iron and sulfur → iron sulfide

**b** fast – sodium + oxygen, magnesium + chlorine, iron + sulfur; slow – silver + oxygen

**6 a** a substance that speeds up a chemical reaction without being used up

**b** because they are very expensive

**7** platinum catalyst speeds up the reaction changing harmful gases into harmless gases. Carbon monoxide, nitrogen oxides and hydrocarbons become carbon dioxide, water and nitrogen.

**8** any appropriate answers, e.g. copper electrical wiring, as it is a good conductor of electricity; steel in radiators, as it is a good conductor of heat; aluminium for doors and windows, as it is light and strong; lead for flashing on roofs, as it is malleable; copper for water pipes, as it is strong and flexible or unreactive or malleable

### Activity Pack

#### 8Ga-1 Metals

**1** yes: good conductors of electricity; shiny solids when polished

**2** copper – water pipes, iron – building frames, aluminium – window frames

**3 a** strong    **b** conductor    **c** react  
**d** flexible    **e** faster

#### 8Ga-4 Metals and reacting

**1** Reactions which occur quickly without a catalyst:  
iron + fluorine → iron fluoride

<b>Group</b>	1	2	3	4	5	6	7
<b>Valency</b>	1	2	3	4	3	2	1
<b>Examples</b>	Li/Na/K	Be/Mg/Ca	B/Al/Ga	C/Si/Ge	N/P/As	O/S/Se	F/Cl/Br

**2 a** Na<sub>3</sub>P    **b** CaO    **c** Mg<sub>2</sub>C    **d** AlN    **e** BeBr<sub>2</sub>

**f** B<sub>2</sub>S<sub>3</sub>    **g** CaCl<sub>2</sub>    **h** BF<sub>3</sub>    **i** SiO<sub>2</sub>

**3 a** FeF<sub>3</sub>    **b** Ag<sub>2</sub>O    **c** CoO    **d** Cu<sub>3</sub>N

**e** CuBr<sub>2</sub>    **f** Fe<sub>2</sub>S<sub>3</sub>

(zinc + hydrochloric acid → zinc chloride + hydrogen)

Reactions which occur quickly with the help of a catalyst:

copper + oxygen → copper oxide

zinc + hydrochloric acid → zinc chloride + hydrogen

aluminium + iodine → aluminium iodide.

**2** A catalyst is a substance that speeds up a chemical reaction without being used up (permanently changed).

#### 8Ga-5 Metals and properties

**1** Most metals are brittle malleable so they don't bend. Non-metals are usually 'bendy' brittle.

**2** Copper is used because it is cheaper less reactive than iron or zinc.

**3** Metals are used for mirrors because they are good conductors of electricity shiny when polished.

**4** Aluminium, copper, glass iron and wood lead. (or other metals)

**5** Because they need to be able to hold heavy-weights bend without breaking.

**6** All metals react with air when heated conduct electricity.

**7** Aluminium is stronger lighter (less dense) than iron.

**8** Copper is used as it is a good insulator conductor of heat.

#### 8Ga-6 Useful properties

**1** relative cost of metals

**2** aluminium + oxygen → aluminium oxide and copper + oxygen → copper oxide

**3 a** high-energy conduction by electricity

**b** It has a lower density.

**c** It has a lower strength.

**d** good conductor of heat

**e** Copper is too expensive.

**4 a** A catalyst speeds up chemical reactions without being used up. The catalyst in car exhausts helps speed up the reactions which change harmful gases into harmless gases.

**b** density

#### 8Ga-7 Formulae 1

**1**

#### 8Ga-8 Formulae 2

**1 a** N<sub>2</sub>O    **b** CH<sub>4</sub>    **c** BrCl    **d** CaO

**2 a** K<sub>3</sub>N    **b** MgCl<sub>2</sub>    **c** Al<sub>2</sub>O<sub>3</sub>    **d** NCl<sub>3</sub>    **e** AlP

**f** CaO    **g** FeBr<sub>2</sub>    **h** Zn<sub>3</sub>N<sub>2</sub>    **i** Co<sub>2</sub>O<sub>3</sub>

**3 a** 1    **b** 3    **c** 2

**8Gb Corrosion****Student Book****1: 8Gb Corrosion**

- oxygen
- Corrosion is the reaction of any metal with oxygen. Rusting is the corrosion of iron (and steel).
- a, b, c** any appropriate answers, e.g. quick – magnesium; slow – copper; not at all – gold
- The titanium oxide is strong and prevents further corrosion (and looks good).
- a** Pb  
**b** PbO
- a** tin + oxygen → tin oxide  
**b** The ratio of tin to oxygen atoms is 1:2.

There are twice as many oxygen atoms as tin atoms in tin oxide.

- a** oxygen and water  
**b** hydrogen, oxygen and iron  
**c** There is not much water to cause rusting.
- any appropriate answers, e.g. barriers are paint, plastic, oil and tin; they work by keeping out air and water; this needs to be done to protect iron objects from being destroyed by rust

**Activity Pack****8Gb-1 Corrosion**

- a** Corrosion is when a metal ... reacts with oxygen.  
**b** Zinc oxide forms during ... the corrosion of zinc.  
**c** For rusting to occur ... oxygen and water are required.  
**d** Rusting is the ... corrosion of iron.  
**e** Rusting can be prevented ... by painting the metal.
- a** oxide  
**b** corrosion (oxidation)  
**c** rust/corrode/react
- any sensible suggestion such as the rusting of iron
- oxygen

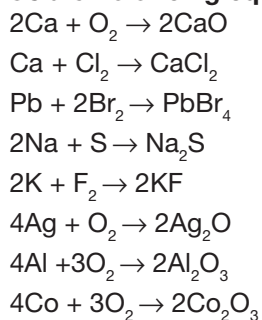
**8Gb-3 Corrosion and rusting**

**Across:** 3 oxide 5 copper 8 reactive 9 water  
10 rusting 11 slowly 12 corrosion

**Down:** 1 oxide 2 oxygen 4 destroys 6 plastic  
7 painting

**8Gb-4 Stop rusting**

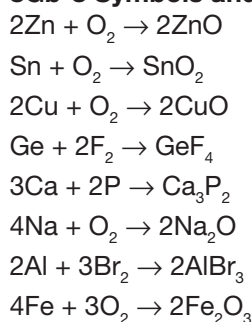
- missing words: iron; water; oxygen; rusting; barrier; oxidation; water
- missing words: Products; titanium oxide; oxygen; chromium oxide

**8Gb-5 Balancing equations****8Gb-6 Oxidation and rusting**

- oxidation
- iron, water and oxygen
- a** paint, oil and plastic  
**b** It acts as a barrier keeping out water and oxygen.
- zinc oxide
- test tube 2: no water present  
test tube 3: no air (oxygen) present  
test tube 4: iron covered by paint to keep out air and water

**8Gb-7 Describing materials**

- When describing substances or reactions.
- a** A transparent, flexible solid is used to make rulers.  
**b** The carbon in pencil leads is a black, brittle solid.
- a** nasty and horrible; four year-old child  
**b** flexible and malleable  
**c** slow  
**d** slower, pure and alkaline  
**e** crumbly and brittle  
**f** Nasty, horrible from quote A. Expensive and ugly from quote F. Time-consuming, interesting and useful from quote G.

**8Gb-8 Symbols and balancing****8Gc Metals and water****Student Book****1: 8Gc Metals and water**

- any three from: caesium, rubidium, potassium, sodium, lithium, calcium, magnesium



2 NaOH, H<sub>2</sub>

3 a photo B: indicator changing colour and gas given off; photo C: bubbles of gas forming/gas given off; photo D: few bubbles of gas formed

b bring a lit splint near and it burns with a 'squeaky pop'

4 potassium + water → potassium hydroxide + hydrogen

calcium + water → calcium hydroxide + hydrogen

5 copper, tin, zinc, lithium

6 a gold, platinum

b caesium, francium

c copper (mercury and silver are also possible answers)

7 a just below magnesium, as magnesium burns in air but reacts slowly with water

b i X oxide ii X hydroxide + hydrogen

### Activity Pack

#### 8Gc-1 Metals and water

1 a calcium b hydrogen c copper

2 a Magnesium reacts very slowly producing a few bubbles.

Potassium burst into flames.

Lithium floats on the surface producing bubbles of gas.

Sodium melts into a ball and fizzes a lot on the surface.

b 1 potassium, 2 sodium, 3 lithium, 4 magnesium

3 lithium hydroxide + hydrogen

4 True: Hydrogen is a gas at room temperature. Hydrogen burns with a 'squeaky pop' when lit.

Other statements are false.

#### 8Gc-3 Reactions of metals

missing words: hydrogen; unreacted; pops (explodes); floating; melts; fizzes

#### 8Gc-4 Reactivity series

1 names of metals and missing words: copper/water; sodium/alkaline; calcium/hydrogen; lithium/gas; magnesium/gas (hydrogen); potassium/burns

2 a potassium hydroxide + hydrogen

b  $2K + H_2O \rightarrow 2KOH + H_2$

c sodium + water

d  $2Li + H_2O \rightarrow 2LiOH + H_2$

#### 8Gc-5 More about reactivity

1 a tin and copper

b magnesium and zinc

c The metals that slow down rusting are higher in the reactivity series than iron, and the metals that make rusting faster are lower than iron in the reactivity series.

d aluminium and calcium (or potassium, sodium or lithium)

2 a magnesium + water → magnesium hydroxide + hydrogen

zinc + water → zinc hydroxide + hydrogen

b because the other metal reacts or is sacrificed instead of the iron

c The order of decreasing reactivity is: magnesium, zinc, iron, tin, copper.

d No changes required, the order is correct.

e Any one of the following metals would slow down the rusting iron in a similar way to magnesium and zinc: aluminium, calcium, potassium, sodium or lithium.

Any one of the following metals silver or gold would speed up the rusting of iron in a similar way to copper and tin: lead, mercury, silver or gold.

#### 8Gc-6 Wet metals

1 missing words:

a fizz/bubble (do not accept reacts and hydrogen)

b alkaline

c most and flames

d calcium

e melt

f hydrogen and alkaline

2 a Place a lit splint near hydrogen and it burns with a squeaky pop.

b the oxidation (or combustion or corrosion) reaction

3 a Because they would react with water.

b Copper doesn't react with water whereas iron does.

#### 8Gc-7 Metals in water

1 a calcium 23 cm<sup>3</sup>, lithium 33 cm<sup>3</sup>, magnesium 0 cm<sup>3</sup> and sodium 43 cm<sup>3</sup>

b *Students' own bar charts.*

c hydrogen

d in order: sodium, lithium, calcium and magnesium

e The order is the same as the reactivity series (getting less reactive).

2 Place a lit taper/splint near the mouth of a test tube and if hydrogen is present it will burn with a squeaky pop.

3 a sodium b copper c calcium

## Metals and their uses

- 4 a sodium + water → sodium hydroxide + hydrogen  
 b magnesium + water → magnesium hydroxide + hydrogen
- 5 metal + water → metal hydroxide + hydrogen

**8Gc-8 Rusting and sacrificial protection**

- 1 a It keeps out air (oxygen) and water.  
 b Eventually the coating will become broken or damaged and the water and air will get in.

- c magnesium and zinc  
 d because it will react until it has all gone

- 2 a If you use iron screws then the screws will corrode quickly, as iron is more reactive than copper. Once the screws have corroded, the roof plates will fall off.

b When the tin coating becomes scratched the water and air get in. As iron is more reactive than tin, the iron corrodes (rusts) faster than usual. The rust will spoil the food inside the can.

c The zinc coating will protect, like paint, by keeping out air and water. In addition, if the coating becomes scratched or broken the zinc will continue to protect the iron, by sacrificial protection, as the zinc is more reactive than the iron.

**8Gd Metals and acids****Student Book****1: 8Gd Quality evidence**

- 1 a It would need to be filled over and over again (which would repeat any error again and again).  
 b any four from: volume of acid, mass of metals, concentration of acid, type of acid, temperature, size/shape of flask, form and cleanliness of metals (e.g. shavings, rusty)  
 c 43 cm<sup>3</sup>

- 2 a result that is very different from the others
- 3 Data is repeatable if the results measured by one experimenter are all very close. Data is reproducible if other people can also get similar close values.
- 4 volume of gas, type of acid used, mass of metal, form of metal, cleanliness of pieces of metals, temperature, size of glassware, concentration of acid, time
- 5 Calcium is most reactive, then magnesium, then zinc. The more reactive metal will produce more gas in the same time.
- 6 a They are reliable as the results are all very similar.  
 b The mean is 22.7 cm<sup>3</sup> (accept 23, which is the mode).

- 7 range = 19 – 5 = 14 (without anomalous results = 12 – 10 = 2). Accept 'from 5 to 19 cm<sup>3</sup>' (ranges in maths and science may be given differently).

8 The anomalous result is zinc, 5 cm<sup>3</sup>. The answer should include an appropriate explanation, e.g. it could have been caused by not cleaning the metal properly, misreading the scale on the measuring cylinder, putting in too little calcium.

**2: 8Gd Metals and acids**

- 1 paint them or use another coating
- 2 add a pH indicator (certain colours indicate if it is acidic) or add litmus (if acidic it turns red) or use a pH meter (any pH value below 7 is acidic)
- 3 a one from: potassium, sodium, caesium, rubidium  
 b one from: copper, mercury, silver, gold
- 4 copper, iron, zinc, sodium
- 5 Use a metal like zinc, which reacts with acid but not with water. If you add it to the liquids, the acid will form bubbles while the water will not.
- 6 a calcium nitrate  
 b lithium chloride
- 7 iron sulfate and hydrogen
- 8 a zinc + sulfuric acid → zinc sulfate + hydrogen  
 $\text{Zn} + \text{H}_2\text{SO}_4 \rightarrow \text{ZnSO}_4 + \text{H}_2$   
 b After the reaction is completed, filter out excess zinc and heat the solution of zinc sulfate to evaporate the water and leave the salt.

**Activity Pack****8Gd-1 Metals and acids**

- 1 How do you test a solution to see if it is an acid? use colour of an indicator  
 Name a metal that does not react with dilute acids. copper  
 What gas is formed when metals react with acids? hydrogen  
 Complete the general equation: metal + acid → salt + hydrogen  
 Name a metal that reacts quickly with dilute hydrochloric acid. magnesium  
 Name the salt formed between hydrochloric acid and magnesium. magnesium chloride.
- 2 a acid b gold c salt d sulfuric acid  
 e zinc f hydrogen

**8Gd-3 Matching salts**

- 2 Possible answers include:  
 potassium + hydrochloric acid → potassium chloride + hydrogen  
 tin + hydrochloric acid → tin chloride + hydrogen  
 zinc + sulfuric acid → zinc sulfate + hydrogen  
 aluminium + sulfuric acid → aluminium sulfate + hydrogen

magnesium + nitric acid → magnesium nitrate + hydrogen

### 8Gd-4 The reactivity series

1 the order is: Potassium, Sodium, Calcium, Magnesium, Aluminium, Iron, Tin, Copper, Silver, Gold

2 potassium + hydrochloric acid → potassium chloride + hydrogen

sodium + hydrochloric acid → sodium chloride + hydrogen

calcium + hydrochloric acid → calcium chloride + hydrogen

magnesium + hydrochloric acid → magnesium chloride + hydrogen

aluminium + hydrochloric acid → aluminium chloride + hydrogen

iron + hydrochloric acid → iron chloride + hydrogen

tin + hydrochloric acid → tin chloride + hydrogen

### 8Gd-5 Modelling reactions

1  $\text{Zn} + 2\text{HCl} \rightarrow \text{ZnCl}_2 + \text{H}_2$

$\text{Ni} + \text{H}_2\text{SO}_4 \rightarrow \text{NiSO}_4 + \text{H}_2$

$\text{Co} + 2\text{HCl} \rightarrow \text{CoCl}_2 + \text{H}_2$

$\text{Mg} + 2\text{HNO}_3 \rightarrow \text{Mg}(\text{NO}_3)_2 + \text{H}_2$

$\text{Ca} + \text{H}_2\text{SO}_4 \rightarrow \text{CaSO}_4 + \text{H}_2$

2 a  $\text{Ni} + 2\text{HCl} \rightarrow \text{NiCl}_2 + \text{H}_2$

b  $\text{Ba} + 2\text{HCl} \rightarrow \text{BaCl}_2 + \text{H}_2$

c  $2\text{Na} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + \text{H}_2$

d  $\text{Sn} + 4\text{HCl} \rightarrow \text{SnCl}_4 + 2\text{H}_2$

e  $2\text{Al} + 3\text{H}_2\text{SO}_4 \rightarrow \text{Al}_2(\text{SO}_4)_3 + 3\text{H}_2$

f  $2\text{Fe} + 6\text{HCl} \rightarrow 2\text{FeCl}_3 + 3\text{H}_2$

### 8Gd-6 Reactions and metals

1 potassium

2 sodium hydroxide and hydrogen

3 copper oxide

4 magnesium

5 a iron

b copper (or silver)

c magnesium (or aluminium)

6 chloride

7 sulfuric acid

8 reactive (accept dangerous)

9 aluminium

10 water

### 8Gd-7 Quality evidence

1 Sulfuric acid reacts faster than nitric acid as in all experiments the magnesium disappeared more quickly in the sulfuric acid.

2 The concentration and volume of acid used, the size, form and cleanliness of the magnesium and the temperature.

3 The size and cleanliness of magnesium ribbon will vary slightly in each experiment (or deciding when the magnesium has completely disappeared will vary between students).

4 The mean for sulfuric acid = 36 s, and for nitric acid = 51 s.

5 Accurate means a result is close to the true value.

6 They are repeatable because the results for each acid are very close.

7 The second try for sulfuric acid is anomalous as it is very different from the other results.

8 The results look reproducible, as the results obtained by the different groups are close.

9 Group 5 used sulfuric acid that was twice as concentrated, as it took half the time to react compared to the other groups.

10 Group 3 used 2 cm pieces of magnesium ribbon, as it took twice the time to react compared to the reactions of both acids in most of the other groups.

11 a magnesium + sulfuric acid → magnesium sulfate + hydrogen

b magnesium + nitric acid → magnesium nitrate + hydrogen

### 8Gd-8 Making salts

1 a 2 b 3 c 2 d 4

2 a 1 b 3

3 a NaCl b  $\text{MgF}_2$  c  $\text{CuCl}_2$  d CaO

e  $\text{Co}_2\text{O}_5$  f  $\text{PbS}_2$

4 a  $\text{MgSO}_4$  b  $\text{Li}_3\text{PO}_4$  c  $\text{ZnCO}_3$  d  $\text{Mg}(\text{NO}_3)_2$   
e  $\text{Al}_2(\text{SO}_4)_3$  f  $\text{FePO}_4$

### 8Ge Pure metals and alloys

#### Student Book

#### 1: 8Ge Pure metals and alloys

1 A pure substance only contains one substance; a mixture contains two or more substances that are not chemically joined together.

2 shiny, hard, strong, high melting point, high boiling point, malleable, flexible, ductile, good conductor of heat, good conductor of electricity

3 a stainless steel

b joining pipes or wires in electrical circuits

c It is strong but light making flying easier/cheaper.

4 a a metal with another element added/an impure metal

b In the pure metal the atoms are arranged in regular rows and so they can slip over each other fairly easily, allowing the metal to bend. In the alloy, the different-sized atoms disrupt the structure so

## Metals and their uses

the rows of atoms cannot slip over each other easily and therefore it is harder to bend.

- 5 a lead 327 °C, tin 232 °C  
b 61% tin, 39% lead

6 a Iron X is the pure metal as it has an exact melting point.

b Iron alloys have better properties for building, e.g. stronger, resist corrosion, etc.

### 2: 8Ge New alloys (STEM)

1 a An alloy is a metal made from a mixture of elements.

b Three examples of alloys include: solder, main metal lead; duralumin, main metal aluminium and steel, main metal iron.

2 Alloys can have better/more useful properties than the pure metals.

3 Spectacles made from shape memory metal are less likely to break.

4 A metallurgist

5 a The alloy will need to be, strong, unreactive, high melting point, malleable and resist wear. (The answer requires any two of these properties.)

b Any two starter questions similar to the following. What present alloy has most of the required properties? How could we try to change a present alloy to make it have the properties we want?

6 a Pure nickel is stronger than pure copper.

b Starting with pure copper, as the % of nickel increases the alloy strength first increases then decreases. The 60% nickel (40% copper) mixture is the strongest alloy.

### 3: 8Ge Metals in art

1 a Rust is iron hydroxide (or a compound of iron, oxygen and hydrogen). It is formed by the reaction of iron with oxygen and water.

b a mixture of metals or a metal mixed with another element or an impure metal

c The alloy forms a strong rust-coloured coating and does not rust like iron.

2 a In copper, the atoms are arranged in regular rows and they slip over each other fairly easily, allowing the metal to bend. In bronze, the different-sized tin atoms disrupt the structure so the rows of copper atoms cannot slip over each other easily and therefore it is harder.

b They would last longer/cut things better, etc.

3 a It keeps out air and water.

b zinc sulfate and hydrogen

## Activity Pack

### 8Ge-1 Pure metals and alloys

1 Missing words (clockwise from top right): cooling, solid, melting, evaporation and heating.

2 Left-hand diagram is a pure substance and the right-hand diagram is a mixture.

- 3 a mixture, metals  
b stronger, harder  
c corrosion  
d lower

### 8Ge-2 Looking at particles

2 a In a pure metal all the atoms are the *same*.

An alloy contains *different* atoms mixed together.

b The melting point of an alloy will be lower and less precise (it will melt over a range of temperatures) than that of the pure main metal.

### 8Ge-3 Explaining properties

- 1 a another metal (element) mixed with it  
b properties  
c uses, properties  
d lower  
e solder, steel and brass

### 8Ge-4 Mixtures, alloys and change

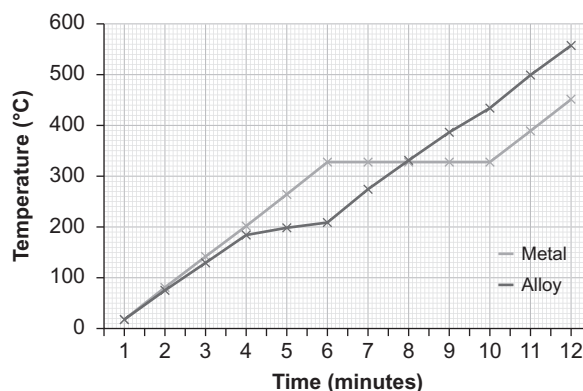
1 Across: 3 point 5 harder 6 alloy  
8 evaporation 9 useful

Down: 1 corrode 2 pure 4 melting 7 liquid

- 2 a nickel  
b aluminium and alumin bronze  
c they are less and melt over a range of temperatures

### 8Ge-5 Identifying metals

1 Students' own graphs.



- 2 328 °C  
3 186–212 °C  
4 It doesn't level off completely during melting and it eventually rises to a higher temperature in

the same time. (Or it stops rising so fast at a lower temperature.)

5 Alloys have different properties and these can sometimes be more useful than the pure metal.

### 8Ge-6 Information on mixtures

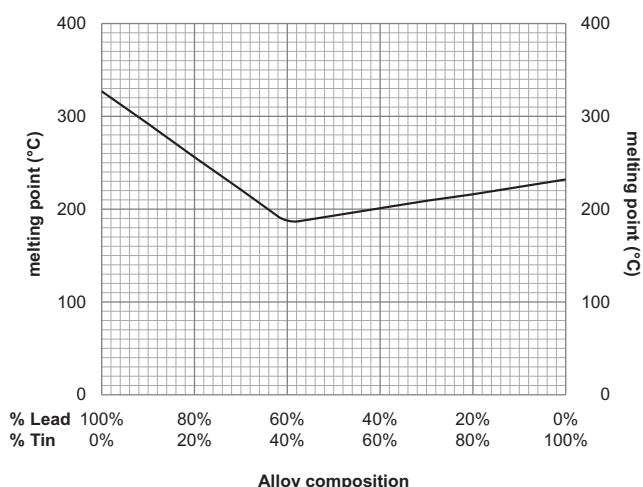
1 a mixture of metals or a metal with another element added

2 because they have different (better) properties than pure metals

3 It should melt at a low temperature and not corrode/react easily.

4 It will have a lower melting point.

5 *Students' own graphs.*



6 a pure lead b around 75% lead and 25% tin  $\pm$  2%

7 It lowers it.

8 By making the line wider to show the range of temperatures, or by drawing two lines with one line showing the minimum melting temperature and the other showing the maximum melting temperature.

### 8Ge-7 Measuring purity

1 a two from: it could have a better appearance/colour, harder, cheaper

b to get some better property

c non-poisonous and unreactive

d i pink gold ii red gold iii green and dental gold iv pure gold

e pure gold = 1000, green gold = 750, pink gold = 375, red gold = 585 and dental gold = 750

f Pure substances have precise melting points while mixtures melt over a range of temperatures.

2 a 328°C

b When a substance reaches its melting temperature, the temperature stops rising until all the element has melted.

c The particles move about faster (and move further apart).

## 8H Rocks

### 8Ha Rocks and their uses

#### Student Book

#### 1: 8Ha Disaster!

1 a any suitable answer, e.g. building, making statues, making roads

b Most rocks are hard. They are more resistant to weathering/being worn away than other materials such as wood.

2 a It dissolves in rainwater to form acid rain. The acidic rain damages crops.

b Sulfur dioxide is produced when fossil fuels containing impurities are burnt, causing acid rain to form.

3 a It increases the temperature/keeps the Earth warm.

b burning fossil fuels/burning forests

4 a Possible answers include the colour, size of grains (or 'pieces') that make up the rock, how hard/crumblly the rock is, etc.

b *Students' own answers.*

#### 2: 8Ha Rocks and their uses

1 a a chemical compound found in rocks

b one of the pieces of minerals that make up rocks

2 a sandstone (or any other sedimentary rock)

b granite/gabbro (or any other igneous or metamorphic rock)

3 the rocks with rounded grains/the rocks making up the gentle hills; they have worn away more to form lower hills

4 granite has interlocking, sharp-edged grains, sandstone has rounded grains that do not interlock; granite is not permeable, sandstone is; there are four main minerals in granite, there is only one main mineral in sandstone

5 There are gaps between the grains. (In fact, the gaps are usually filled with a matrix of smaller particles/cement, but this, too, has gaps.)

6 drop water onto different rocks and see how much is absorbed

the description also indicates how the test will be made fair (e.g. dropping the same amount of water onto each rock, noting how much is left after a certain time)

7 a any two from: easy to carve, resistant to wearing away, attractive appearance

b strong, resistant to wearing away.

8 sandstone: both oolite and sandstone are made from mostly a single mineral (oolite from calcite, sandstone from quartz) whereas granite contains four main minerals; both oolite and sandstone are

## Rocks

made from rounded grains, whereas granite is made from interlocking crystals

**Activity Pack****8Ha-1 Rocks and their uses**

- 1 False – Sinkholes form when limestone dissolves in water in the ground.
- 2 True
- 3 True
- 4 False – A crystal in a rock is made of one mineral.
- 5 False – Rocks with interlocking grains are not porous. OR Rocks with rounded grains are porous.
- 6 False – Granite has interlocking grains. OR Sandstone has rounded grains.
- 7 True
- 8 False – Sandstone has rounded grains. OR Granite has interlocking grains.
- 9 True
- 10 True

**8Ha-2 Permeable rocks 1**

5 To make a fair comparison. A large rock might absorb more than a small rock, so it would be best to test the same size pieces of rock. However, this is not easy to do so we make a fair comparison by working out how much water is absorbed per gram of rock.

**8Ha-3 Permeable rocks 2**

5 To make a fair comparison. A large rock might absorb more than a small rock, so it would be best to test the same size pieces of rock. However, this is not easy to do so we make a fair comparison by working out how much water is absorbed per gram of rock.

**8Ha-4 Rock textures**

- 1 A – 5, B – 4, C – 2, D – 1, E – 6, F – 3
- 2 **a** 1, 2 and 4 (B, C and D) are probably permeable, as they are made from rounded grains.  
**b** C – 2 could be sandstone, as it is made from one type of rounded grain, and F – 3 could be granite as it is made of four different minerals with interlocking grains.

**8Ha-5 Describing rocks 1**

- 1 B and C
- 2 **a** 1    **b** 2    **c** 3    **d** 3
- 3 A
- 4 D
- 5 A and D
- 6 A, there are more gaps between the grains.
- 7 C
- 8 D

**8Ha-6 Describing rocks 2**

- 1 Good answers should include the following:  
A = rounded, non-interlocking grains, all of similar size and all made of the same mineral  
B = interlocking sharp-edged grains of two different minerals, grains of similar sizes  
C = interlocking sharp-edged grains of three different minerals. Two minerals form small grains, the third forms larger grains/crystals.  
D = rounded non-interlocking grains of three different minerals. Two of the minerals form large grains.
- 2 A is likely to be the most porous, then D, then B and C. A has the biggest gaps between the grains, so will be more porous than D, where the gaps are filled up by the small grains. B and C are not likely to be porous at all.
- 3 **a** A could be sandstone, as the grains are rounded and all the same size.  
**b** D could be conglomerate, as it has larger pebbles with much smaller grains between them.  
**c** C could be granite, as there are three minerals present, one of which forms large crystals.
- 4 W is quartz, X is feldspar, Y and Z are quartz and mica (or vice versa).
- 5 Diagram should be similar to diagram B on the worksheet, but with three different types of shading to indicate three different minerals.

**8Ha-7 Minerals and formulae**

- 1 20 million
- 2 10 million carbon atoms, 30 million oxygen atoms
- 3 **a** 8 million  
**b** 4 million  
**c** 3 million
- 4 **a** Calcium and sodium are together in the first set of brackets, so it must always contain one or the other or a bit of each.  
**b** Aluminium, magnesium and iron are in the second bracket together. If there is no aluminium, the augite must contain some magnesium or some iron or some of each. Aluminium is also in the third bracket with silicon, so if the sample has no aluminium there must be some silicon.  
**c** The formula shows that the augite contains two of the atoms shown in the third bracket for every six oxygen atoms. If there is no silicon, then there must be two aluminium atoms for every six oxygens. Aluminium also appears in the second bracket – there is one of these elements for every six oxygens, but this atom may be magnesium or iron instead of aluminium.

**8Hb Igneous and metamorphic****Student Book****1: 8Hb Igneous and metamorphic**

**1** Magma is liquid rock under the surface; lava is magma that reaches the Earth's surface.

**2** It forms gabbro if it cools down slowly (e.g. underground) and forms basalt if it cools down quickly (e.g. on the surface). Basalt is also formed in thin intrusions such as dykes and sills, but students have not covered this yet.

**3** If the rock cools slowly the crystals will be bigger because there will be more time for the crystals to grow.

**4** Magma underground cools more slowly because it is trapped and insulated by the surrounding rocks. It therefore doesn't cool as much as the lava that escapes onto the surface of the Earth.

**5** at position 2: this is existing rock that is heated by the molten rock next to it

**6 a** The rocks at position 3 will cool more quickly than the rocks at position 4, because they are in contact with the cooler existing rock. They will therefore have smaller crystals.

**b** small crystals: the magma here will cool quickly because it is just a thin sheet surrounded by cooler rock

**Predicting eruptions**

**1** Physics to study the forces in rocks, and the waves produced by earthquakes (and also to work out where flows of lava or ash may go when the eruption happens). Chemistry to study the composition of the gases and magma.

**2** Scientists can compare their findings with other scientists. Scientists can also explain what will happen and how certain they are to people, who are not scientists, like government officials.

**3** If people are evacuated and an eruption does not happen, they may go back to their homes. This will put them in danger if the eruption *does* then happen. In addition, if there is another warning in the future, they may not believe it.

**4 a** Visiting a volcano to study it can be dangerous. Using satellite data reduces the need for scientists to be on the volcano.

Satellites can be used to study volcanoes in areas that are difficult to get to.

**b** Not all types of information can be studied using satellites. For example, volcanologists need to collect samples of gas given off by a volcano, or collect samples of lava to find its composition.

**5** There is more magma inside it.

**6** Any two from: the composition of the magma, the size/shape of the volcano, the amount of magma inside.

**7** Possible measurements include: the change in angle of the volcano sides, change in height, change in amounts and/or types of gases, change in temperature, earthquakes (including changes in type or frequency of occurrence).

**Activity Pack****8Hb-1 Igneous and metamorphic rocks**

A-E; K-D; F-B; T-J; C-P; L-U; I-R; V-O; N-S; M-G; H-Q

**8Hb-2 Runny lava 1**

**3** Jelly gets thicker/less runny as it sets, so it may start to set if it has a very long ramp to run down.

**4** Lava can be runny or quite sticky, and the different jelly mixtures are also runny or sticky.

**8Hb-4 Densities of igneous rocks**

**2** They are made from different combinations of minerals.

**3** More like gabbro. The experiment should show that their densities are similar.

**4** Yes – the table shows that gabbro and basalt have similar combinations of minerals.

**5** It has 72% silica – so nearly three-quarters of the rock is silica.

**6** Gabbro has more iron oxide in it than granite or rhyolite, so compared to those rocks it is iron-rich.

**8Hb-7 Rocks and crystals**

**1 a** crust      **b** magma      **c** lava

**2 a** A and C      **b** D, B, E

**3 a** basalt (or any other igneous rock with small grains)

**b** granite or gabbro (or any other igneous rock with large grains)

**4 a** E, B and F      **b** A, C or D

**5 a** heat and pressure

**b** quartzite, sandstone

**c** Metamorphic rocks have interlocking crystals, like the first one. Sandstone has rounded grains, like the second diagram.

**8Hb-8 Sills, dykes and plutons**

Note: the level of detail of cooling processes expected will depend on whether or not students have already studied Unit 8I.

**1** Intrusive igneous rocks form when magma cooled down underground. Rocks do not conduct heat well, so the underground magma would have taken a long time to cool. This allowed crystals time to grow, so the rock has large crystals.

If a rock cools slowly there is more time for particles to join to form crystals, so larger crystals can be formed.

## Rocks

**2** A pluton. There is less mass of magma in a dyke, so there is less heat to transfer and it will cool down quicker. It also has a greater surface area compared to its volume in contact with the surrounding rock, which will also help it to cool quicker. Quicker cooling results in smaller crystals in the dyke.

**3** The magma around the edges is in contact with the cooler existing rock, so it will cool down faster.

**4** sills – X and Z; dyke – Y

**5** in order: **b** and **f**; **a** and **d**; **c** and **e**

**6** in the rocks immediately adjacent to the pluton

**8Hb-9 Minerals in igneous rocks**

**1** **a** olivine

**b** Gabbro has large grains so must have cooled slowly, which means it must have formed beneath the ground.

**2** **a** granite, diorite

**b** diorite, gabbro, peridotite

**c** granite

**3** **a** andesite, rhyolite

**b** basalt

**c** basalt

**4** **a** They contain mainly pale minerals.

**b**

Composition of granite		
Mineral	Minimum percentage	Maximum percentage
amphibole	0	8
biotite mica	4	12
muscovite mica	0	10
plagioclase feldspar	8	30
quartz	23	26
potassium feldspar	18	50

**5** A particular named rock can have slightly different proportions of the main minerals. It is easier to use the diagram than to use ranges of percentage compositions given in a table.

**6** Peridotite is found in the upper parts of the Earth's mantle. It is rarely found on the Earth's surface because it reacts quickly with water.

**8Hc Weathering and erosion****Student Book****1: 8Hc Weathering and erosion**

**1** It contains dissolved gases from the air.

**2** Copper sulfate, water, carbon dioxide.

**3** The rock expands when it gets hot, and contracts when it gets cold. Forces from the expansion and contraction break up the rock.

**4** **a** freeze–thaw action, because there is plenty of rain to run into cracks in the rock, and it gets cold enough to make the water freeze

**b** onion-skin weathering, because of large, frequent temperature changes; freeze–thaw is not likely as there is no water to freeze and chemical weathering is not likely as there is no (acidic) rain

**c** very little weathering: water is frozen all the time so it cannot run into cracks in rocks, there is little liquid water so chemical weathering is not very likely, and the temperature changes are not enough to cause much onion-skin weathering

**5** bits of rock in a stream or river, or bits being blown by the wind

**6** They bump into each other and into the river bed.

**7** **a** They get more rounded.

**b** Their masses will get less, as bits are knocked off them.

**8** *Students' own answers*, e.g.

The sugar cubes will bump into each other and into the walls of the jar and bits may be knocked off them. This is similar to rocks being knocked against each other and the river bed as they are moved along by water. It is a good model because in both cases the lumps/rocks will become smaller and more rounded. Rocks are much harder than sugar lumps, so abrasion will take much longer in a river than in the model.

It is harder for things to move fast through water than through air, so the water in a river may have a cushioning effect.

**Activity Pack****8Hc-1 Weathering and erosion**

**1** **a** weathering

**b** erosion

**c** physical weathering

**d** chemical weathering

**e** biological weathering

**f** wind

**g** glaciers

**h** transport

**i** abrasion

**j** sediment

**2** **a** D, it is the largest

**b** A, it is the smallest

**c** either A, C or E, as these have the smoothest, most rounded surface

**8Hc-3 Wearing away**

**1** A onion-skin weathering, **B** chemical weathering, **C** biological weathering, **D** freeze–thaw weathering



**2 a** freeze–thaw weathering, onion-skin weathering

**b** chemical weathering

**c** freeze–thaw weathering, chemical weathering. Some students may also put biological weathering, as plants need water to grow.

**d** freeze–thaw weathering, onion-skin weathering

**e** chemical weathering

**f** freeze–thaw weathering, onion-skin weathering

**3** transport

**4 a** they get rounder

**b** they get smaller

**c** abrasion

### 8Hc-4 Weathering

**1** north-west Scotland

**2** eastern England

**3** Scotland

**4** north-west Scotland

**5** north-west Scotland. The temperature drops below freezing most often and it is the wettest place in the country.

**6** The stone will be worn away. A good answer will explain chemical weathering and freeze–thaw action.

**7** south-east England and near the coast, as it has the lowest rainfall and fewest nights with frost

### 8Hc-5 Limestone scenery

**1** acidic rainwater dissolving the rock

**2** A is a collapse doline – the fallen rocks can be seen at the bottom. B is a solution doline – there are no fallen rocks and no grass cover. C is a subsistence doline (or shakehole) – there is still a covering of soil over the dip.

**3 a** a stream disappearing into a hole in the ground

**b** water appearing from a hole in the ground/ side of a hill

**c** a depression in the ground, but no hole in the bottom of the depression

**4** Shale is impermeable (i.e. does not let water flow through it). The stream is on the surface above the top layer of shale, so it does not allow the stream to soak through the bottom layer.

**5** A good answer will describe/show the caves bigger, the dolines bigger (perhaps with more collapses), and will explain that this is due to weathering continuing to dissolve more of the limestone.

**6** Clints are the ‘blocks’ in a limestone pavement, grykes are the gaps between them. The grykes are formed when limestone dissolves along cracks in

the rock (joints), and the clints are the bits that get left behind.

## 8Hd Sedimentary rocks

### Student Book

#### 1: 8Hd Sedimentary rocks

**1 a** when sediments are squashed by layers of sediments above them

**b** when minerals crystallise in the gaps between grains of sediment and stick them together

**2** minerals dissolved in the water that was between the grains

**3 a** The conglomerate has a mixture of grain sizes, some very large and others much smaller, held together by cement. The mudstone has grains that are too small to see in the photograph.

**b** by abrasion while they were being transported

**4** the shape of a living organism preserved in the rock

**5** Each layer could represent a different flooding event.

**6** two pairs from: limestone/marble; mudstone/slate; slate/gneiss; slate/schist; granite/schist; granite/gneiss; schist/gneiss; sandstone/quartzite

**7 a** Quartzite is metamorphic, so it will consist of interlocking crystals. Sandstone is made from rounded grains.

**b** Quartzite will be harder and more difficult to erode than sandstone. Sandstone is porous and quartzite is not.

**8** A sedimentary rock would have separate grains, usually rounded and stuck together. Igneous and metamorphic rocks are made from interlocking crystals. If the crystals are lined up or in coloured bands, then it is a metamorphic rock. If there is no alignment of crystals, then the rock is likely to be igneous. (Marble and quartzite are exceptions to this, as they often have randomly oriented crystals.)

#### 2: 8Hd Theories in geology

**1** Earth scientists cannot easily do experiments, they have to rely mainly on observations.

**2** Answers should resemble figure A but have ‘gather more observations’ instead of the ‘experiment’ and ‘data’ boxes.

**3 a** coal

**b** soft rocks containing fossils, with granite further down

**4** Two answers are possible: sedimentary – because it crystallised from water; igneous – as it consists of crystals. Metamorphic is not acceptable, because there is no indication that Werner thought the rocks had been changed after deposition.

**5 a** metamorphic rocks

**b** no, Werner thought that granite was the oldest rock because it had been deposited first; here the granite is clearly younger than the surrounding rocks

**6 a** This could support the hypothesis, as Werner considered basalt to be one of the younger rocks.

**b** This contradicts the hypothesis, as in Werner's hypothesis the basalt would have been laid down as a layer in a similar orientation to the rest of the rocks.

**7** They both disprove Werner's ideas. The Torres del Paine mountains have granite within other rocks, so granite cannot have been formed first/is not below all other rocks. At High Force the dolerite (equivalent to basalt in Werner's hypothesis) has limestone above it, so it is not the last rock to form.

**8** It does not disprove it, as there may be some basalt somewhere that *does* contain fossils. However, it does not support the hypothesis either.

### Activity Pack

#### 8Hd-1 Sedimentary rocks

**1** deposited, compacted, cemented, fossils

**2 a** slate                      **b** marble

**3** From top to bottom:

melting and cooling

erosion, deposition, compaction, sedimentation

heating and/or pressure

#### 8Hd-4 Layers of sediment

**1** From the bottom upwards: conglomerate, sandstone, shelly limestone, shale, coal, chalk

**2** conglomerate

**3** chalk

**4** Conglomerate, because it is the first layer deposited so will be the oldest rock and pressurised by all the other layers on top of it.

#### 8Hd-5 The rock cycle

The order of the statements may vary:

Rocks get weathered by chemical ... and physical weathering.

Small fragments of rock get transported away ... from rock faces by rain, streams and rivers.

When the river slows down, the sediments ... are deposited at the bottom of the river.

Over many years, these sediments ... build up to form layers.

The layers of sediment gradually get squashed ... and eventually form sedimentary rock.

Some sedimentary rocks get heated and ... compressed under the surface of the Earth.

This changes the rock into ... metamorphic rock.

If the rock is heated enough, it melts ... and forms magma.

Some magma rises to the surface of the Earth ... through cracks and volcanoes.

When the magma cools, it forms ... igneous rocks.

Some igneous rocks get buried and compressed ... and are changed into metamorphic rock.

### 8Hd-6 The age of the Earth

#### 1 Forming the grey rocks

Existing rocks are weathered and break up into smaller pieces.

The pieces are transported by rivers.

The pieces abrade and become rounded.

The sediments are deposited on the sea bed by underwater avalanches.

More layers of sediment cover the deposits.

The sediments are compacted, which squashes water out from between the grains.

The sediments become cemented together to form greywacke rock.

More horizontal layers of greywacke form on top.

#### Tilting and eroding the grey rocks

Earth movements tilt the layers.

Earth movements lift the layers up.

The rocks above get weathered and eroded, leaving a horizontal surface.

#### Forming the red rocks

Sediments are deposited by rivers on top of the weathered and eroded surface.

More layers build up and cover the deposits.

The sediments are compacted, which squashes water out from between the grains.

The sediments become cemented together to form red sandstone.

The layers above the sandstone are weathered and eroded.

The sandstone is exposed at the surface of the Earth.

**2 a** It would have taken much longer than that for all the processes to happen.

**b** The description shows at least two different sets of rocks being formed through erosion, sedimentation and compaction.

### 8Hd-7 Rocks and the rock cycle

**1** sediments, slows down, deposited, layer, sediment, compacted, cement, sedimentary

**2 a** igneous, metamorphic

**b** sedimentary

**c** sedimentary

**d** sedimentary

**e** all three

**f** Sedimentary (accept metamorphic as well)

**3** limestone → marble

mudstone → slate

schist → gneiss

slate → schist

### 8Hd-8 Looking at limestones

**1** Answers should include the following:

Deposition of sediments happens when the wind or water carrying the sediments slows down.

Compaction is when layers above squash the sediment and squeeze most of the water from between the grains. Cementation happens when minerals in the remaining water crystallise and cement the grains together.

**2** The sediments that form limestone are the shells of sea creatures, not bits of weathered rock.

**3** Mud or plant remains would make the chalk coloured. It is white because it only contains calcium carbonate, which is white.

**4 a** Bits of rock knock into each other while they are being transported, and bits break off (abrasion).

**b** The grains in oolitic limestone grow with time, rather than getting smaller.

**5 a** Marble is formed when limestone is heated/compressed.

**b** Limestone is made of grains (or bits of broken shell). Marble is made from interlocking crystals.

**6** any two from: building, making cement, making lime to neutralise acid soils

### 8Hd-9 Explaining the characteristics

**1 a** Grains of 0.25 mm are deposited when the water speed slows to 0.02 m/s, so the water could not be transporting any grains larger than this. Grain sizes will range from very small up to 0.25 mm.

**b** Well sorted, because only very small grains can be carried.

**c** sandstone or mudstone (see diagram on 8Hd-2)

**2 a** A mixture of sizes. They can move large grains, but they can also move small grains. If the water speed drops suddenly, grains of a wide range of sizes will all be deposited at once.

**b** Very poorly sorted, as the deposits will contain a range of sizes.

**c** Either angular or a mixture are both acceptable answers.

Angular, because the flood does not last very long and there is little time for rocks to be abraded and become rounded.

Mixture – some angular fragments (explanation as above), but the flood may also pick up grains that have already been rounded.

**3** This is a full answer – students would not be expected to identify all of these points, and details of sorting is only expected for students working at the *Exceeding* progression band.

Near the source the river will carry grains of a wide range of sizes, and these will be deposited as it starts to slow down. The grains will not have been carried very far, so will be angular. They may be poorly sorted, as smaller grains may be trapped when the larger grains are deposited.

Fifty miles from the source the river will be moving more slowly and cannot transport such large grains. The maximum grain size in the deposits will be smaller, and they will probably be moderately sorted. As the grains have been transported some distance, there will have been time for abrasion to make them more rounded, so deposits may be sub-angular or sub-rounded.

By the time the river reaches the sea it will be travelling slowly and only able to transport much smaller grains. As the river slows down on entering the sea, the largest grains will be deposited first. The maximum grain size of sediments will get smaller as you get further from the coast. As there are only small grains to be deposited, the sediments will be well sorted. There has also been much more time for abrasion, so the grains are also likely to be well rounded.

## 8He Materials in the Earth

### Student Book

#### 1: 8He Materials in the Earth

**1** A mineral is a single chemical compound. An ore is a rock (a mixture of different minerals) that contains enough of a metal in its native state (or enough of a metal-containing mineral) to be worth mining.

**2** Gold is all one type of atom. Pyrite contains two different types of atom/iron and sulfur atoms bonded together.

**3** disturbs habitats, causes pollution

**4** It costs money, so would reduce profits.

**5** crushing up the ore

**6 a** Recycling reduces the need for mining more metals, so it reduces the pollution caused by mining. It also means less metal will go to landfill, so will reduce any toxic substances escaping from landfill sites.

**b** Usually less energy is needed to recycle metals than to extract them, so less fossil fuel will be burned to provide this energy. Some rare metals are needed in wind turbines and solar panels – if

## Rocks

recycling helps to keep these metals cheaper/sufficiently available, then more wind turbines/solar panels might be built, which will in turn reduce the need for burning fossil fuels in power stations.

**2: 8He Living in danger****1 a** igneous rock

**b** Sedimentary rocks are formed when tiny pieces of existing rocks build up in layers and are cemented together.

Sediments are compacted, which squeezes the water from between the grains, and cementation occurs when minerals dissolved in the water become solid and 'glue' the sediments together. Metamorphic rocks are formed when existing rocks are subjected to high temperature and pressure, and the minerals in them change.

**2 a** two from: chemical weathering – minerals in rocks react with chemicals in rain/water; biological weathering – plants grow in rocks, breaking them apart; freeze–thaw weathering – water gets into rock cracks then freezes, expands and breaks the rock; onion-skin weathering – rocks expand and contract with temperature changes and cracks form

**b** two from: wind, water, ice

**3** It may be the only land available to them; they may not believe that the volcano will erupt.

Areas around volcanoes often have very rich soils (this is not mentioned in the text).

**Activity Pack****8He-1 Materials from the Earth**

**1** native state – When a metal is found in the Earth as an element, not as part of a compound.

mining – Digging metals or ores out of the ground.

ore – A rock that contains enough of a metal or metal compound to make it worth mining.

mineral – A chemical compound found in rocks.

**2** Anticlockwise from left: pollution

pollution, landfill

energy, ore

last longer

**8He-2 Where in the UK...?**

Students answering these questions will be working at a higher level, although this depends on whether they are using paper maps or the online viewers (it will be harder to interpret the keys on paper maps), and on how much help they get.

**2** The main areas for intrusive igneous rocks are Cornwall, parts of the Lake District, parts of Skye and the Outer Hebrides, and a band from Aberdeen towards Mull.

The main areas for extrusive igneous rocks are Skye, parts of Mull, a band across the Midland Valley of

Scotland, parts of the Lake District and Snowdonia, and the eastern part of Northern Ireland.

**3** Most of the Scottish Highlands are metamorphic rocks.

**4** The oldest rocks are in the Outer Hebrides and the far north-west of the Scottish mainland.

The youngest rocks are in a triangular shape with its apex just west of Reading, extending eastwards to the coast from Margate to Ipswich.

**5** The main outcrops of the Coal Measures are in the Midland Valley of Scotland, around Newcastle and Durham, down the Pennines from just north of Leeds and Bradford to Derby, and in south Wales from west of Swansea to nearly as far east as Newport, and as far north as Merthyr Tydfil and Ebbw Vale.

**8He-3 Opencast or underground?****1 & 2***Opencast mining*

Advantages: Old opencast mines can sometimes be filled in afterwards, or converted to lakes.

Disadvantages: A lot of dirt and dust is produced. Mining the ore is noisy. Can cause pollution of rivers and streams. Large areas of vegetation are removed, destroying habitats.

Neither: Ores are extracted from a large hole in the ground.

*Underground mining*

Advantages: These mines do not take up much space on the surface.

Disadvantages: Can cause pollution of rivers and streams. Can pollute underground water supplies. Old tunnels and shafts can sometimes collapse, causing subsidence on the surface. There is a lot of waste rock to be disposed of. Spoil heaps may contain toxic materials.

Neither: Deep shafts and tunnels are dug to reach the ore.

**3** Students should present the advantages and disadvantages concisely and in a logical order.

**4** Recycling metals reduces the requirements for mining ores, so it reduces pollution from mines, including the need for spoil heaps and environmental disturbance. In most cases it takes less energy than extracting metal from an ore, so there is less contribution to climate change. It reduces the amount of rubbish sent to landfill sites, and so also reduces the pollution these can cause.

**8He-4 Rocky words**

**1** igneous

**2** sedimentary

**3** metamorphic

**4** crust

**5** chemical

**6** sediments

**7** fossil

**8** marble

**9** freeze–thaw

**10** compaction

C O M P A C T I O N Q P  
 F S B C U U L L T Y C M  
 F M E T A M O R P H I C  
 R F C D N M O X L A F V  
 E C H L I A C N Y I E Q  
 E D E U G M J R V I D M  
 Z P M I G N E O U S U A  
 E O I J S R V N Y S F R  
 T I C N C U N I T P T B  
 H P A F O S S I L A T L  
 A P L D S Y H J C B R E  
 W P S E D I M E N T S Y

### 8He-5 Finding gold

**1 a** The water is flowing more slowly on the inside of the bend (near X) and faster on the outside of the bend (near Y).

**b** The water is moving more slowly on the inside of the bend and cannot carry such large grains as the water flowing round the outside of the bend. The largest grains being carried will be deposited where the water slows down, which is on the inside of the bend.

**2** The water in the stream flows over the rocks that stick out of the river bed. Some water will be trapped upstream of the projections and will slow down and therefore deposit the largest grains it is carrying.

**3** Less resistant materials would be broken up into much smaller pieces, and small pieces are less likely to be deposited.

**4** More reactive minerals are more likely to undergo chemical weathering and change/break up.

**5** Dense materials are more likely to sink/be deposited.

**6** A large area of river bed will be dredged up, destroying habitats. Silt will be stirred up by the dredging and travel downstream. Machinery will produce noise and dust.

**7** Recycling reduces the need for new metals and so reduces the environmental effects of mining; it reduces the amount of metals sent to landfill and so reduces pollution from landfill sites; it often requires less energy to recycle metals than to extract ores, so it reduces our energy use and so helps to reduce pollution/climate change.

**8** Gold is unreactive and stays as gold. Iron rusts, so not all iron collected for recycling may be usable/iron would have to be extracted again from the iron oxide/rust.

### 8He-6 Extracting metals

**1 a** In a physical change no new substances are formed. Examples could be dissolving, freezing, melting, evaporating, condensing. In a chemical change, new substances are formed (from the atoms present in the reactants). Examples could include combustion, rusting, respiration, etc.

**b** any two from: sieving, filtering, evaporating a solution, fractional distillation, chromatography

**2 a** Sn and CO<sub>2</sub>      **b** SnO<sub>2</sub> and C

**3** zinc oxide + carbon → zinc + carbon dioxide

**a** Zn, CO<sub>2</sub>      **b** ZnO, C

**4** silver, gold, platinum – they are unreactive and so they can be found in their native states

**5 a** heating with carbon

**b** electrolysis

**6** Magnesium is more reactive than carbon.

**7** To extract aluminium the ore has to be melted and energy is also needed to generate electricity. For lead, the ore only has to be heated with carbon.

**8** If heating the ore with carbon works, it is cheaper to extract the metal that way than by using electrolysis.

## 8I Fluids

### 8Ia The particle model

#### Student Book

#### 1: 8Ia Exploring extremes

**1 a** solid      **b** gas      **c** liquid

**2 a** solids keep their shape, liquids and gases take the shape of their container

**b** solids and liquids have a fixed volume, gases expand to fill their container

**3** suggestions could include the following (students are not expected to give all of these):

**a** breathing underwater, keeping warm enough, withstanding pressure, providing light underwater

**b** keeping warm enough, providing shelter from the weather, providing light during the Antarctic night, preventing people being buried by snowfall

**c** providing air to breathe, keeping warm/cool enough (keeping cool is more of a problem than keeping warm when in sunlight), providing air pressure around the body

#### 2: 8Ia The particle model

**1 a** any three solid materials

**b** any three liquids

**c** any three gases

**2 a** similarity – keep same volume/incompressible; difference – solids keep their shape and liquids do not

**b** similarity – both take up the shape of their container; difference – liquids keep the same volume but gases expand to fill their container/ gases are compressible and liquids are not

**3 a** Particles are already close together, so they cannot be made to go any closer.

**b** Particles are far apart, so it is easy to push them closer together.

**4 a** The forces between particles are strong so all the particles are held tightly in their places.

**b** The forces between particles are weak so it is easy for the particles to move around and move apart.

**5 a** The movement gets less.

**b** it gets smaller/the volume gets smaller

**6 a** The volume of the liquid inside the thermometer depends on the temperature. As it expands and contracts the volume of liquid in the tube changes and the relevant temperature is read off the scale.

**b** Fill a flask with coloured water and put a tube in the top. To make the scale, the thermometer needs to be at two known temperatures, e.g. put the flask in ice and boiling water for  $0^{\circ}\text{C}$  and  $100^{\circ}\text{C}$  to be marked. Having marked the level of the liquid at these two temperatures, the scale can then be divided into equal divisions.

**7 a** The metal would expand in hotter weather, so the bridge might buckle.

**b** The metal would contract in colder weather, so the bridge might break/be pulled apart.

### 3: 8la Calculations with density

**1**  $15\text{ cm}^3$

**2** Fill a displacement can with water and place a measuring cylinder under the spout. Carefully drop the lump of clay in. The volume of water pushed into the beaker is the same as the volume of the modelling clay.

**3** mass = 64 g, volume =  $8\text{ cm}^3$ , density =  $8\text{ g/cm}^3$

**4 a** mass = density  $\times$  volume

**b** mass =  $2.7\text{ g/cm}^3 \times 50\text{ cm}^3 = 135\text{ g}$

**c** volume =  $810\text{ g}/2.7\text{ g/cm}^3 = 300\text{ cm}^3$

**5 a** mass of water =  $1000\text{ kg/m}^3 \times 2500\text{ m}^3 = 2500000\text{ kg}$

**b** As the water warms up the particles move faster and take up more space.

**c** It will decrease, because there will be the same mass in a bigger volume.

**d** density of the warmer water =  $2500000\text{ kg}/2505.25\text{ m}^3 = 997.9\text{ kg/m}^3$

### Activity Pack

#### 8la-1 The particle model

**1 a** False – you can pour liquids and gases but not solids.

**b** True

**c** False – particles in solids vibrate about fixed positions.

**d** False – liquids cannot be compressed because the particles are close together.

**e** False – when a substance expands the particles in it stay the same size but either vibrate more or move around faster.

**f** True

**g** True

**h** False – particles in gases move faster when the substance is heated.

**i** False – gases expand to fill their containers because there are weak forces between the particles.

**j** False – solids expand or contract when their temperature changes.

#### 8la-2 Make a thermometer

**1 a**  $0^{\circ}\text{C}$

**b**  $50^{\circ}\text{C}$  (the temperature of the water bath)

**c**  $10^{\circ}\text{C}$

**3** not enough space to mark smaller divisions

**4** Divide the space between the 10 degree marks by 10, or divide the distance between the top and bottom marks by 50.

**5** difficult to read to small intervals, or similar answer

**6** have a smaller reservoir of liquid

**7** It would freeze if the temperature dropped below  $0^{\circ}\text{C}$ .

#### 8la-3 Finding the density

**1** Not correct. If students have measured a range of materials, there should be some materials denser than water and some less dense.

#### 8la-4 States and particles

**1** liquids, volume, compress, close together, strong volume, shape, container, close together expand, far apart, weak

**2 a** They move around faster.

**b** The volume gets bigger/the liquid expands.

**c** They move more slowly.

**d** The volume gets less/the liquid contracts.

#### 8la-5 Density calculations

**1 a** 2.7

**b**  $20\text{ cm}^3$

**c** 1700 kg

**d** 46;  $\text{g/cm}^3$

**e**  $\text{kg; m}^3$ ; 7800

**f**  $0.5\text{ m}^3$

**g** 500 g

- 2 **a** density =  $75 \text{ kg}/0.285 \text{ m}^3 = 263 \text{ kg/m}^3$   
**b** mass =  $1000 \text{ kg/m}^3 \times 0.065 \text{ m}^3 = 65 \text{ kg}$   
**c** total mass =  $75 \text{ kg} + 65 \text{ kg} = 140 \text{ kg}$

total volume =  $0.285 \text{ m}^3 + (0.066 \text{ m}^3/2) = 0.318 \text{ m}^3$

density =  $140 \text{ kg}/0.318 \text{ m}^3 = 440 \text{ kg/m}^3$

- 3 **a** volume of  $5 \text{ kg}$  of water at  $0^\circ\text{C} = 5 \text{ kg}/1000 \text{ kg/m}^3 = 0.005 \text{ m}^3$

**b** volume of  $5 \text{ kg}$  of water at  $300^\circ\text{C} = 5 \text{ kg}/700 \text{ kg/m}^3 = 0.007 \text{ m}^3$

**c** change in volume =  $0.002 \text{ m}^3$

### 8la-6 Changing size 1

- 1 **a** It will rise.

**b** It will expand/get bigger, because the particles have more energy and vibrate more.

**c** It will probably not go up as much, because the hot water is being run onto the lid, not the glass.

**d** The lid will get bigger. The table shows that glass does not expand as much as steel for the same temperature rise, so even if the temperature of the glass jar rises by the same amount as the steel lid, it will not expand as much. The lid will be looser and easier to remove.

- 2 **a** The iron will expand so the rod will get longer.

**b** When the rod cools down again it will go back to its original length. As it was tightened up when it was longer, the contraction will help to pull the walls of the house inwards.

3 The weather is warmer in the summer and so the wires will have expanded. When the weather is colder in the winter the wires will contract. If they are put up so they are tight/shorter in the summer, when they contract in the winter they could break.

4 They are less dense in summer. Their mass does not change, and in summer their volume is greater because they expand in the warmer weather, so their density is less.

### 8la-7 Changing size 2

1 length change =  $10 \text{ m} \times 10^\circ\text{C}/10 \times 1.1 \text{ mm/m}^\circ\text{C} = 11 \text{ mm}$

2 length change =  $20 \text{ m} \times 15^\circ\text{C}/10 \times 1.2 \text{ mm/m}^\circ\text{C} = 36 \text{ mm}$

3 length change =  $33.5 \text{ m} \times 20^\circ\text{C}/10 \times 1.1 \text{ mm/m}^\circ\text{C} = 73.7 \text{ mm}$

4 When the indicator is turned on the switch is closed and a current flows through the coil of wire. Electric current has a heating effect, so the bimetallic strip warms up and bends. As it does so the two contacts move apart and there is a gap in the circuit. The current stops flowing, so the strip cools down again and goes back to its original shape. Once the contacts touch, current flows again and the whole cycle repeats.

5 **a** For the same length strip and temperature rise, copper will expand more than iron. As the bottom of the strip is trying to get longer, the end that is not fastened down bends upwards.

**b** Brass expands more than steel, so the strip will bend in the same direction. However the difference in expansion between brass and steel is  $0.8 \text{ mm/m}^\circ\text{C}$ , compared to the difference between copper and iron of  $0.5 \text{ mm/m}^\circ\text{C}$ , so the brass and steel strip will bend more.

**c** Any pair of metals where the one on the top expands more than the one on the bottom (for example, copper above iron, brass above steel, brass above copper, etc).

### 8lb Changing state

#### Student Book

#### 1: 8lb Changing state

1 **a**  $0^\circ\text{C}$  **b**  $0^\circ\text{C}$

2 the substances do not change/the atoms in the molecules are not rearranged

3 **a**  $50^\circ\text{C}$  **b**  $80^\circ\text{C}$

**c** The energy being transferred to the substance is being used to break the particles away from their fixed arrangement.

**d** The graph should be a mirror image of the one in figure B, where temperatures decrease with time. Two plateaus for condensing (boiling) and freezing (melting) must be shown with suitable explanations. A suitable title for the graph could be 'How the temperature of a substance changes as it cools down'.

4 **a** Particles vibrate further (for a solid) or move around faster (liquids and gases) so the substance takes up more space.

**b** The volume of the liquid iron gradually gets less as it cools down, then it decreases suddenly when the liquid turns into a solid.

5 **a** As the temperature of the ice increases it expands and so its density decreases. When the ice melts its density suddenly increases because the liquid water takes up less space than the solid. As the water warms up from  $0^\circ\text{C}$  to  $4^\circ\text{C}$  it gets more dense and then starts getting less dense again as the particles in the warmer water move around faster and take up more and more space.

**b** For other substances, as the solid starts to melt the volume it takes up will be less and so the density will increase. The volume will continue to get less and the density more as the liquid warms up.

#### Activity Pack

#### 8lb-1 Changing state

1 **a** chemical **b** physical **c** physical  
**d** physical **e** chemical

## Fluids

- 2 solid, melting, liquid, condensing, gas  
 3 a physical  
 b evaporate, boiling, evaporation  
 c water vapour, drops of liquid water  
 d more, less

**8Ib-2 Cooling wax 1**

- 5 The temperature fell.  
 6 It did not change.  
 7 It started to fall again.  
 9 graph should rise, level out and then rise again

**8Ib-3 Cooling wax 2**

- 4 The particles will lose energy and become bonded in fixed positions.  
 5 The method should include recording the temperature at regular intervals until the wax has solidified, and at least one safety recommendation such as not touching hot equipment.  
 9 b It is easier to see a pattern in the results/it is easier to compare with the graph sketched for the prediction.  
 11 The temperature remains the same as the liquid is turning back into a solid. Energy is still being transferred away from the wax, but the particles are also releasing energy as they begin to form a solid, so the temperature does not drop.  
 13 graph should rise, level out and then rise again

**8Ib-4 Weathering rocks**

Onion-skin weathering – diagrams 1 and 4, statements M, I, D, B, E, J, A  
 Freeze-thaw weathering – diagrams 2 and 3, statements K, H, G, F, C, L, N

**8Ib-5 States questions**

- 1 physical  
 2 a E                    b I                    c G  
    d B                    e G                    f H  
 3 a C                    b B  
 4 a W and Z  
    b X  
    c the particles are vibrating more/the solid takes up more space/has expanded  
    d Y

**8Ib-6 Kitchen questions**

- 1 The bubbles form as liquid water turns into a gas, so they are full of water vapour.  
 2 graph should rise, level out and then rise again  
 3 If the water is bubbling, it is at the boiling point of 100 °C. Having the heat on full will make the water turn to a gas more quickly, but the temperature of the water will not change, so the same amount of energy is transferred to the potatoes in both pans.

4 Paul is using up more gas/electricity, which has to be paid for (and also filling the kitchen with steam).

5 a Cooking oil can be heated to a higher temperature than water without boiling (or smoking), so energy is transferred to the things being cooked more quickly.

b Water does not get hot enough to burn potatoes, even if you have the cooker turned up as high as it will go, because it will boil away rather than getting hotter. Cooking oil reaches higher temperatures before it boils (or smokes), so it can burn potatoes.

6 Answers to a and b may vary slightly.

a The temperature inside the freezer is lower than the freezing point of lemonade. The water in the lemonade freezes, so it expands and splits the bottle.

b The freezer is below the freezing point of the wine, so the water in it freezes. The glass bottle is stronger than the plastic lemonade bottle, so it does not break but the cork is pushed out.

c The freezing point of vodka is below the temperature inside the freezer, so it does not freeze.

**8Ib-7 Explaining ice**

1 It has more massive atoms. OR The atoms are packed together more closely.

2 a Zinc atoms have slightly greater mass than copper atoms.

b Although it has atoms with smaller mass, copper is more dense than zinc, so the copper atoms must be packed together more tightly than zinc atoms.

3 Aluminium atoms have more mass than magnesium atoms, but only 12.5% more. Aluminium is over 60% denser than magnesium, so the extra mass of the atoms probably does not account for all the difference. Therefore the atoms in aluminium must also be more tightly packed. Accept qualitative answers to the same effect.

4 The molecules have less energy in ice, so are not trying to move around as much. In water they have enough energy to overcome the weak forces between the molecules.

5 When the atoms are held in a fixed arrangement in ice, the pattern they make takes up more space than the same number of molecules in liquid water. As the volume is larger for the same mass, the density is lower.

6 As water cools the molecules do not move as fast so they take up less room and the density increases. At 4 °C they are moving slowly enough for some of the weak bonds to hold some molecules together. These groups of molecules take up more space, and so the density decreases slightly.



**8Ib-8 Latent heats**

**1** It is breaking the bonds between the particles in the solid to form a liquid.

**2** All the solid has melted.

**3** The graph should descend, level out and then descend, level out and descend again. Some students may include a final levelling off as the temperature of the ice reaches the temperature inside the freezer, but this has not been specifically covered in this unit and so is not expected here. The rate of cooling will also reduce as the difference between the temperature of the water and the freezer gets less, but again students are not expected to show this.

The temperature goes down at first because energy from the water vapour is being transferred to the air in the freezer. As the gas starts to condense, some of the extra energy that the gas particles have is released and this stops the temperature falling until all the gas has condensed. This energy is the latent heat of vaporisation. Once it is all liquid, the temperature falls again as energy continues to be transferred to the air in the freezer. Once the water reaches freezing point, more energy is released as the liquid starts to become solid; this is the latent heat of fusion. This causes the temperature to level out again until all the liquid has frozen. Some students may add that the temperature continues to fall until the temperature of the ice is the same as the temperature inside the freezer.

**4** Liquids evaporate faster closer to their boiling points. The boiling point of alcohol is lower than that of water, so it should evaporate more easily.

The latent heat of vaporisation of alcohol is less than half that of water, so alcohol needs to absorb less energy from its surroundings to evaporate.

**5** Steam. Water has a higher latent heat of vaporisation, which is a measure of how much energy is released when it condenses.

**6 a** All the particles in a substance need to absorb energy to melt/evaporate (or release energy when they condense/freeze), so the amount of energy absorbed/released will depend on how much of the substance is present.

$$\text{b energy} = 335 \text{ kJ/kg} \times 2 \text{ kg} = 670 \text{ kJ}$$

$$\text{c energy} = 2272 \text{ kJ/kg} \times 0.5 \text{ kg} = 1136 \text{ kJ}$$

**7 a** If the water is bubbling, it is at the boiling point of  $100^\circ\text{C}$ . Having the heat on full will make the water turn to a gas more quickly, but the temperature of the water will not change, so the cooking time will stay the same.

**b** Energy has to be paid for, and if the heat is kept higher it will use more energy (which just goes to evaporate more of the water) without speeding up the cooking time.

**8Ic Pressure in fluids****Student Book****1: 8Ic Pressure in fluids**

**1** particles hitting the walls of a container/particles hitting something in the fluid

**2** The air pressure outside is greater than the air pressure inside because some air has been removed. This means there is a greater force pushing them together than pulling them apart.

**3** any two from: put more particles into a container (if there are more particles there will be more collisions with the walls of the container and so the total force from the particles on the area will be increased), heat the fluid (if the fluid is heated the particles will move around faster and the collisions will be harder, so the total force will be increased), make the volume of the container smaller (if the volume is decreased the particles don't have to move as far before they hit the walls again, so there will be more collisions)

**4 a** There is less air above you so the particles are further apart. Not as many particles hit you each second, so the pressure from the air on you is less.

**b** There are fewer particles in each lungful of air, so each breath will not get as much oxygen into the body. The oxygen mask provides extra oxygen.

**5** When the bag was sealed at sea level, there were a certain number of air particles in it, giving the same pressure inside the bag as outside it. When the bag is taken up a high mountain, the pressure outside the bag is less. This means there are more particles hitting the inside of the bag than the outside, so the bag bulges outwards.

**6** They had to withstand much higher pressure than the sides of ships, because the *Trieste* went down to the deepest part of the ocean where the pressures are very high.

**7** Pressure is caused by particles in the fluid hitting us. The particles in a liquid are much closer together than the particles in a gas, so there are many more of them hitting each square centimetre of our skin. Pressure also depends on the weight of the fluid above us. Water is much denser than air, so the change of pressure with depth/height is greater.

**Activity Pack****8Ic-1 Pressure in fluids**

**1** liquids or gases

**2** the forces from particles hitting the container

**3** they have more air particles inside them

**4** is the same in all directions

**5** gets less as you go higher

**6** 100 000 Pa

**7** increases

**8** gets bigger as you go deeper

**8lc-2 Investigating manometers 1**

**3 a** This should be the liquid with the smallest density.

**b** The same liquid as in **a**. The greater the height difference the more precise the measurement.

**5 a** The less dense the liquid, the greater the height difference.

**b** Choose the liquid with the lowest density.

**8lc-5 A question of pressures**

**1 a** B

**b** The pressure is bigger as you go further down, so the water comes out fastest near the bottom and slowest near the top.

**2** Arrows should be on every surface, perpendicular to the surfaces, and become longer near the bottom.

**3** The pressure inside the body exactly matches the pressure outside the body.

**4** correctly plotted graph

**5** approx. 65 kPa

**8lc-6 Manometers**

**1** Atmospheric pressure on the open side of the tube provides a force on the liquid. If the pressure of the gas supply was only atmospheric pressure, it would provide the same force on the surface of the liquid in the other arm, the two forces would cancel each other out and the liquid would not move. The manometer measures the force from the gas pressure, after the force provided by the atmosphere has been cancelled out.

**2** The difference in the height of the liquid in the two arms depends on the density of the liquid and the force on it, not on the area of the liquid.

**3 a**  $P = 1000 \text{ kg/m}^3 \times 9.81 \text{ N/kg} \times 0.5 \text{ m} = 4905 \text{ Pa}$

**b**  $h = P \div (\rho \times g) = 4905 \text{ Pa} \div (789 \text{ kg/m}^3 \times 9.81 \text{ N/kg}) = 0.63 \text{ m}$

**c**  $h = 4905 \text{ Pa} \div (13590 \text{ kg/m}^3 \times 9.81 \text{ N/kg}) = 0.036 \text{ m}$  (or 3.6 cm)

**4 a** A manometer filled with mercury could measure high gas pressures without the manometer having to be too big, as its density means that relatively small height differences are produced.

**b** Water is not toxic (like mercury), and not flammable (like ethanol). Some students may add that it is also cheap and readily available, so the manometer does not have to be stored with the liquid in it. It would be better than mercury for measuring pressures that were not much above atmospheric pressure, as you could use a larger scale.

**8lc-7 Diving bells and depths**

**1** In a liquid the particles are all very close together and there is no space for them to get even

closer, so the liquid cannot be compressed. In a gas the particles are all a long way from each other, so they can be pushed closer together when pressure is applied.

**2 a** It gets higher.

**b** It would compress it, so the volume would get smaller. This would make the pressure of the air rise.

**3** The compressed air presses back on the water, and stops the volume of air in the diving bell getting too small. The people in the diving bell also need a supply of oxygen or they would suffocate.

**4** The bathyscaphe can go deeper as it does not rely on a supply of compressed air. If students have studied the work on decompression sickness, they may also point out that the crew would not need to decompress after using a bathyscaphe.

An advantage of a diving bell could be that the scientists inside can be in direct contact with the water, whereas everything in a bathyscaphe would have to be controlled remotely.

**5 a** In both cases the pressure increases with an increase in fluid above (or students may describe this the other way round, and say that air pressure gets less as you move away from the surface and water pressure gets greater).

The graph showing the change in pressure with depth in water is a straight line, which shows that the change in pressure for each metre change in depth is the same however deep you go. The graph for air is a curve, showing that the change in pressure for each metre change in height is less the higher you go.

**b** Water is not compressible, so the change in pressure with depth does not change as you get deeper. Air is compressible, so the air at the bottom of the atmosphere is more compressed than the air higher up, which contributes to the pressure.

**8lc-8 Barometers and altimeters**

**1** 750 mm = 0.75 m

pressure =  $13590 \text{ kg/m}^3 \times 9.81 \text{ N/kg} \times 0.75 \text{ m} = 99988 \text{ Pa}$

**2** height =  $95000 \text{ Pa} \div (13590 \text{ kg/m}^3 \times 9.81 \text{ N/kg}) = 0.713 \text{ m}$  (or 713 mm)

**3** Reason 1: Water would freeze in the winter when the pressure dropped below freezing point. Mercury does not freeze at temperatures that normally occur in the UK.

Reason 2: A barometer filled with water would have to be very tall to measure atmospheric pressure. For a pressure of 100 000 Pa, height =  $100000 \text{ Pa} \div (9.81 \text{ N/kg} \times 1000 \text{ kg/m}^3) = 10.19 \text{ m}$ . A 10 m high barometer would not fit in most houses or laboratories!

4 Temperatures in the Antarctic fall below the freezing point of mercury, so a liquid-filled barometer would have to use ethanol. This is even less dense than water, and so it would have to be even taller (the height of ethanol on a day where the air pressure was 100 000 would be 12.9 m). They would need a tall ladder to set up the barometer and read it.

5 Air pressure changes from day to day. The knob allows the pilot to adjust the altimeter for the pressure on a particular day so that the altimeter reads zero when the plane is on the ground. Also, not all airports are at sea level, so the knob allows the pilot to set the altimeter to read either height above sea level or height above the airport.

6 An aneroid barometer consists of a sealed container with most of the air removed. The box is slightly flexible, and part of its surface is connected to a pointer. The pressure of the atmosphere produces a force on the outside of the sealed box. If the air pressure changes, the box is compressed by different amounts and the movement moves the pointer against a scale.

### 8Id Floating and sinking

#### Student Book

##### 1: 8Id Floating and sinking

- a weight and upthrust

b They are the same size when you are floating.
- 500 N
- a weight (gravity) and upthrust

b They are the same.
- Find the weight of the object, then suspend it in water and find the weight again. The difference between the two weights is the upthrust.
- Take pieces of different materials all of the same size and shape. Find the upthrust for each object. If the upthrust depends on the materials it will not be the same for all of them.
- a Iron will float in mercury because it is less dense than mercury.

b Polystyrene is less dense than water, so it floats in water. It is more dense than air, so it will not float in air.
- The ship includes air spaces, so the overall density of the ship and the air inside it is less than the density of sea water.
- For the balloon to fly it must be less dense overall than the air around it. Heating the air makes the particles move faster and take up more space. This makes the density of the hot air less than the air surrounding it. If the air inside the balloon is made even hotter, the particles move around faster and the air expands. This makes it less dense than it was and increases the upthrust.

### Activity Pack

#### 8Id-1 Floating and sinking

- a upthrust

b weight
- wood – float; iron – sink; polystyrene – float; ice – float; aluminium – sink
- density, less, air, faster, more, less density, water

#### 8Id-2 Factors affecting upthrust

4 Students should find that the upthrust depends only on the submerged volume of the solid.

#### 8Id-3 Upthrust in different liquids

- Students should find that the upthrust does depend on the liquid used.
- Students should find that denser liquids produce more upthrust.

#### 8Id-4 Floating questions

- weight, upthrust
- upthrust from the water
- a iron weight                      b iron weight
- a 11, 40, 6, 2                      b wooden block
- a wooden block

b it does not weigh anything in water/its weight in air is the same as the upthrust

#### 8Id-5 The Plimsoll line

- They could carry more cargo and so make more money.
- The ship might sink in a storm.
- Paint a line on the side of the ship that showed when they must stop loading the ship.
- Sea water is denser than fresh water, so it provides more upthrust. A ship loaded to the sea water line would float lower in the water if it sailed into fresh water.
- The particles in warm water are moving around faster and take up more space. This makes the density of warm water less than cold water. As the upthrust depends on the density, warm water produces less upthrust than cold water.
- The water is warmer in the tropics than in the North Atlantic winter, so it is less dense, and fresh water is less dense than sea water.
- The apple should float higher in the water, because the dissolved salt will make the water denser and so it will provide more upthrust.

#### 8Id-6 Archimedes

- a 8 N

b 3 N

c 3 N

d Upthrust is less than its weight.

## Fluids

- 2 a 1 N  
b 1 N  
c 1 N  
d Upthrust is equal to weight.
- 3 a Y, it has displaced the most water.  
b Y, X, Z. Y displaces most water, Z displaces least.
- 4 a It would sink lower/displace more water.  
b 1 N
- 5 a An Archimedes screw is used for pumping water uphill. It can be used to pump water from rivers into irrigation channels at a higher level.

b The king thought the worker had stolen some of the gold provided for making a crown and mixed silver with the rest of the gold so there was enough to make the crown. Silver is not as dense as gold. Archimedes worked out the density of pure gold and compared it with the density of the crown. The densities were different, which showed that the man was stealing.

**8Id-7 Submarine sums**

- 1 a 8000 tonnes/8 000 000 kg  
b volume = mass/density = 8 000 000 kg/1030 kg/m<sup>3</sup> = 7767 m<sup>3</sup> (sea water has a density of 1030 kg/m<sup>3</sup>, which is more dense than fresh water at 1000 kg/m<sup>3</sup>).
- 2 a When it is on the surface, not all of the submarine is displacing water, but the whole volume of the submarine is displacing water when it is submerged.  
b Density will be the same as the density of seawater – 1030 kg/m<sup>3</sup>.  
c It is less than the submarine's density when it is submerged, and it is also less than the density of sea water. We cannot say how much less its density is than seawater unless we know how much of the submarine is below the water.  
d Water has been blown out of/pumped out of ballast tanks to reduce the density.
- 3 a They displace some air.  
b When the air pressure is increased the air is denser, so the weight of air displaced by the sphere and the block increases. Because the sphere is much bigger than the block the difference in the upthrust between normal and increased pressure is greater, so it rises.  
c The sphere will sink, because the reduction in upthrust due to the lower pressure (and hence lower density) is greater than for the block.

**8Ie Drag****Student Book****1: 8Ie Drag**

- 1 the resistance force caused when an object is moving through a liquid or a gas

- 2 make the surface smoother, give the object a smooth shape, reduce the area of the object that faces the oncoming fluid
- 3 The large area gives them a large drag, so they will fall slowly and the crates will not be damaged when they land.
- 4 size – the naval submarine is much bigger than *Alvin*, which would give it a higher drag for a given speed; shape – the naval submarine is much smoother than *Alvin*, which would reduce the drag at the same speed; speed – the naval submarine is much faster than *Alvin*, so will have a higher drag when travelling at its top speed
- 5 a any two from: crouching down over the handlebars to make his shape smaller, wearing smooth clothing to give himself a smooth surface, wearing a specially shaped helmet to give himself a streamlined shape  
b The backwards force on him is less.
- 6 a Particles transfer heat energy to the object when they hit it.  
b Fewer particles are hitting the object each second, and they are not moving as fast when they hit, so the total force is less.
- 7 *Students' own answers*, but the adverts should explain the benefits of driving more slowly in terms of fuel economy.
- 8 a & b any two from: increase power/make engine bigger (increasing the amount of force produced by the engine increases the forwards force of the car), decrease drag/make car more streamlined (decreasing the drag force means more of the engine forces are used to move the car forward – increases the forwards force of the car), decrease weight of car (a lighter car uses less of the engine force to move at a steady speed – more forwards force gives a greater speed)
- 9 A boat has to move through water as well as through the air above it. Water is denser than air, so there will be more particles hitting the boat per second at the same speed and water resistance will be much higher than air resistance.

**2: 8Ie Operating aeroplanes (STEM)**

- 1 Possible answers include the following. Students should get credit for making one sensible suggestion for each part:

a Winds affect aeroplanes when they take off and land, and winds (e.g. headwinds, tailwinds, sidewinds) can change their journey times. Pilots need to know where there might be thunderstorms so they can plan their route to fly around them.

Pilots need to know if there will be ice or water on runways (as the aeroplane might skid), or if ice might form on the outside of the aeroplane in flight

(ice on the wings changes their shape, and can reduce the lift produced).

Pilots and controllers need to know if there will be fog or cloud that will prevent the pilot seeing the runway. Airliners have instruments and controls that allow the aeroplane to land even in fog, but many small aeroplanes do not.

**b** Pilots need to be able to point the aeroplane in the right direction to get to their destination. Modern aircraft use radio beacons and satellite systems for navigation, so pilots need to be able to use these.

**2** One of: Each different type of aeroplane has different instruments, so pilots need to become familiar with them. The take-off and landing speeds depend on the size and mass of the aeroplane. There are differences in the way the aeroplane is controlled.

**3** They need to know whether it will be safe for aeroplanes to land at a particular airport (e.g. wind not too strong, not too much ice or snow), how winds might affect the aeroplanes they are controlling, and where there might be thunderstorms so they can help pilots to fly around them.

**4** To help pilots to avoid flying into them when they are approaching or leaving airports.

**5** Moving the wheels inside the body gives the aeroplane a more streamlined shape, which reduces the drag and means the aeroplane will need to use less fuel for its journey.

**6** Air pressure reduces as you get higher, and there is less oxygen in the air. Having the aeroplane pressurised makes sure there is enough oxygen in the air for the pilots and passengers and breathing masks will provide oxygen if the cabin's oxygen is lost.

### Activity

**1** The density is approximately  $0.32 \text{ kg/m}^3$  at 12 km height, compared to  $1.22 \text{ kg/m}^3$  at sea level. The density at 12 km is about  $1/4$  of the density at sea level.

**2 a** The lift is less, as lift increases with increasing speed (or similar explanation).

**b** The lift is less. At a greater height the air density is less. As lift is proportional to air density, the lift also decreases.

**3** On a hot day the density of the air decreases, and so the lift for a given speed decreases. This means that to get the same amount of lift as on a cold day, the aeroplane needs to go faster.

### 3: 8le Humans at the extremes

**1** The size of the balloon in the photo is due to a balance between the pressure inside it and outside it. As the balloon ascends the pressure of the air outside it will get less.

There are still the same number of particles inside the balloon so now the pressure inside the balloon is greater and the balloon expands. As it expands the pressure drops because the particles have further to go between each time they collide with the sides of the balloon so there are fewer impacts per second. The balloon carries on expanding until the pressure inside and outside is equal. This happens continuously as it gets higher and higher.

**2 a** solid – ice, human, immersion suit; liquid – water/the sea; gas – air

**b** solid – particles are held in fixed positions and only vibrate; liquid – particles can move around freely within the liquid and do not have a fixed arrangement; gas – particles can move around and the gas expands to fill its container

**c** solids: keep their shape and volume and are hard to compress – the particles are fixed in position with strong bonds; liquids: keep volume but not shape, are hard to compress, flow and take the shape of their container – the particles are in close position with less strong bonds which allow sliding movement; gases: change shape and volume, compressible, expand to take shape of their container – the particles are spaced far apart and move freely with only weak bonds between them

**3** graph should show temperature increasing, levelling out then increasing again with labels for the three states describing the particles (solid – close and strongly bonded with not much movement; liquid – close with medium bonding and can move easily around each other; gas – far apart with weak bonds and moving freely) and labels for the two changes of state (melting – the energy supplied breaks strong bonds in the solid and water becomes liquid; boiling – the energy supplied breaks medium bonds in the liquid and water becomes gas)

**4** Objects float when they are less dense than the fluid they are floating in, and ice is less dense than water. Most solids are denser than their liquids.

Normally when an object melts the particles get further apart and so the liquid is less dense than the solid. In ice the opposite happens – the solid is less dense than the liquid and so the ice floats on water.

The lower density of ice is explained in terms of forces between oxygen and hydrogen atoms in the water.

### Activity Pack

#### 8le-1 Drag

**1** Helmet pointed at the back – streamlined shape

Strong leg muscles – larger force to balance the drag forces

Crouched down riding position – smaller area that meets the air in front

Black painted bike – makes no difference to speed

## Fluids

2 a B                    b B

- 3 a US Navy submarine  
 b US Navy submarine  
 c US Navy submarine  
 d *Alvin*.

It is smaller and slower, so it has two things that would help it to have a small drag and only one thing (its shape) that would give it a big drag.

#### 8le-4 Diving experiments

1 a It would have been too dangerous to experiment on humans, as the experiments might have killed or permanently harmed them.

b They needed to find out how the results from the experiments on goats applied to humans.

2 a & b *Students' own opinions*, including some justification of their opinion.

3 a Computers were not available when Haldane's team did their research.

b answers may vary, but may include: computer models are better because they do not involve animals suffering or possible harm to humans; to build a computer model, you need to know something about the thing you are modelling, so some other form of research is always necessary before a computer model can be made

4 a informed consent and the necessity for prior animal research

b *Students' own opinions*, including some justification.

#### 8le-5 Word puzzle

- |            |             |
|------------|-------------|
| 1 upthrust | 8 density   |
| 2 drag     | 9 melting   |
| 3 pressure | 10 solid    |
| 4 vibrate  | 11 expand   |
| 5 sink     | 12 freezing |
| 6 physical | 13 fluid    |
| 7 liquid   |             |

#### 8le-6 Fuel consumption

1 a correctly plotted and labelled graph

b It makes it easier to see any trends or patterns in the results (or similar answer).

2 The engine force is needed to balance the forces of friction and air resistance, which are trying to slow the lorries down.

3 a They travel fewer miles per litre of fuel when their speed is higher.

b Air resistance is greater when they are travelling faster, so a bigger engine force is needed to balance it, so the engine uses more fuel per mile, and travels fewer miles per litre of fuel.

4 a Daisy's lorry has a part on top of the cab that makes its shape smoother.

b The smoother shape will mean that Daisy's lorry has less drag than Fred's.

c Fred. It has a higher drag, so it will use more fuel at a certain speed, and go fewer miles per litre of fuel.

5 A good answer will include some or all of the following points: 50 mph is the average speed, so the lorry will have changed speed, so it will have used extra fuel when accelerating. It may have gone up hills, which would have used up extra fuel. There may have been a head wind, which would have increased the air resistance. Accept any other sensible suggestions.

6 a They should use less energy as friction will be less. More important is that less force (and hence fuel) will be needed to accelerate an empty lorry, but students are not expected to know this at this stage.

b They should be able to travel further for each litre of fuel.

c The additional line should be above the line originally plotted for lorry B.

7 answers could include: reducing the costs of buying fuels; making limited fossil fuel supplies last longer; reducing pollution; reducing the amount of CO<sub>2</sub> put into the atmosphere, which might help to limit the effects of climate change

#### 8le-7 Drag coefficients

1

Speed (mph)	Drag (N)
10	11
20	44
30	99
40	176
50	275
60	397
70	540

(note that these resistive forces are only due to air resistance – cars have other resistive forces due to friction in the components)

2 correctly plotted and labelled graph

3 a The drag goes up by a factor of 4, so is 4 times as large.

b It doubles.

c Accept any reasonable answers, such as those below, or involving working out examples and comparing them.

The equation for drag has  $V^2$  in it, so if the speed goes up  $\times 2$ , the drag must go up  $\times 4$ .

The equation has  $A$  in it, so drag must be proportional to  $A$  so drag doubles if speed doubles.

**4** As the vehicle moves through the air it hits air particles, which bounce off it. Each particle exerts a force when it hits, and the total force from all the particles is the drag force.

**5** If the air is denser, there are more particles in a certain volume, so the vehicle will hit more particles per second as it moves through the air and the drag force will increase.

**6** If the air density is less the drag force for a given speed will be less, as fewer particles will hit the vehicle each second.

**7 a** It will increase the drag.

**b** increase

## 8J Light

### 8Ja Light on the move

#### Student Book

##### 1: 8Ja Seeing things

**1** any four light sources, e.g. the Sun, light bulb, candle, TV screen

**2 a** Light can pass through it.

**b** any three transparent materials, e.g. air, glass, water, clear acrylic block

**c** any three opaque materials, e.g. wood, metal, brick

**3** People can see the buildings because the light from the spotlights reflects off the buildings and enters their eyes. Some of the light from the buildings then reflects off the water so that people can see that too.

**4 a** Some of the light in the room is blocked by the hands. As light travels in straight lines, the shadow has the same shape as the opaque object that formed it.

**b** there is no light shining on it/we are not seeing light, we are detecting a place where there is no light

**c** Diagram should show a spotlight, the hands and an eye, with arrows going from spotlight to the hands and from the hands to eye.

##### 2: 8Ja Light on the move

**1** Light travels faster than sound, so if the light and sound are made at the same time, the light reaches us before the sound.

**2 a** sketch showing light going from the TV directly to eyes

**b** sketch showing light going from a light bulb (or other light source) to the book and then to eyes

**3 a** Z (it is letting most of the light pass through it, but the direction of the light is changed)

**b** Y (it is reflecting or absorbing all the light that hits it: no light can pass through)

**4** *Students' own answers*, e.g. Use the thread pulled tight to line up the three holes. Check that the candle can be seen when viewed through the holes. Show that the candle cannot be seen if it is moved out of this sight line or if one of the pieces of card is moved so that the holes no longer line up.

**5** Sound can pass through the materials that the door/wall is made of, but light cannot.

**6** The pinhole camera has a very small hole to let light in. Because light rays travel in straight lines, the light rays that come from the bottom of the object can only reach the top of the screen in the camera, and light from the top of the object can only reach the bottom of the screen. (Similarly, light from the left-hand side of the picture will only reach the right-hand side of the screen and light from the right-hand side of the picture will only reach the left-hand side of the screen. The image is fully inverted.)

#### Activity Pack

##### 8Ja-1 Light on the move

**1 a** L                      **b** S                      **c** L  
**d** L                      **e** S                      **f** S

**2** absorbed – when light is taken into a material  
transparent – a material that lets light pass through without scattering

transmitted – when light passes through a material  
translucent – a material that scatters the light passing through it

reflected – when light bounces off a material

opaque – a material that light cannot pass through

**3 a** rays shown reflecting from material

**b** rays shown going straight through material

**c** rays shown going through material but being scattered

**4 a** correctly labelled diagram

**b** Draw two lines from the light bulb through the pinhole and onto the screen – one from the top of the bulb, one from the bottom. Clearly showing why the image is inverted.

##### 8Ja-2 Reflecting light

**4 a** One factor that is difficult to control is the light from the room falling on the materials (for example, they may be shadowed sometimes slightly by students moving around).

**b** A possible suggestion is to carry out the test inside a dark box. By using switches that are outside the box, it should be possible to obtain results without interference.

**8Ja-3 Pinhole cameras**

4 The image formed by a bright light is brighter than one formed by a dim light, because more light enters the camera/there is more light to form the image.

5 A larger hole produces a brighter image, but the image becomes more blurred as the hole is made larger. The ray diagram should show how light from the top (or bottom) of the bulb can take more than one path through a wider hole.

6 There are the same number of images as there are holes. Ray diagram showing rays of light from the bulb going through each hole to form separate images.

**8Ja-4 At the cinema 1**

1 torch, projector

2 sound cannot travel through empty space

3 a reflects                      b opaque, shadow

4 arrow from torch to sweets, and from sweets to eye

5 Light travels faster than sound.

**8Ja-5 Light and space**

1a & b Copy of diagram from worksheet, with one ray from the Sun to the Earth, and one from the Sun to the Moon, which then reflects towards the Earth. Rays should include arrows to show the direction of travel away from the Sun.

2 4 years

3 a  $5 \times 8.5 \text{ minutes} = 42.5 \text{ minutes}$

b  $1.5 \times 8.5 \text{ minutes} = 12.75$ , so 13 minutes to the nearest minute.

4 8.5 minutes (or between 8 and 9 minutes). On average, the Moon is the same distance from the Sun as the Earth.

5 a  $300\,000 \text{ km/s} \times 8.5 \times 60 = 153\,000\,000 \text{ km}$

b  $300\,000 \text{ km/s} \times 1.3 \text{ s} = 390\,000 \text{ km}$

c  $4 \text{ years} = 4 \times 365 \times 24 \times 60 \times 60 = 126\,144\,000 \text{ s}$

distance =  $300\,000 \text{ km/s} \times 126\,144\,000 \text{ s} = 37\,843\,200\,000\,000 \text{ km}$

6 time =  $58\,000\,000 \text{ km} / 300\,000 \text{ km/s} = 193 \text{ s}$

**8Ja-6 At the cinema 2**

1 a Sound cannot travel through a vacuum/empty space.

b see the flames first, because light travels faster than sound

c Sound travels via longitudinal waves and light travels via transverse waves; sound is transmitted through any solid object, but light is only transmitted through transparent or translucent objects.

2 It should be good at reflecting light, so as much as possible of the light from the projector reaches the audience.

3 Diagram showing light going from the projector to the screen and then reflecting to the eye. Arrows showing the direction of travel.

4 The screen is reflecting light into the cinema, sufficient for the person to see their seat. Sketch to show this.

5 The seats are opaque, so they will absorb/block light reflected from the screen.

6 Some of the light is reflected by specks of dust in the air.

**8Ja-7 Shadows**

1 Copy of diagram from worksheet, with two rays coming through the hole in the card, passing each side of the object and extending to the screen. Area of the screen between these lines is labelled as the shadow. An explanation that no light reaches that part because the object is opaque and absorbs light.

2 a The shadow will be bigger. Diagram similar to above, with the object closer to the light source.

b The shadow will be bigger. Diagram similar to above, with the screen further from the light source.

3 a On the diagram, the central area on the screen between the two parallel rays of light.

b The areas on the screen outside of the angled rays.

c The areas between the parallel rays and the angled rays.

(So, from top to bottom of the diagram the different sections should be labelled b, c, a, c, b.)

4 A large source (hole) produces a shadow with blurred edges because light from the source can go past the edge of the object in several directions. This means that light from the source is only completely blocked in part of the shadow. The blurred edges are formed when light from part of the source, but not all of it, reaches some parts of the screen. A small source produces a sharp-edged shadow because the light only goes past the edge in one direction.

**8Jb Reflection****Student Book****1: 8Jb Drawings and conventions**

1 A ray box makes it easier to investigate the behaviour of light. The box produces a narrow beam or beams of light that can be marked on paper. This makes it easier follow and measure the paths of light rays.

2 Most of the light in the ray is going along the ray and you only see this if you look directly into the ray box (which is not good for your eyes!). Some of the light hits the paper and is reflected: you see the part of this light that is reflected towards your eyes.



3 The angle of reflection is the same/almost the same as the angle of incidence. Students may suggest that more accurate results would be needed to confirm this conclusion.

4 so that all scientists can understand diagrams

5 If the ray is narrower it is easier to mark the middle and more precise measurements can be obtained. A brighter beam is easier to see, which may also help accuracy when looking at the beam a long way from the source.

## 2: 8Jb Reflection

1 metal, the reflecting part of a mirror is made of metal

2  $20^\circ$

3 light is not reflected from the paper evenly/ reflection from the paper is diffuse/not specular

4 Polishing makes the surface smoother, so light is more likely to be reflected evenly/less likely to be scattered.

5 The image is the same distance behind the mirror as you are in front, so you are 4 m ( $2\text{ m} + 2\text{ m}$ ) from the image.

6 they are showing where the light seems to have come from/they are not representing real rays of light

7 a specular reflection – you can see images in the water, so the angles of incidence and reflection must be the same/you must be seeing the results of specular reflection

b A ray of light from the sky is reflected from the vehicle and then reflected from the lake. The angles of incidence and reflection should be the same where the light is reflected from the water.

c the wind will make ripples on the water/ make the surface of the water rough, so the reflection will be diffuse/will not be specular/ the angles of incidence and reflection will not be the same

## Activity Pack

### 8Jb-1 Reflection

1 reflect, reflection, incidence, scatter

2 a diffuse                      b specular  
c diffuse                      d diffuse

3 a correctly labelled diagram  
b the same size

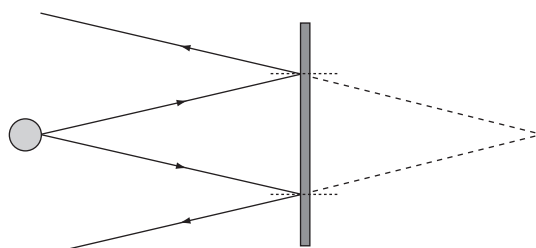
### 8Jb-4 Investigating curved mirrors

1 Diagram should resemble the one on the left of the worksheet, with rays drawn accurately ( $i = r$ ) for each section of plane mirror on the 'model'.

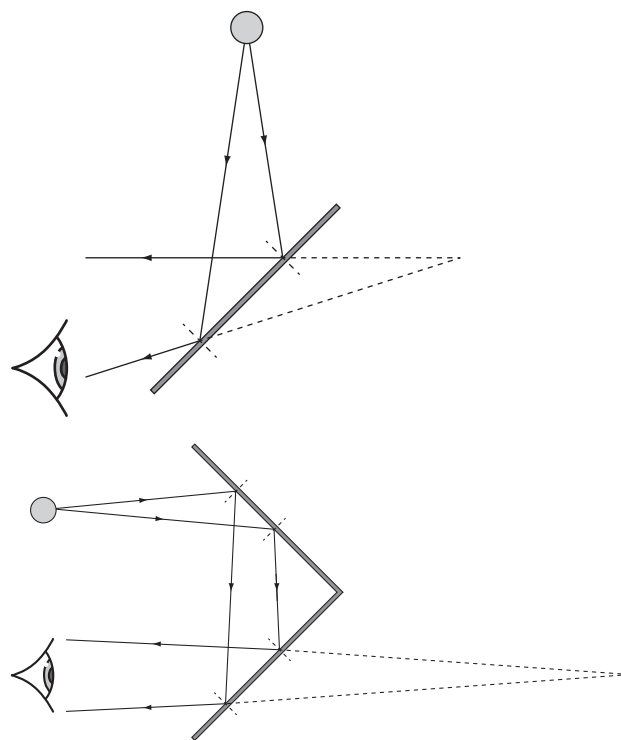
2 Pair of diagrams similar to those on the worksheet, showing convex mirrors, with rays drawn accurately on the 'model'.

### 8Jb-5 Ray diagrams for mirrors

1



2



### 8Jb-6 Mirrors and reflections 1

1 the same size

2  $90^\circ$

3 a Ray reflects off the first mirror vertically downwards, where it reflects off the second mirror horizontally towards the eye.

b Arrowheads show direction of travel towards the eye.

4 correctly labelled diagram

5 A mirror reflects light evenly/specular reflection (the angles of incidence and reflection are the same). When paper reflects light it is scattered in all directions/diffuse reflection.

### 8Jb-7 Mirrors and reflections 2

1 a Ray reflects off the first mirror vertically downwards, where it reflects off the second mirror horizontally towards the eye.

b arrowheads show direction of travel towards the eye

**c** Two mirrors are needed to change the direction of the light ray twice so it can reach the eye and also not be inverted.

**2 a** The rays are transmitted directly through the glass to the eye.

**b** Light from the candle reflects off the glass surface into the eye. The eye sees a virtual image of the candle the same distance behind the glass, which happens to be the same distance as the bottle. In addition, candle light is also transmitted directly through the glass onto the bottle.

**c** A mirror would not allow light to be transmitted. Glass partially reflects and partially transmits the light.

**d** To exclude all other light sources as the candlelight is not very bright.

**3 a** If the hidden room was lit up, reflections of the hidden room would also be visible on the glass.

**b** The spotlight shines on the actor. Rays of light reflected by the actor are then reflected by the glass and appear to the audience to be coming from the part of the stage they can see.

**c** answers could include: the difficulty of setting a large sheet of glass across a stage and hiding the joins from the audience; avoiding unwanted reflections in the sheet of glass; the difficulty of the actor playing the ghost while inverted so moving/looking in the correct direction to interface with 'normal' actors on the main part of the stage

### 8Jb-8 Periscopes

**1** Rays of light reflected by the top of the tree are above rays of light reflected by the bottom of the tree when they reach the eye since they have been reflected in two mirrors.

**2** We only need to use two rays – one from the top, one from the bottom – to show the range of rays coming from the object.

**3** Diagram showing a close and distant tree with light rays from the top and bottom of each showing that the two rays of light from the closer object make a larger angle when they reach the eye.

**4 a** Diagram with the image of the tree as far above the top mirror as the object is to its left.

**b** Diagram with the image of the tree level with the bottom mirror and to the left of the position of the original by the vertical length of the periscope.

**5 a** The image you see in the bottom mirror is an image of the image in the top mirror. The distance of the final image is the distance the light has travelled from the real tree, so it is the distance of the tree plus the length of the periscope.

**b** If the periscope has a longer tube, the light from the object has to travel further before reaching the final mirror.

**6** In tanks, they allow the crew to see outside while still remaining protected by the tank.

In submarines they allow the crew to look around without the submarine coming to the surface, which will make it less likely that the submarine will be detected by enemies.

**7** If a submarine is underwater, the periscope may need a very long tube. The submarine might also be looking for distant ships. Both these factors will make the image very small, so lenses are needed to magnify it.

## 8Jc Refraction

### Student Book

#### 1: 8Jc Refraction

**1 a** to give a sharp image

**b** to make distant things look closer

**c** to make small things look bigger

**2** the bending/change in direction of light as it passes from one medium to another

**3 a, b, c** ray diagram with normal, angle of incidence and angle of refraction correctly marked (as in image C in the Student Book).

**4** *Students' own answers*, e.g. Put the block on a piece of paper and draw around it. Shine a ray of light at it, and mark the incident ray, where it enters the block and where it leaves the block. Remove the block from the paper and use a ruler to join the marks to show where the light went. Draw a normal at the point the light entered the block, and measure the angles of the light ray from the normal.

**5** Rays of light reflected by the object bend away from the normal as they leave the water. The rays of light appear to be coming from a place above the bottom of the water, so the water looks shallower than it really is.

**6** thicker/fatter in the middle than at the edges

**7 a** They would converge to a point closer to the lens (include a diagram similar to diagram E, but the prisms should have more steeply sloping sides).

**b** shorter

**8** A converging lens bends the light so that it comes together, so it can be used to make diverging rays parallel if a lens with suitable curvature/strength is used (include a diagram showing this).

### Activity Pack

#### 8Jc-1 Refraction

**1** labels from top left going clockwise: ray, refraction, normal, towards, away from, glass, light ray, refraction

**2** Light rays are refracted as they pass through the lens and meet at the focal point.

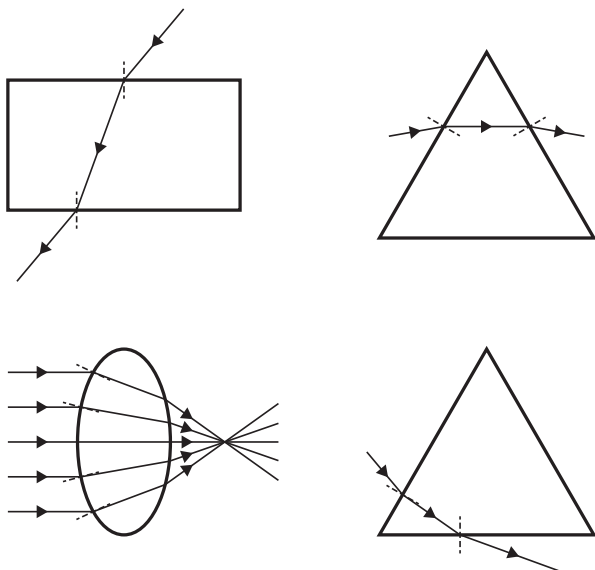
**3** refraction

**8Jc-2 Investigating refraction 1**

- 1 labels from top left going clockwise: air, glass, ray box, normal
- 2 glass, light, draw, move, ray, block, ruler, angle
- 3 towards, away from, parallel

**8Jc-5 Refraction questions**

- 1 Angles labelled correctly, with angle of incidence within the block above the normal, and the angle of refraction outside the block.
- 2 **a** towards the normal  
**b** away from the normal
- 3

**8Jc-6 Fresnel lenses**

- 1 They would not be big enough to give a bright enough beam of light to be seen from long distances out at sea.
- 2 to concentrate the beam so that it is visible from further away
- 3 **a** It is lighter and so easier to put into the lighthouse. It is also easier to rotate than a heavy single lens would be.  
**b** It is more complicated to make, which means it will cost more.
- 4 **a** It helps them to see an area behind the car that is normally not visible, so they can make sure that they do not reverse into anything.  
**b** It is thin and made from plastic, so it does not stick out and it is easier to mount.  
**c** The quality of the view is not as good as a converging lens. This does not matter so much for parking as long as the driver can see a car or other obstacle behind, but it does matter for cameras.
- 5 The lens shown magnifies a larger area than the magnifying glass. Being made of plastic, it is less likely to get broken, and is lighter. No real disadvantages.

**6** Advantages – the same focusing power can be obtained with a thinner, lighter lens than if a glass lens is used. No real disadvantages.

**7** The sharp edges within the lens will cause distortion and so they may not give clear pictures. Diagram could show part of a Fresnel lens with a ray of light going through one of the flat surfaces joining two curved sections.

**8Jc-7 Prisms and fibres**

**1 a** Total internal reflection is when light is fully reflected inside a piece of glass or other transparent material as the angle of incidence is larger than the critical angle.

**b** Optical fibres, prisms used in binoculars, telescopes and cameras.

**2** Refraction is the changing in direction of light, reflection is when light rays bounce off a surface.

**3 a** They are lighter and more compact so are easier to carry and use.

**b** It doesn't make much difference if the image of a star or a planet is upside down.

**4** Optical fibres can bend to fit inside various tubes in the bodies. Periscopes are rigid.

**5 a** The ray is internally reflected by the first interface, so it turns  $90^\circ$  downwards. It exits the prism at the bottom interface without any refraction.

**b** The ray is internally reflected by the first interface, so it turns  $90^\circ$  downwards. At the next interface the ray is again internally reflected so will turn  $90^\circ$  to the left. At the third interface it exits the prism without any refraction and will travel parallel to the original direction.

**6 a** Some angles at where the light is hitting the interface are less than the critical angle, so total internal reflection would not occur. Therefore, the reflective coating makes sure the light is only reflected.

**b** With a triangular prism the image in the viewfinder would be upside down.

**c** They would take up more space inside the camera, and the arrangement shown would not turn the light through  $90^\circ$ , which is needed in the camera.

**8Jd Cameras and eyes****Student Book****1: 8Jd Cameras and eyes**

- 1 **a** lens **b** sensor
- 2 **a** any two from: has a hole for light to enter, image is formed at the opposite end, image is upside down/inverted  
**b** any three from: digital camera has a lens, digital camera has a larger hole/aperture, digital

## Light

camera has a shutter, digital camera makes a record of the image, pinhole camera has no moving parts, pinhole camera doesn't need electricity

**3 a** pupil **b** retina

**4** In a camera the focusing is done by moving the lens closer to or further away from the sensor. In the eye, focusing is achieved by changing the shape of the lens.

**5 a** red, green, blue

**b** red and blue make magenta, red and green make yellow, blue and green make cyan

**6 a** rods, cones

**b** Rods detect faint light levels, but cannot tell the difference between different colours.

There are three types of cones, each one detects a different colour.

**7 a** The photo with the large pupil is an eye in dim light (if the light is dim the pupil needs to be large to let a lot of light into the eye). If the light is too bright it might damage the retina, so the pupil gets smaller in brighter light.

**8** *Students' own answers* (either opinion is justified, but should be backed up with reasons); reasons for it being a good model: light enters through a lens, which focuses the light to form an image; reasons for it being a bad model: focusing in the eye is done by changing the shape of the lens (in a camera it is done by moving the location of the lens)

## 2: 8Jd Looking after our eyes (STEM)

**1 a** Cataracts make the lens cloudy, so light cannot get through.

**b** Macular degeneration damages the retina, so light getting into the eye is not detected properly.

**2** Any answer derived from the technology shown in photo A (accept any other sensible suggestions). Examples could include microscope, camera or laser.

**3** An outline similar to the diagrams in the book, showing light rays coming together beyond the retina. Label stating the eyeball is too short.

**4** Answers could include:

When they are using a chart, they need to ask the patient to read out the letters.

They need to talk to the patient about any problems they are having.

They need to explain to the patient what is wrong and what treatments are available.

If they need to send the patient to an ophthalmologist, they need to explain to the ophthalmologist what the patient's problems are.

**5** Expected answer (from the Student Book) is cataract surgery.

## Activity

Posters should clearly describe the problem and what causes it, and how it should be treated.

## Practical

**3** They are short sighted. They cannot see distant objects clearly, so they can only read the largest letters on the chart.

## Activity Pack

### 8Jd-1 Cameras and eyes

1

A	P	E	R	T	U	R	E	S	C	L	R	M
I	S	O	P	T	I	C	N	E	R	V	E	U
P	U	P	I	L	U	C	O	N	E	S	T	S
E	S	H	U	T	T	E	R	S	O	E	I	C
L	E	N	S	I	R	I	S	O	C	R	N	L
R	O	D	S	C	E	C	O	R	N	E	A	E
M	E	M	O	R	Y	C	A	R	D	E	U	S

### 8Jd-2 Combining colours

**1** The one with red, green and blue. These are the three primary colours, and our eyes see a mixture of these as white light.

**2** V: yellow (red: green)

W: white (red: green: blue)

X: white (red: orange: yellow: green: blue: indigo: violet)

Y: magenta (red: blue)

Z: pale red (magenta: yellow)

Predictions may vary, but should be based on the colour combinations shown in the diagram on the worksheet.

### 8Jd-3 Light true or false

**1** True

**2** False, 90°

**3** True

**4** False, angle of reflection

**5** True

**6** False

**7** False, towards the normal

**8** True

**9** False, refraction

**10** True

### 8Jd-5 Using lenses

**1** A: Another ray drawn from the top of the flame passing through the hole to the screen. The image the same size as the flame but will be inverted.

B: Another two rays drawn from the top of the flame passing by the two edges of the hole to meet the screen. The image will be larger than the flame, inverted and blurred.

**2** Second set of rays drawn from the bottom of the flame passing through the lens and converging on one point on the screen. The image would be inverted but sharp.

**3 a** Rays of light from the top of the flame cross rays of light from the bottom as they pass through the pinhole (or similar explanation).

**b** The hole is bigger, so more light can get into the camera.

**c** In A, rays of light from one part of the flame can only reach one part of the screen. In B, rays of light from one part of the flame can reach more than one place/an area of screen.

**4** Cameras need to let in plenty of light so the sensors/film can form an image. Without a lens this would cause the image to be blurred. A lens allows the image to be both bright and sharp.

**5** Light enters the eye through the pupil, which is larger than a pinhole. The lens helps to focus the light to form a sharp image on the retina.

#### 8Jd-7 Seeing things

**1** A and I: lens

B aperture

C sensor

D shutter

E optic nerve

F retina

G iris

H pupil

J cornea

**2 a** H – pupil

**b** I – lens (accept J – cornea)

**c** C – sensor

**d** F – retina

**e** E – optic nerve

**3** The iris makes the pupil large if the light is dim. The iris makes the pupil small if the light is bright.

#### 8Jd-8 Taking photographs

**1 a** The one taken at f8 will be the brightest, as this is a larger aperture so more light can enter the camera while the shutter is open.

**b** She should make the shutter speed slower.

**2 a** Larger apertures give smaller depths of field, which means that not everything in the image will be in focus. This will allow the photographer to blur the background.

**b** The photographer needs a certain amount of light to hit the sensor. A large aperture could let in too much light, so the shutter speed needs to be fast to limit the amount of light. (Some may answer that fast shutter speeds may be necessary due to the fast movements/reaction times of insects.)

**3** A fast shutter speed can give a sharp picture of the fast-moving racing car. If the shutter is open for a longer time the movement of the car will give a blurred image.

**4 a** The iris changes the size of the pupil.

**b** This is similar to using the aperture to control the light entering the camera.

**c** In a camera the shutter speed can also be used to control the amount of light. Eyes do not have an equivalent of the shutter.

**5** In the eye, refraction occurs as light passes through the cornea and through the lens. In a camera refraction happens only in the lens.

**6** In eyes, the shape of the lens is changed by muscles. In a camera, the shape of the lens does not change, but the distance from the lens to the sensor is adjusted.

**7** The shutter can be kept open for a long time, so the sensor can collect more light to form the image.

**8** Red, blue and green. These are the three primary colours of light and are the same as the colours detected by the cones in human eyes. Any image formed using only these three colours can be seen as all colours.

#### 8Jd-9 Eyes and spectacles

**1** the shape of the lens

**2 a** close things

**b** distant things

**c** When you look at distant things, the lens bends light too much so it focuses in front of the retina (because the lens is too strong or the eyeball too long).

**d** diverging lenses

**e** They make the light spread out before it reaches your eye, so that it has further to bend back to be in focus (or equivalent explanation).

**3 a** distant things

**b** close things

**c** When you look at close things, the lens does not bend the light enough to focus on the retina (it would focus behind the retina if the retina was transparent). This happens because the lens is not strong enough or the eyeball is too short. Diagram showing this.

**d** converging lenses

**e** They would make the light start to converge before it reached your eye, so not as much convergence was needed from the lens in the eye.

**8Je Colour****Student Book****1: 8Je Colour**

- 1** red, orange, yellow, green, blue, indigo, violet
- 2** raindrops in the air refract sunlight/split up sunlight
- 3** **a** He would have seen green light again (as there was only green light entering the prism, the prism could not spread it out any more).
- b** They might have expected to see another spectrum, if they believed that the prism was giving colour to light.
- 4** **a** blue
- b** all the other colours (red, orange, yellow, green, indigo, violet)
- 5** It transmits the blue light and absorbs all the other colours.
- 6** trousers – all the colours; sleeves – red; body – none (absorbs all colours); hat – blue
- 7** **a** The red sleeves are reflecting the red light shining on them. The white trousers can reflect all colours, but there is only red light shining on them so they only reflect red light.
- b** The body absorbs all colours, so it looks black. The blue hat can reflect blue light, but there is no blue light shining on it so it cannot reflect any light and looks black.

**2: 8Je Invisibility cloaks**

- 1** **a** Light from a source is reflected by the model cat and some of it reaches our eyes. (Or the same explanation in terms of light being reflected by photo B in the book!)
- b** White light contains all the colours of the spectrum. The red collar reflects red light and absorbs the other colours.
- 2** A mirror reflects light evenly, so that the angle of reflection is equal to the angle of incidence (a mirror produces specular reflection), whereas the light reflected by the model cat is reflected in all directions (diffuse reflection). A mirror reflects all the frequencies in white light, the model cat only reflects only the colours/frequencies of light that mix to make brown.
- 3** **a** refraction
- b** when light goes from one transparent medium to another
- 4** **a** lens, aperture, shutter, sensor, memory card
- b** lens – focuses light, aperture – controls the amount of light that enters the eye, shutter – protects the sensor when a photo is not being taken, sensor – converts energy transmitted by light into electrical signals, memory card – records the image

- 5** **a** cornea, iris, pupil, lens, retina, muscles, optic nerve

**b** cornea – lets light into the eye, iris – controls the size of the pupil, pupil – is a hole through which light enters the eye, lens – focuses the light, retina – converts the energy transferred by light into nerve impulse, optic nerve – carries nerve impulses to the brain, muscles – control the shape of the lens, for focusing on objects at different distances

**Activity Pack****8Je-1 Colour**

- 1** **a** Diagram coloured correctly with red at the top and colours in order (red, orange, yellow, green, blue, indigo, violet).
- b** **i** white light **ii** prism **iii** spectrum
- 2** The spectrum on the left of the filter coloured in order (red to violet from top to bottom), arrow to right of filter and filter both coloured yellow.
- 3** **a** clothes coloured according to descriptions
- b** cap and shirt coloured red, trousers coloured black

**8Je-2 Splitting light**

- 2** **a** yes **b** yes
- 3** Yes, a spectrum is only produced when light enters the prism at certain angles.
- 4** **a** red, orange, yellow, green, blue, indigo, violet
- b** red
- c** violet

**8Je-3 Rainbows and glories**

- 1** The rainbow is  $42^\circ$  above the point opposite the Sun (the antisolar point). When the Sun is high in the sky this point will be in a downwards direction and a rainbow may not form at all. When the Sun is low in the sky (in the morning or evening), this point is fairly near the horizon, and so a rainbow might be quite high in the sky.
- 2** Light rays are reflected back from the Sun by water droplets, and would appear to an observer to be coming from inside the rainbow.

**8Je-4 Colour questions**

- 1** white, prism, spectrum, dispersion, seven
- 2** filter, transmits, absorbs, orange
- 3** **a** blue
- b** red, black
- c** black, green
- d** black
- e** black, black

**8Je-5 All cats look grey ...****1 a** retina**b** They detect the three different colours.**c** Rod cells can detect fainter light than cone cells, but do not detect different colours. Cone cells need brighter light before they can detect it, and each type of cone cell detects light of only one colour.**2** The trousers look black because they absorb all the colours in white light and do not reflect any of it. The white T-shirt reflects all the colours. The blue coat only reflects blue light and absorbs all the other colours.**3 a** They do not reflect any light, so the colour of light falling on them does not affect their appearance.**b** Her T-shirt will look orange, as it can reflect all colours but there is only orange light falling on it. Her coat will look black, as it is not reflecting any light (it will only reflect blue, but there is no blue light falling on it). (In practice, the orange light from streetlights is not usually bright enough to make a white object truly appear orange.)**4** The light would not spread out as far if the pole was shorter, so more streetlights would be needed.**5 a** The light comes from the Sun and is reflected by the Moon.**b** Moonlight reflected from coloured objects is not bright enough for our cone cells to detect. We are detecting things by the rod cells, which do not differentiate between different colours.**c** A black cat will always look black, as it absorbs all the colours of light that fall on it.**6** Coloured filters are used. These transmit one colour of light and absorb the rest.**7 a** A red light will make a white costume look red, because the costume will reflect the red light falling on it.**b** Red and green lights both need to be shone on the costume. It will reflect both colours, and our eyes will detect the mixture of the two colours as yellow.**8Je-6 Blue skies and sunsets****1 a** Some sunlight must be scattered to allow it to hit objects in the shadow and be reflected into your eyes. Without this scattered light, objects not in direct sunlight on a sunny day could not be seen.**b** Objects in a shadow do not appear to change colour (they only look darker), so all the colours in the white light from the Sun must be scattered.**c** Blue light is scattered more than the other colours.**2** They must be scattering all the wavelengths by about the same amount, as our eyes see the combination of all the colours as white.**3** The light from the Sun has to travel through more atmosphere to reach person B than person A. The Sun would appear to be low in the sky/setting to person B. So there is more chance for the blue light to be scattered and less of it would reach our eyes. White light without the blue frequencies will appear more red. (Some students could add that green may also be scattered more than red, as its frequency is closer to the frequency of blue light.)**4** If blue light is scattered more than colours with longer wavelengths, you might expect violet (with an even shorter wavelength than blue) to be scattered more as well.

(The reason the sky does not appear violet is partly because of some of the violet light being absorbed by the atmosphere, and partly to do with the relative sensitivities of the different cones in the human eye – but this is beyond the scope of this worksheet.)

**5 a** from the Sun, as the only source of light in the Solar System**b** As the Moon is in the shadow of the Earth, light from the Sun cannot reach it directly so the path of the light must have been bent. This cannot be due to the solid Earth, so must happen in the atmosphere.**c** Blue light is scattered by the atmosphere, so not much of it will get through. As the blue component of white light is missing (and possibly other colours as well) the light that does get through appears red.**6** The red colour of the Martian sky is due to clouds of red dust in the atmosphere.**8K Energy transfers****8Ka Temperature changes****Student Book****1: 8Ka Living in extremes****1 a** any four from: light/radiation, heat/thermal, sound/waves, electricity, magnetism, forces/movement**b** any four from: thermal, gravitational potential, elastic potential/strain, chemical, nuclear/atomic**2 a** Solids keep their shape and volume and are incompressible because the particles are held close together by strong forces. Liquids keep their volume because the particles are close together but the bonds between them are not strong enough for the liquid to keep its shape. Gases do not have a fixed shape or volume because the particles are far apart with only very weak forces between them.**b** When energy is transferred to a substance the particles in that substance move more (they

## Energy transfers

vibrate more about their fixed positions in a solid, and move around faster in fluids). When energy is transferred out of a substance, the particles move less.

**c** In melting and evaporation/boiling the particles gain enough energy to escape from their current state. In freezing/condensation the particles lose energy and become more firmly bonded together.

**3** Evaporation can happen at any temperature. Boiling is when a liquid is evaporating as fast as it can, and the temperature of the liquid will stay the same while this is happening even if energy is still being supplied.

Students working at a higher level might also point out that evaporation happens at the surface of a liquid, whereas in boiling the gas can form within the liquid.

### 2: 8Ka Temperature changes

**1 a** Internal energy is a store of energy; temperature is a description of how hot or cold something is.

**b** Energy is measured in joules/J, temperature in degrees Celsius/°C.

**2** The material in each spark has a very low mass, so each spark does not have much energy stored in it.

**3 a** the kettle

**b** the water in the kettle; both containers have the same material at the same temperature, but there is a greater mass of water in the kettle

**c** More energy needs to be transferred to it because there is a greater mass of water to be heated.

**4 a** from the drinks to the room, because the drinks are hotter than the air in the room

**b**  $-5^{\circ}\text{C}$ /the same as the air temperature, because energy will continue to be transferred from the drink to the room while the drink is hotter than the air

**5 a**  $37^{\circ}\text{C}$ /the same temperature as your body, as it has come from your body

**b** Some of the liquid in the sweat evaporates. The particles that escape to form a gas are the ones with the most energy/highest speeds, so the liquid left is cooler than it was. Energy can be transferred from your body to the cooler liquid.

**6** Some of the water will evaporate, leaving the rest of it cooler than before. Energy is then transferred from the warmer air to the cooler water. Students working at a higher level may also add that spraying the water in the air via a fountain helps the water to evaporate as it provides a greater surface area from which evaporation can occur.

**7** It might be colder than the coldest measurement in other parts of the Earth where

there are no thermometers to measure it. The coldest temperature may have occurred before measurements were started.

### Activity Pack

#### 8Ka-1 Temperature changes

**1** joules (J) – the units for measuring energy  
degrees Celsius – the units for measuring temperature  
temperature – how hot or cold something is  
internal energy – another name for thermal energy

**2 a** tank      **b** kettle      **c** tank

**3** the correct words are cooler, lemonade, air, up, down

**4** any temperature, its boiling point, evaporates, cooler

#### 8Ka-2 Sweating and cooling 1

**4** The one wrapped in wet paper should have cooled the fastest.

**6** Sweating can help us cool down.

**7** As a control, so that the presence of the towel itself can be ignored.

**8** If it was wetted with cold water, energy would have been transferred from the hot water in the bottle to the cold water in the towel, so it would have produced some cooling without any evaporation.

#### 8Ka-4 Outdoor survival

**1 & 2** Possible answers: hypothermia – an illness/condition resulting from the body getting too cold, it can be fatal; manifests – shows itself; heart rate – pulse rate, how fast the heart beats; respiratory rates – how fast someone is breathing; muscle co-ordination – being in control of muscles; irrationally – not sensibly/logically; paradoxical undressing – when victims take their clothes off even though they are cold; terminal burrowing – trying to hide/get into small spaces

overexertion – being too energetic; over-cooling – getting too cold; evaporative cooling – cooling down when sweat dries up/evaporates; breathable waterproofs – clothing that allows water vapour out but does not let rain in; wicking clothing – clothing that draws sweat away

**3** Possible answer.

Hypothermia happens when your body gets too cold. It can be fatal. If you are suffering from hypothermia your pulse will be slow and you might also be breathing very slowly. Your skin may look blue and you may start to act in strange ways. People with severe hypothermia sometimes take their clothes off, even though they are cold, and may also try to 'burrow' into small places.

Avoid hypothermia by keeping warm and dry.



Wear a breathable raincoat – this allows water vapour out so that sweat does not build up and make your coat wet inside.

Wicking underwear helps to move the sweat away and helps it to dry up.

Don't walk too fast and get too sweaty.

Shelter from the wind.

### 8Ka-5 Energy and temperature

- a** joules

**b** degrees Celsius

**c** thermometer
- a** large bowl, it has the greatest mass

**b** soup at 80 °C, it has the highest temperature
- a** Out of the soup as it is hotter than the air.

**b** Into the ice cream as it is colder than the air.
- evaporation

### 8Ka-6 Relative humidity

- The amount of water vapour in the air compared to the maximum amount it can 'hold'.
- 30% – the air has a lower relative humidity, so sweat will evaporate more easily and you would keep cooler.
- The air has some water vapour in it. Cold air can hold less water vapour than warm air. As the temperature drops at night, the air might cool below the point at which it can hold all the water vapour in it. If this happens, the excess water vapour condenses as dew.
- a** Water from the wet cloth around the wet bulb thermometer will evaporate. As it does, it will absorb some energy from the thermometer, so the thermometer will get colder.

**b** It will read less when the air is less humid, as a low humidity makes evaporation easier, so more water from the cloth is likely to evaporate, giving a greater cooling effect.

**c** You need to compare the wet bulb thermometer with the actual air temperature so you know how much cooling effect the evaporation has caused.

### 8Ka-7 Breathable waterproofs

- a** It evaporates.

**b** The sweat absorbs energy as it turns from a liquid to a gas.
- a** It bounces off and does not go through.

**b** Your body is warm and transfers heat energy to it.

**c** raincoat

**d** It condenses.

**e** The jacket is colder than the sweat vapour, and energy is transferred from the sweat vapour to the jacket.

- If the water comes in contact with your skin again it will absorb energy from your body, particularly if it evaporates again.
- The vapour from sweat has to be able to get out.
- a** It prevents rain/liquid water from getting through the outer layer, but it also allows water vapour out, so that sweat does not condense on the inside of the jacket.

**b** There is no water inside the jacket to absorb energy from the skin.
- The wicking clothing spreads the sweat out so there is not too much sweat vapour to go through the jacket in any one place.

### 8Ka-8 Absolute zero

- The mean speed of the particles.
- 0 K is when particles stop moving, and you cannot have less movement than that.
- a** It was more convenient at very low temperatures.

**b** He published a scientific paper.
- a** 273 K (actually 273.15 K)

**b** degrees K = degrees C + 273
- Scientists were used to the amount of change represented by one degree. The same thermometers could still be used for many things – you just had to adjust the number if recording the temperature in Kelvin.

### 8Kb Transferring energy

#### Student Book

#### 1: 8Kb Transferring energy

- any three from: no medium required, can go through transparent substances, can be focused, can be reflected
- mug of hot water, because the hotter the object the more infrared radiation it emits
- a** so that heat from the cooker is conducted to the food quickly

**b** so that heat from the saucepan is not conducted to the user's hands
- Heating an object makes the particles vibrate more. The vibrating particles make the particles near them vibrate more as well, so the vibrations are passed through the object.
- Their particles are in a close, regular arrangement which makes it easy for vibrations to be passed on.
- a** by conduction through the metal radiator

**b** by a convection current

## Energy transfers

7 a It is more dense.

b diagram of an ice lolly with arrows going downwards next to the lolly

8 There are no particles to pass on vibrations or to move.

9 radiation; there is air between the hot element and the food, and air is a very poor conductor so not much energy will reach the food this way; convection currents are not likely to form as the air in the oven will be hottest near the top and so will tend to stay at the top of the oven

**Activity Pack****8Kb-1 Transferring energy**

1 a radiation

b conduction

c radiation and conduction

d convection

e conduction

f convection

g conduction and convection

h convection

2 a & b H and D near the heater

c circular currents indicated, moving up near the heater and down at the opposite end of the tank

d a convection current

**8Kb-4 Explaining conduction and convection**

2 diagram with statements correctly positioned

3 statements E, F and J should be coloured/shaded

**8Kb-5 Kitchen questions 1**

1 a conduction

b convection

2 The metal pan conducts heat from the flame to the food well. The wooden handle is not a good conductor and stops your hands getting burnt.

3 a X on the part of the spoon in the water

b Conduction heats all the spoon as particle vibrations are passed along the spoon.

4 The air heated by the element will rise because it is less dense than the rest of the air in the oven.

5 a by radiation

b Air is a poor conductor, so not much energy will be transferred by conduction. Convection will transfer the heat upwards, not sideways.

**8Kb-6 Candles**

1 a Heat transfers by either conduction, convection, radiation or evaporation.

b Convection, as it depends on density differences causing rising or sinking.

2 The gases are hot, so they expand and become less dense than the air around them, so they rise. Colder gases move in to take their place.

3 This is the only area where oxygen is mixed with the fuel. Oxygen diffusing in from the air is used up before it reaches the inner part of the flame.

4 Less dense gases only rise because they are lighter than their surroundings. In a 'weightless' environment this does not happen. As convection cannot happen, diffusion is the only means of transferring CO<sub>2</sub> and H<sub>2</sub>O to the surrounding air.

5 It diffuses in.

6 a With the air hole open the flame is hot, with a blue centre section of unburned gas and a purple outer section where combustion is taking place. With the hole closed, the flame is not as hot, and is mainly yellow. This flame produces soot (unburned carbon from the gas).

b With the hole open, oxygen is mixed with the fuel (gas) before it reaches the flame, so oxygen can get to most of the gas and allow it to burn. With the hole closed, the flame is more like a candle flame, with oxygen reaching the gas through diffusion and convection currents. Not as much oxygen reaches the gas, so it does not burn as well.

7 In space, oxygen only gets into the flame by diffusion. On Earth, oxygen would diffuse into the flame, but the rising hot gases would also set up a convection current, and this current would bring more oxygen into the flame. On Earth, more oxygen gets to the flame, so more wax vapour can burn in the same time and the flame is hotter or the extra oxygen allows more complete combustion, so the flame is hotter.

8 suggested answers include: naked flames could cause fires; burning uses up oxygen, which has to be supplied for the astronauts to breathe; burning produces carbon dioxide, which has to be removed from the air as too much of it would harm the astronauts; electric lights are easier to control

**8Kb-7 Kitchen questions 2**

1 a The energy from the flame makes the particles in the pan vibrate more, and these vibrations are passed through the pan and into the water – this is conduction.

b The particles in the heated water move faster so that part of the water becomes less dense and rises, setting up a convection current.

2 Cork is an insulating material, so it will stop energy being transferred from a hot pan to the table. Metals are conducting materials, so they would not provide any protection without feet made from an insulating material such as plastic.

- 3** Air is a poor conductor, so not much energy will be transferred by conduction. Convection will transfer the heat upwards, not sideways.
- 4** The air heated by the element will rise because it is less dense than the rest of the air in the oven.
- 5** The metal spoon conducts energy transferred from your hand, so the part of the spoon you are touching does not warm up much. The wooden spoon does not conduct the energy away, so the part you are touching warms up quickly.
- 6** The metal spike will conduct heat to the inside of the potato so it is heated from both the outside and the inside and should cook more quickly and evenly.
- 7** Air inside the freezer is cold, and so will be more dense than the air in the kitchen. When it comes out of the freezer it will sink.

### 8Kb-8 Wind chill

- 1 a** Sam, because there is a greater temperature difference between their skin and the surrounding air.
- b** It will warm up, because energy is being transferred to it.
- c** The rate will reduce, because as the air warms up the temperature difference becomes less.
- d** It would eventually become very close to their skin temperature, although convection currents would form to remove the warmed air even without a breeze.
- 2** If the warmed air is replaced by colder air, the temperature difference between the skin and the air remains large, so the rate of energy transfer remains large.
- 3** When water evaporates, some water vapour in the air condenses at the same time. If the rate of evaporation is greater than the rate of condensation then sweat on the skin will dry up and will cool the skin. The more water vapour there is in the air, the greater the rate of condensation, so the net rate evaporation becomes less as the sweat dries, and the cooling effect reduces. A breeze removes the air with water vapour in it, so sweat can continue to dry up/cool the skin at the original rate.
- 4** Wind chill only affects objects that are warmer than the air around them. The water in the puddles will be the same temperature as the air. The wind may affect the rate at which the puddles evaporate, but will not affect their temperature.
- 5** The paragraph should include some of the following points, expressed in clear English and a logical order:  
fleece is an insulating material because it contains trapped air

- warmth from your body warms up some of the trapped air
- when the air trapped in the fleece is the same temperature as your body, you don't lose any more heat/energy
- not all the air in a fleece fabric is immobilised
- on a windy day, the wind can move away some of the trapped and warmed air
- leaving cooler air near the skin again
- using a thicker fleece won't stop this effect
- but the windproof coating will stop this happening

### 8Kc Controlling transfers

#### Student Book

#### 1: 8Kc Controlling transfers

##### 1 a

Thermal conductors	Thermal insulators
aluminium foil	wool
copper	plastic
	wood
	paper
	feathers

##### b wool, feathers

- 2** *Students' own descriptions*, which should include a method (cover the containers with different materials, fill both containers with hot water and record the temperature at specified time intervals for a specified time), how to make the test fair (use same starting temperature, use same volume of hot water, use same thickness of each material) and an indication of how to judge the results (the best insulator is the one around the container with the highest water temperature at the end)
- 3** add insulation inside the walls, replace the windows with double-glazing/improve the insulation of the windows
- 4 a** the black one, because dark colours absorb infrared radiation better than light colours
- b** the black one, because dark colours are the best emitters of infrared radiation
- 5** If the water is cooler than their bodies, energy will be transferred to the water from their bodies. Some of the water will also evaporate, which will cool the remaining water and so help to cool the elephant.
- 6 a** It reduces evaporation from the hot drink and it stops convection currents removing air warmed by energy from the liquid.
- b** It reduces energy transfers between the contents of the mug and the outside. If there is a cold drink in it, it reduces the energy transferred in from the outside air. If there is a hot drink in it, it reduces the energy transferred from the drink to the surroundings.

## Energy transfers

**7** Some energy is transferred from the radiator by radiation, the foil will reflect energy radiated from the back of the radiator back into the house instead of it being absorbed by the wall.

**8 a** the silver coatings on the glass walls, because shiny/light surfaces are poor at absorbing and emitting radiation

**b** the glass walls and plastic stopper, as these materials are poor thermal conductors; the vacuum between the glass walls, as conduction only transfers energy through a medium

**c** the vacuum between the glass walls, as convection only transfers energy through a medium; the stopper, as it stops warmed air above the liquid rising

**d** the stopper, as not much liquid will be able to evaporate into the air space above the liquid

## 2: 8Kc Accuracy and precision

**1 a** The important difference is that the oven thermometer (photo A) has a scale marked in tens of degrees, the clinical thermometer (photo B) has scale intervals of 0.1 degree. The other relevant difference is the range (50–300 °C for the oven thermometer, only 35–42 °C degrees for the clinical thermometer).

**b** Ovens can be used at a wide range of temperatures, and the temperature only needs to be controlled to something like the nearest 10 degrees. Body temperature needs to be measured to the nearest 0.1 degree, but the overall range of temperature of (live) human bodies is only a few degrees.

**2 a** They are precise, as they are all within 0.2 minutes of each other.

**b** The true value is likely to be close to the mean obtained by the rest of the class, so this implies that the measurements in part a are not accurate.

**3 a** X = 63 °C and Y = 58 °C

**b** 63 °C

**c** Always look at an instrument from the same angle, preferably with a line of sight perpendicular to the scale.

**4 a** random errors

**b** systematic errors, e.g. holding the ruler with the zero in the wrong place

**5** Sally will need to use the most accurate measuring instrument, because the change in length of the brass rod will be very small. Ben does not need such an accurate instrument and the water will move much further up the tube than the brass will expand.

## Activity Pack

### 8Kc-1 Controlling energy transfers

Statements can be in any order:

The flask keeps hot drinks hot ... because it reduces the energy transferred ... from the drink to the surroundings.

The flask keeps cold drinks cold ... because it reduces the energy transferred ... from the surroundings to the drink.

The vacuum between the walls reduces ... energy being transferred by conduction and convection ... because there are no particles to move or pass on vibrations.

The silvered surfaces reduce ... energy being transferred by radiation ... because light shiny surfaces are poor emitters and absorbers of radiation.

The glass walls reduce ... the energy transferred by conduction ... because glass is a thermal insulator.

The plastic stopper reduces ... energy being transferred by evaporation and convection ... because it stops warmed air and evaporated liquid escaping.

The plastic stopper reduces ... energy being transferred by conduction ... because plastic is a thermal insulator.

### 8Kc-2 Radiation and colours

**6 a** The one painted black, because black absorbs more heat.

**b** The one painted white, as this absorbs less heat.

**c** The one painted black, because black absorbs more heat.

**7** If there are any errors with the measurements, you can spot them with a series of readings (or similar answer).

**8** Air is a poor conductor, and convection would tend to transfer the energy upwards (it will eventually circulate around the whole room, but the energy from a small bulb like this would not significantly raise the temperature of the air in the room).

An alternative answer is that energy transferred by conduction or convection would be likely to increase the temperature of both thermometers by the same amount.

### 8Kc-5 Traditional homes

**1** A and C – hot; B and D – cold

**2** A: white paint reflects infrared radiation from the Sun; narrow streets mean most of the walls of houses are in the shade; thick walls and tiled floors take a long time to warm up; louvred shutters allow breezes through without allowing sunlight in

B: thick walls with earth filling will reduce conduction; warmth from the animals will help to heat the house; lack of a chimney means convection is reduced (although smoke often escaped through the thatch)

C: stilts allow breezes beneath the house; the overhanging roof shades the walls; palm trees

shade the houses; lack of internal walls, slatted outer walls and slot in the roof allow breezes through the house

D: sleeping level is higher as warmer air will be near the top of the igloo; sunken entrance prevents convection letting warm air out (the air vent *will* let some warm air out, but occupants would suffocate without it!); packed snow contains trapped air and is a good insulator

**3** Double roofs and walls shade the inner wall of the house from solar radiation.

Underground – rock takes a long time to warm up/is a good insulator.

Covered verandas shade the walls and allow doors/windows to be left open without allowing solar radiation in.

Wet screens – evaporation of the water has a cooling effect.

Black chimneys – the black absorbs radiation and heats the chimney, which creates a convection current that draws air through the building.

Windcatchers are structures on the roofs of buildings in hot countries that act to draw air through the building. If the air is forced to flow over water, the cooling effect of the draught is increased.

Courtyards provide shaded outdoor areas, and fountains provide some cooling by evaporation.

### 8Kc-6 Keeping warm

**1** temperature differences are: 20, 11, 10, 9, 8 °C

**2** correctly drawn bar chart

**3** same volume of water in each beaker, same starting temperature

**4** The greater the number of layers of fleece, the better the insulation.

**5** It traps air, which is a poor conductor of heat.

**6** B: White reflects radiation/is not good at absorbing radiation so the water in that can will not heat up as much

### 8Kc-7 Accuracy and precision

**1 a** B: it can measure smaller quantities more accurately than the kitchen scales. C is more accurate, but this degree of accuracy is not needed in school experiments.

**b** A: you often need more than 200 g of an ingredient, and this is cheaper to buy and sufficiently accurate for baking.

**c** C: very small amounts of drugs are often needed, together with high accuracy.

**2 a** make a series of readings of the same object, and see how close the results are

**b** C is likely to be the most precise – the higher cost means it is probably better made/made to be more precise as well as accurate.

**3** Two people are needed to use a tape measure, but the laser instrument can be used by one person. It will also be easier to use this to measure the height of the walls. It doesn't cost much more than the tape.

**4 C:** scientists carrying out research on chemical reactions/pharmacists measuring out drugs, etc.

F: surveyors/mapmakers/other people needing to make detailed accurate plans.

These people need high levels of accuracy and precision, so they are prepared to pay the higher cost of the instruments.

### 8Kc-8 Wetsuits

**1** It has lots of tiny air pockets in it.

**2** It traps a layer of water between the suit and the skin. Body heat warms the water, which stays warmer because of the insulating material the suit is made from.

**3** so the water warmed by the body cannot escape (if it was too loose), and so it does not restrict circulation of blood in the body (if it was too tight)

**4 a** for suits intended to be used in very cold water

**b** Thicker material might make the suit too warm in some circumstances, and it would also be heavier and restrict movement more. It would also be more expensive.

**5** The trapped air in the neoprene makes it less dense than water, so the neoprene floats.

**6** Air is a better insulator than water, and energy from the body does not have to be used up heating the layer of water.

**7** The diver wears insulating clothing under the drysuit.

### 8Kc-9 Thermal mass

**1** The inside temperature fluctuates in a similar way to the outside temperature, but never gets as hot or as cold. Also the peaks and troughs inside are later than the ones outside.

**2** During the day the walls warm up as they absorb energy from the Sun and from the warm air inside the house. They must therefore be colder than the air inside the house at the start of the day. At night when the outside air is colder, the walls are warmer than the air inside the house. They emit energy into the house which helps to keep the air warm. The ventilation allows some of this warm air to escape, allowing the walls to cool further. The walls are then cool enough to start absorbing energy when the air warms up again during the day.

## Energy transfers

**3** The changes in the air temperature inside the house would be closer to the outside air temperatures, as there is not as much thermal mass to store energy.

**4 a** warmer during the day than at night

**b** The slab will warm up when the Sun shines on it during the day. At night the slab will be warmer than the air temperature inside the house, so it will emit energy and help to keep the air warm.

**c** Energy can escape through the window more easily than through the walls, so the small size of the window helps to reduce heat transfers. The Sun never shines on the north side of the house so it is no use for absorbing energy.

**5** The Sun is higher in the sky in summer, so the overhanging eaves will prevent the Sun shining into the house. The floor slab will remain cooler and so it will absorb energy from warm air and help to keep the house cool.

**8Kd Power and efficiency****Student Book****1: 8Kd Power and efficiency**

**1 a** any three heating appliances, e.g. kettle, cooker, oven, tumble dryer, hairdryer

**b** any three appliances whose primary purpose is not heating, e.g. TV, DVD player, radio, fridge, computer, electric drill, lawnmower

**2 a** 10 000 W                      **b** 10 kW

**3 a** 3 kJ or 3000 J

**b** It does not need to heat as much water as quickly.

**4 a** efficiency = useful energy ÷ total energy × 100% =  $9 \div 20 \times 100\% = 45\%$

**b** *Students' own Sankey diagrams* with 20 J on the left-hand side of the arrow, '9 J light' as an arrow approximately one-third the size of the main arrow on the right, '11 J transferred by heating' as an arrow approximately two-thirds the size of the main arrow on the right; arrows should be labelled

**5 a** 80% of 200 kJ = 160 kJ

**b** *Students' own Sankey diagrams* with 'useful energy' arrow approximately four times the width of 'wasted energy' arrow, both on the right; labelled with 'energy used by a kettle', 'useful energy stored in hot water' and 'wasted energy stored in kettle and surroundings'

**c** Kettles have lids/are enclosed so less energy is transferred from the water by evaporation and convection while the water is heating up.

**2: 8Kd Managing disasters (STEM)**

**1** Answers could include:

**a** Which parts of a country/which towns or villages have been damaged/flooded etc. Whether roads in the area are open or blocked.

**b** How many emergency and medical workers the country can provide. How much equipment for rescuing people and treating the injured they have. What extra help they need. The best way of getting more people and supplies to the disaster areas.

**c** Detailed reports (by mobile phone, Internet or radio) of damage in the area. Reports of people missing (who need to be found).

**2** Sleeping in tents will help to keep them warm at night. Without tents, many people would die from the cold.

**3 a** Answers could include: providing lighting or heating or cooling in hospital and other temporary buildings, operating other medical equipment, operating computers and communications equipment.

**b** A more efficient generator will need less fuel to produce a certain amount of electricity, meaning that less fuel has to be taken to the disaster area.

**4** The most likely two renewable resources are wind and solar power. She would need to find out how windy the place is, and how much sunshine it gets at that time of year.

**5 a** Adding insulation to the cool box reduces the rate at which the contents will warm up. This means that less energy will be needed to keep the inside cool, so the box is more efficient.

**b** The cool box would be useful if vaccines have to be taken to remote areas in a small vehicle or on foot. The solar panel is required to power the cool box or refrigerator as there is unlikely to be a reliable electricity supply in the disaster area.

**Activity**

**a** a Phi Phi is an island, so road transport is not an option. It is hot all year round (between approx. 22°C and 33°C all year round). There is some rainfall Dec-Mar, and heavy rainfall in the other months of the year.

**b** Lapu is in the Gorkha province of Nepal. Roads, where they exist, are stony tracks on steep mountainsides. Minimum temperatures vary from 8°C in December and January to 25°C in June-August. Maximum temperatures vary between 22°C and 35°C. Rainfall is low from October to April, and high in the remaining months.

**b** People could include: search and rescues teams; engineers to supervise digging people out of ruined buildings or to repair bridges and roads; doctors and nurses; search and rescue teams, people to make records of people saved and people still missing, to give out tents, food and water.

Equipment could include: search equipment such as infrared cameras; digging and engineering equipment such as bulldozers, diggers, shovels; shelters, such as tents or other temporary buildings; computers; medical equipment.

Supplies could include: blankets, food, water, bandages, medicines, materials to rebuild houses and other buildings. Phi Phi is warmer than Lapu, so blankets may not be needed.

c Phi Phi, Thailand: The tsunami damage shown is on an island, so people, equipment and supplies can be transported by boat. Urgent supplies may have to be transported by helicopter.

Lapu, Nepal: There are not many roads, and some of them may be damaged. People, equipment and supplies may have to be flown in by helicopter (for urgent supplies) or carried in by humans or animals such as yaks.

### Activity Pack

#### 8Kd-1 Power and efficiency

- a quantities in watts circled: 3000 watts, 1000 watts

b the fan heater

c It has a higher power rating of 3000 watts.
- electric shower – 10 000 J

efficient light bulb – 20 J

electric kettle – 3000 J
- a A                      b A                      c B
- a light                      b heating

#### 8Kd-2 Sankey diagrams and efficiency 1

- the percentage of the total energy that is transferred as useful energy
- a the number of joules of energy transferred each second

b 2 J

c  $2\text{ J}/16\text{ J} = 12.5\%$
- a light and sound

b TV 2. The wasted energy/heating arrow is narrower. OR It wastes less/a smaller proportion of the energy.
- a kettle and electric shower – high power

TV and radio – low power

b Heating appliances need more power.

#### 8Kd-3 Sankey diagrams and efficiency 2

- a 10 kJ

b efficiency =  $40\text{ kJ}/50\text{ kJ} \times 100\% = 80\%$
- a 48 J

b efficiency =  $12\text{ J}/60\text{ J} \times 100\% = 20\%$

c If left side of arrow is 3 cm, the light arrow should be 5 mm wide, the sound one 1 mm wide and the wasted energy arrow should be 24 mm wide.
- a 650 MJ

b  $350\text{ MJ}/1000\text{ MJ} \times 100\% = 35\%$

c Sankey diagram should have arrows in correct proportions. For instance, if the left side of arrow is 5 cm, the electricity arrow should be 1.75 cm wide and the heating arrow 3.25 cm.

#### 8Kd-4 Kettles and bulbs

1 a the number of joules of energy transferred each second

b electric shower, kettle, TV, radio

The shower and kettle both heat water, so they will need more power than the other two items. The shower needs to heat water faster than the kettle so will be more powerful. The TV needs to transfer energy by both light and sound, so will need more power than the radio.

2 a 80 kJ

b It is transferred to the kettle or the surroundings (as thermal energy).

3 a the top two arrows (thermal energy in kettle and surroundings and energy stored in the remaining hot water)

b 50%

c 50%

4 a 16 W

b 2 J

5 a efficiency can never be more than 100%, as you can never get out more energy than you put in.

b Efficiency =  $2\text{ J}/16\text{ J} \times 100\% = 12.5\%$

#### 8Kd-5 Power, energy and time

- 3 kW = 3000 W, 2 minutes = 120 seconds

energy =  $3000\text{ W} \times 120\text{ s} = 360\,000\text{ J}$
- $850\text{ W} \times 5 \times 60\text{ s} = 255\,000\text{ J}$
- a  $36\,000\text{ J}/20\text{ W} = 1800\text{ s}$

b  $1800\text{ s}/60 = 30\text{ minutes}$
- energy = 300 000 J, time =  $5 \times 60 = 300\text{ s}$

power =  $300\,000\text{ J}/300\text{ s} = 1000\text{ W}$  (or 1 kW)
- 40 minutes = 2400 s

power =  $7\,200\,000\text{ J}/2400\text{ s} = 3000\text{ W}$  (or 3 kW)
- $150\,000\text{ J}/850\text{ W} = 176\text{ s}$

#### 8Kd-6 Efficient heating

1 a (chemical) energy stored in gas or oil

b stored (as thermal energy) in the hot water flowing through the pipes

c stored (as thermal energy) in the hot gases that leave the boiler

2 Gas particles have more energy than particles in a liquid, even when they are at the same temperature. When a gas condenses to form a liquid this energy is released (as thermal energy).

3 The energy stored in the movement of the particles of water vapour would normally escape into the atmosphere, and so be wasted. In a condensing boiler some of this energy is instead used to heat the water going into the boiler.

4 a Efficiency is defined as the useful energy transferred as a percentage of the total energy supplied to a device or system. As energy cannot be created or destroyed, the energy transferred by a

## Energy transfers

machine can never be more than the energy supplied to it, so the efficiency can never be more than 100%.

**b** The useful energy produced by the ground source heating system comes partly from energy stored in the ground outside and partly from the electricity used to run the pump (and also from gas or electricity used to make washing water hotter). However only the electricity or gas has to be paid for, so if the useful stored energy in the hot water in the house is compared to the paid for energy transferred to the system, then the efficiency will come out as greater than 100% because some of the input energy has been ignored.

**c** A yes or no answer is acceptable if accompanied by a sensible explanation.

Yes – if someone is considering the cost of running a heating system, then the 300% ‘efficiency’ is a useful piece of information.

No – it is misleading as it is using the word ‘efficiency’ incorrectly.

**5** Some energy that was originally stored in the gas used by the power station is wasted at the power station. The amount wasted at the power station must be more than is wasted by a gas boiler, as the electric fire is less efficient overall than the boiler.

**6** Normally energy stored in warm air in the rooms of a house is counted as useful energy. However if only one room in the house is being used, then the warm air in the other rooms could be thought of as wasted energy.

### 8Ke Paying for energy

#### Student Book

##### 1: 8Ke Paying for energy

**1 a** 5 kWh

**b** The numbers they use are very big.

**2** A more efficient appliance uses less energy to transfer the same amount of useful energy.

**3** to see if the more efficient appliance will save you money overall

**4 a**  $\text{£}150 \div \text{£}150 \text{ per year} = 1 \text{ year}$

**b**  $\text{£}50 \div \text{£}15 \text{ per year} = 3.3 \text{ years}$

**5** At least two factors may affect energy use in a house, e.g. cost of energy, type of house, size of house, external temperature, internal temperature.

**6** difference in running costs is £5 per year, difference in price is £30

payback time for buying fridge B instead of fridge A is  $\text{£}30 \div \text{£}5 = 6 \text{ years}$

A fridge should last longer than 6 years, so it is worth Mrs Holman spending extra to buy fridge B.

##### 2: 8Ke Keeping warm

**1 a** Conduction transfers energy through solids, convection transfers it through fluids, evaporation cools liquids.

Radiation transfers energy through empty space and transparent materials.

**b** conduction – use insulating materials;  
convection – trap air (or other fluid) so it cannot move, such as by putting a lid on a container  
radiation – use silvered surfaces

evaporation – put a lid on/cover the liquid

**2 a** Energy refers to the energy stored in something and cannot be measured directly. Temperature is how hot or cold something is and can be measured with a thermometer.

**b** Power is the energy transferred in a certain time. Energy can be stored or transferred, it does not depend on time.

**3 a** it is cheaper, it contributes less to climate change/global warming

**b** divide the useful energy transferred by the total energy supplied ( $\times 100\%$ )

### Activity Pack

#### 8Ke-1 Paying for energy

**1** joules – energy; watts – power; kilojoules – energy; kilowatt-hours – energy; kilowatts – power

**2** kilowatt-hour, electricity

one hour, one kilowatt

unit

joules, big

less, gas, more

**3 a** top label – more efficient; bottom label – less efficient

**b** to save money on running costs

**c** It might cost more than they would save in running costs.

#### 8Ke-3 Warmer homes

**1 a** with carpet and loft insulation the total percentages come to  $(30 + 15 + 10 + 15 + 12) = 82\%$

**b** with carpet, loft insulation, double glazing and draught excluder, the total is  $(30 + 8 + 10 + 8 + 12) = 68\%$

**c** with cavity wall insulation, loft insulation and draught excluder, the total is  $(15 + 15 + 15 + 8 + 12) = 65\%$

**2**

Insulation	Saving
cavity wall filling	15%
double glazing	7%
carpet	5%
draught excluder	7%
loft insulation	13%



- 3 cavity wall filling
- 4 Suitable diagram. Energy loss is 53% of that lost by the uninsulated house.
- 5 Leaflets should summarise the different insulation methods. Bar charts can be drawn using the information supplied on the worksheet and should have a title.

#### 8Ke-4 Energy true or false

- 1 False – Temperature is measured using a thermometer.
- 2 True
- 3 False – Radiation can transfer energy through transparent materials and empty space.
- 4 True
- 5 True
- 6 False – Some insulating materials contain trapped air.
- 7 False – Dark, dull materials are good at absorbing radiation. OR Light shiny materials are poor at absorbing radiation.
- 8 True
- 9 False – When part of a liquid evaporates, what is left is cooler than before.
- 10 True
- 11 True
- 12 False – An efficient machine does not waste a lot of energy.

#### 8Ke-5 Saving in the kitchen

- 1 a  $750 \times 2 \times 60 = 90\,000\text{ J}$  (or 90 kJ)  
b  $750 \times 2.5 \times 60 = 112\,500\text{ J}$  (or 112.5 kJ)
- 2  $3000 \times 10 \times 60 = 1\,800\,000\text{ J}$  or 1800 kJ
- 3 This answer assumes the oven is actually using power for about half the time it is switched on. Refer to students' assumptions in their answer to question 5 to check their calculations.  
a  $3000 \times 15 \times 0.5 \times 60 = 1\,350\,000\text{ J}$  (or 1350 kJ)  
b  $3000 \times 20 \times 0.5 \times 60 = 1\,800\,000\text{ J}$  (or 1800 kJ)
- 4 a 3 150 000 J (or 3150 kJ)  
b 3 600 000 J (or 3600 kJ)
- 5 that the oven is only using power for half the time once it has reached its desired temperature (accept any other reasonable assumptions)
- 6 3060 kJ
- 7 payback time = cost/savings per week =  $\pounds 45/\pounds 0.75 = 60$  weeks

#### 8Ke-6 Carbon capture and storage

- 1 It traps the carbon dioxide emitted by power stations or other large industrial plants and stores it so that it cannot enter the atmosphere.
- 2 It would reduce it. As energy is needed to capture and compress the carbon dioxide, less of

the energy originally stored in the fossil fuels would be usefully transferred by electricity.

3 one from: pipelines would need to be built to take the gas to the places where it was to be stored; storage containers at ports for the gas that is to be taken to oil fields by ships; suitable oil fields, coal seams or aquifers would need to be identified; possibly more research done into the effects of injecting carbon dioxide into saline aquifers

4 a Gas, as only a small percentage of thermal energy is lost through the flue. Electric fires are more efficient in themselves, but not when the much lower efficiency of the power station is taken into account.

b Gas – the addition of CCS at the power station would reduce the overall efficiency of using electricity for heating even more.

c Electricity – in spite of the overall lower efficiency, only a very small proportion of the carbon dioxide produced will enter the atmosphere. It is not practical to capture the carbon dioxide produced by a domestic gas boiler, so all of this would enter the atmosphere.

5 a Less carbon dioxide will be put into the atmosphere.

b They will be able to get more oil and/or natural gas from their oil field, and so would probably make money overall.

c Although most of the carbon dioxide is being stored, it is also helping the oil company to produce even more fossil fuels, which will produce carbon dioxide when they are burnt.

6 Oil field advantages: geology is known; possibly more likely to happen as oil companies can get a return on money used to store the carbon dioxide. Disadvantages: often results in more fossil fuels being produced; not many suitable locations, so gas might have to be transported long distances which would cost more.

Saline aquifer advantages: plenty of suitable places, so gas would not have to be transported long distances. Disadvantages: more research needed on long-term effects.

## 8L Earth and space

### 8La Gathering the evidence

#### Student Book

#### 1: 8La Changing ideas

- 1 spherical
- 2 a any three from: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune  
b a planet orbits the Sun, a moon orbits a planet
- 3 a The Earth spins once every 24 hours, and this is what gives us night and day.

**b** The Sun can only shine on half of the Earth at any one time. As Ecuador is on the opposite side to the Malaysia, it is dark in the Malaysia when the Sun is shining on Ecuador.

**4** The shadow of the edge of the staircase moves across the curved scale as the Sun appears to move across the sky.

### 2: 8La Gathering the evidence

**1** They were the only ones that could be seen with the naked eye/without telescopes.

**2** The Sun moved around the Earth, so it was day when the Sun was above a particular part of the Earth and night when the Sun had moved around the other side of the Earth.

**3 a** half of it

**b** The lit-up half is always facing the Sun, so we see different parts of the lit up half as the Moon moves around the Earth.

**4** He had information observed using telescopes/better instruments.

**5 a** In Copernicus' model the orbits of the planets were circles. In Kepler's model they are elliptical.

**b** Ptolemy's model had the Earth at the centre, the modern model has the Sun at the centre. Ptolemy's model had circular orbits, the modern one has elliptical orbits. Ptolemy's model only had six planets (including the Earth), the modern one has eight.

**c** it fits observations/can explain observations

**6** any three suitable answers, e.g. telescopes in space; space probes landing on planets/moons; space probes flying past planets/moons; bringing back Moon rocks to study; astronauts visiting the Moon

### 3: 8La Working in space (STEM)

**1 a** If someone has an accident or becomes ill in space, they cannot be taken to a hospital.

**b** If something goes wrong and they land in the wrong place, they have to survive until someone finds them.

**2** Astronauts from many different nations have visited the space station, and to make sure everyone could understand each other, it was agreed that the common language would be English. All astronauts are transported to the space station by Russian Soyuz spacecraft, and train for the flight in Russia, so they need to speak Russian as well.

**3** Astronauts are weightless in space, and they feel as if they are floating. Training under water helps them to get used to this feeling. It also helps them to get used to a situation where they must wear their space suits to allow them to breathe.

**4 a** Any two from: urine, sweat, moisture in exhaled air.

**b** If it wasn't recycled, water would have to be sent up to the space station. This would be very expensive and involve a lot of rocket flights.

**5** Students may suggest drinking through straws from cups with lids, squeezing food from plastic pouches, or having meals using a thick sauce that binds everything together. Accept any other sensible suggestions.

### Activity Pack

#### 8La-1 Gathering the evidence

Ptolemy's model: B, C, F, G, H or J, K, O

modern model: A, D, E, H or J, I, L, M, N

#### 8La-2 Astronauts or probes?

**1 & 2** [Key point] G Other planets can be explored by sending humans or space probes.

[Evidence for key point] E Astronauts visiting the Moon made many scientific observations and brought back rock samples.

[Objection] A Many people say it will be too expensive to send astronauts.

[Reason for objection] D It does cost much more to send people than to send space probes.

[Counter argument] B However, the public are more interested in human stories.

[Explanation for counter argument] C They will be more willing to allow tax money to be spent on sending astronauts than on sending space probes.

[Conclusion] F So sending astronauts would be best.

**3** Possible answers:

*In favour of sending humans*

[Key point and evidence] (Likely to be similar to that above.)

[Objection] Space travel is dangerous and astronauts will have to be protected against radiation and the effects of weightlessness.

[Counter argument] However there are plenty of volunteers willing to accept a risky journey if it means they can visit Mars.

[Conclusion] Therefore sending astronauts is best/acceptable.

*In favour of sending space probes*

[Key point] Other planets can be explored by sending humans or space probes.

[Evidence] Space probes have been sent to many other planets and have returned information.

[Objection] Astronauts can make decisions on the spot if anything goes wrong.

[Counter argument] Although we can afford to send many space probes to different parts of Mars for the same cost as sending one team of astronauts.

[Conclusion] So we can find out much more about Mars by using space probes.

#### 8La-3 Solar System questions

**1 a** Ptolemy's

**b** Kepler's/modern

- c both
- d Ptolemy's
- e Kepler's/modern
- f Ptolemy's
- g Kepler's/modern
- h Kepler's/modern
- i Kepler's/modern

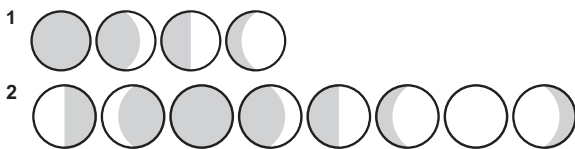
2 Ptolemy's model: E in centre, then M then S top right

Kepler's/modern model: S in centre, then E and then M top right

3 a The Earth spins on its axis, so we have day when our part is facing the Sun and night when it is facing away.

b The Sun goes around the Earth, so we have day when the Sun is above our part of the Earth.

**8La-4 Phases of the Moon**



**8La-5 Measuring the Earth**

- 1 about 2200 years ago, or 200 BCE
- 2 shadows had different lengths at different places
- 3 a midsummer's day  
b because the Sun was overhead at Syene.
- 4 the angle of the shadow (Sun) at Alexandria, and the distance between Alexandria and Syene
- 5 a Suggestions could include more accurate instruments, making measurements from satellites, using lasers for distance measurement, etc.  
b Suggestions could include measuring the angle a planet makes in a telescope and working out the diameter from the magnification, or using information from space probes.

**8La-6 Cassini and Huygens**

1 radio dish – to send information back to Earth; computer – to control the probe and its instruments; Huygens probe (strictly speaking, Cassini did not need this, Cassini was the means of transporting Huygens); thrusters – to make it point in the correct direction for sending information to Earth or for taking images or scientific readings; spare engine – in case the main engine failed; main engine – to put

it into orbit around Saturn or one of its moons, or to change its orbit; nuclear power supply – to provide electricity to work the computer/instruments/camera/radio; cameras – to take pictures of Saturn or its moons; scientific instruments – to make other scientific measurements.

2 radio transmitter – to send information back to the Earth; scientific instruments – to take measurements; battery – to provide electricity for the instruments and radio; parachute – to slow it down so it does not break when it lands; heat shield – to protect it when it goes through the atmosphere.

3 Huygens only had to operate for a few days, so a battery would provide enough electrical power for this. Cassini had to operate while in transit to Saturn, and was intended to send back data for a long time, so a nuclear generator was needed to provide power for this length of time.

4 a Huygens only needed to transmit data as far as Cassini, in orbit around Titan. Cassini had to transmit data to Earth – a much greater distance.

b So the radio waves could be focused towards Earth, which would give a stronger signal.

5 Advantages: makes long space voyages possible; cheaper than a crewed mission; obtains more detailed information than telescopes on Earth or orbiting Earth; including being able to measure atmospheric conditions on Titan directly (in the case of Huygens).

Disadvantages: can only examine one planet closely; difficult to fix faults with no people there; Huygens probe can only be used once. There may be other sensible answers.

**8La-7 Moon origins**

- 1 samples of moon rocks, and information from moonquakes about the internal structure of the Moon
- 2 a diameter of Moon should be approx. one-quarter the diameter of Earth.  
b Earth's core approx. half of radius  
c about half the radius of the Moon, if they assumed it would have similar proportions to the Earth and its core  
d Moon's core much smaller than half its radius
- 3

Theory	Evidence for:	Evidence against:
The Moon was a passing asteroid that was captured by the Earth's gravity.		If this was the case, the composition of the rocks on the Earth and Moon would probably be different, but in fact they are very similar.

The Earth and Moon formed from the same cloud of dust and gas.	The Earth and Moon have very similar rocks.	You would also expect the cores to be similar sizes, but they are not.
The Moon formed from material flung up from the Earth by a collision.	The Moon would consist of similar materials to the Earth, and it does. The Moon's small core could be explained if mainly rocks from the surface of the Earth had been flung into space.	

4 *Students' own answers.*

## 8Lb Seasons

### Student Book

#### 1: 8Lb Seasons

1 any two sensible suggestions, e.g. no snow in summer no leaves on the trees in winter, no flowers in the field in winter

2 **a** Daylight lasts longer in the summer than in the winter.

**b** It is warmer in the summer than in the winter.

3 half of a sphere

4 **a** spring

**b** autumn

**c** They are the seasons between summer and winter.

5 We spend more time in the zone lit by the Sun in the summer.

6 as in figure D but the lit-up section with the UK is smaller and the dark zone (night time) is larger – the North Pole should be in the dark area

7 winter

8 **a** 24 hours

**b** showing 24 hours of darkness occurs at the North Pole in winter

9 similar to figure E showing that the heat from the Sun is more concentrated at the Equator than in the UK

### Activity Pack

#### 8Lb-1 Seasons

1 from left to right: winter, Sun, summer

2 tilted

3 northern hemisphere at the top, southern hemisphere at the bottom

4 northern, northern

higher, more

more

#### 8Lb-2 Hours of daylight 1

1 in order: 16, 14, 13, 11, 9, 8, 8, 10, 12, 14, 16, 17

2 bar chart correctly drawn with labelled axes

3 **a** December

**b** June/July

**c** November to January, the Sun is shining for longer.

This is summer, so the Sun will also be higher in the sky and so its rays will be more concentrated.

**d** southern hemisphere – it is hot when it is winter in Britain (the values are adapted from those for Stanley in the Falkland Islands)

#### 8Lb-4 Explaining the seasons

##### Summer:

sunrise time: 03:44

sunset time: 20:34

angle of Sun above horizon at midday: 61°

energy from Sun: 195 J each second on 1 m<sup>2</sup>

The northern hemisphere is tilted towards the Sun.

##### Winter:

sunrise time: 08:16

sunset time: 15:55

angle of Sun above horizon at midday: 14.1°

energy from Sun: 24 J each second on 1 m<sup>2</sup>

The northern hemisphere is tilted away from the Sun.

##### Spring and autumn:

sunrise time: 06:08

sunset time: 18:22

angle of Sun above horizon at midday: 38°

energy from Sun: 95 J each second on 1 m<sup>2</sup>

The northern hemisphere is not tilted towards or away from the Sun.

#### 8Lb-5 Different seasons 1

1 **a** summer

**b** winter

**c** summer

**d** summer

2 Ray of light from the Sun at a steeper angle, and shorter shadow drawn.

**3 a** It was still dark when Sal had to get up for school. She put on a t-shirt under her school blouse to make sure she stayed warm during the day. After breakfast she pulled on her thick coat and woolly hat and gloves before leaving the house. The path outside was slippery with frost.

Sal walked around the playground at lunchtime. The Sun was low in the sky and didn't feel very warm, so she didn't stay out long. The Sun was just setting when she waited for the bus to go home after school.

**b** Possible answer: It was light and sunny when Sal had to get up for school. After breakfast she picked up her school jumper in case she needed it, but the weather was warm.

Sal walked around the playground at lunchtime. The Sun was high in the sky and felt very hot, so she enjoyed being outside. The Sun was still quite high in the sky when she waited for the bus to go home after school.

### 8Lb-6 Lines of latitude

**1** In some parts of Norway the Sun can shine at midnight in the summer.

**2** June

**3** It would be completely dark for one day in June, and the Sun would not set on one day in December.

**4** September to March, because it is summer it is lighter for longer.

**5** *Student's letters* could describe what it feels like to go to bed when it is light all night in the summer, or extra activities they might enjoy in the extra daylight. In the winter, they might describe what it feels like on the days when it never gets light, or how strange it is to see the Sun very near the horizon in the middle of the day.

**6** The Sun is directly overhead on the June solstice/midsummer's day/21 June on the Tropic of Cancer and directly overhead on the December solstice/midwinter's day/21 December on the Tropic of Capricorn.

### 8Lb-7 Different seasons 2

**1** East–west. If it ran north–south, then the town would always get some sunshine in the middle of the day when the Sun is to the south shining up the valley.

**2** The Sun is higher in the sky in the summer, so will be high enough to shine over the mountains on the south side of the valley.

**3 a** Mirrors drawn near the top of whichever side of the valley has been marked as the northern side.

**b** The Sun is in the south, so the mirrors need to be on the northern side to reflect sunlight back down into the valley (or similar explanation).

**4 a** The Sun moves across the sky from east to west each day, so the angle of the mirrors needs

to be adjusted so the reflection still hits the town square (or similar explanation).

**b** The height of the Sun changes as it moves across the sky, and also the height of the Sun changes from day to day, being higher in the sky in spring and autumn than it is in winter.

**5** The Sun is highest in the sky in June, which is the middle of summer for the northern hemisphere.

**6 a** The Sun will be higher in the sky at all times.

**b** There won't be very much difference between the maximum height of the Sun throughout the year.

**c** The graph will have the highest altitude in December and the lowest in June (or similar description).

### 8Lb-8 Milankovitch cycles

**1** The tilt of the axis. The Earth is closer to the Sun when it is winter in the UK, and it is colder in the winter when the North Pole is tilted away from the Sun. If the change in the distance to the Sun had more effect, it would be warmer in winter than in summer.

**2** In summer the days are longer, the Sun is higher in the sky, and so the Sun's rays are more concentrated.

**3 a** If the Earth's orbit becomes more elliptical, the Earth could be even closer to the Sun when it is winter in the UK, so winters may become milder/warmer as the Earth will get more energy from the Sun. The Earth will be further away when it is summer in the UK, so summers could become cooler.

**b** If the tilt increases the days will be even longer in summer and shorter in winter, the Sun will be even higher in the sky in summer and lower in winter, and the Sun's rays will be even more concentrated in summer and less concentrated in winter. All these will make summers hotter and winters colder.

**4** The greater the tilt, the larger the area near the poles where there will be midnight Sun. If the Arctic Circle is moving north, the area is getting smaller so the tilt must be decreasing at the moment.

**5** Almost half of the Earth would have continual daylight in summer and continual darkness in winter. This would make the summers very much hotter and the winters colder, especially at the poles.

**6** Uranus is much further from the Sun than the Earth, and so gets much less energy from the Sun. So both summers and winters will be very much colder.

### 8Lc Magnetic Earth

#### Student Book

#### 1: 8Lc Magnetic Earth

**1** a magnet that can swing to point north

**2** because that is the end that will point towards the north

- 3 use iron filings or a plotting compass
- 4 the drawing should look similar to figure C ( for the basic shape of the field, with arrows showing the direction)
- 5 Place the magnets close to each other and then use iron filings or a plotting compass.
- 6 The north-seeking pole of a magnet will point towards the Earth's North Pole. As opposite poles attract each other, the North Pole must have the equivalent of a south-seeking pole there.
- 7 **a** We know the shape of the magnetic field of a bar magnet, and the Earth's magnetic field is similar. It helps us to understand how compasses work.
- b** The magnetic field is not formed in the same way as in a bar magnet, so the model might lead people to misunderstand this.

### Activity Pack

#### 8Lc-1 Magnetic Earth

- 1 **a** compass  
**b** north-seeking pole  
**c** magnetic field  
**d** north magnetic pole
- 2 **a** field lines completed correctly  
**b** arrows from north to south
- 3 **a** drawing correctly labelled, clockwise from top left: magnetic north pole, North Pole, magnetic south pole, South Pole
- b** Arrows in compasses drawn to point along field lines away from the Earth's South Pole towards its North Pole.

#### 8Lc-4 Magnetic questions

- 1 **a** attract  
**b** repel  
**c** repel  
**d** attract
- 2 If the magnet is free to swing it will point north.
- 3 magnetic field
- 4 compasses all pointing along field lines from N to S (as figure C in the Student Book)
- 5 The Earth has a magnetic field/the Earth acts like a magnet. Accept similar answers, but not 'the Earth has a bar magnet inside it'.

#### 8Lc-5 True north and magnetic north

- 1 True north is the direction that points to the North Pole; magnetic north is the direction that points to the north magnetic pole
- 2 because the north magnetic pole is not in the same place as the North Pole.
- 3 the angle between true north and magnetic north

- 4 **a** They can work out which direction they want to go from the map, and the compass helps to make sure they go in the correct direction.

**b** They would not be walking exactly in the correct direction, and might get lost.

- 5 **a** They are printed with magnetic north at the top (they also use different symbols and often a larger scale).

**b** So the runners do not have to waste time adjusting their compasses.

#### 8Lc-6 Animal navigation

- 1 sketch of field lines from pole to pole (similar to figure E in the Student Book)

Arrows on field lines pointing away from North Pole, or bar magnet drawn inside the Earth with the S pole of the magnet near the Earth's North Pole.

- 2 The Sun, or the Earth's magnetic field.
- 3 **a** Pigeons from group B had never seen the direction of the Sun in the morning but they still managed to find their way home.
- b** As a control to make sure it was possible for pigeons to find their way home from the place they were released.
- 4 The magnets on their backs prevented them using the Earth's magnetic field, and they got lost.
- 5 The position of the Sun in the sky changes during the day.
- 6 Some clues may not always be available; for example, the Sun cannot be used at night.
- 7 *Students' own answers.*

#### 8Lc-7 More about compasses

- 1 It is the angle between the horizontal and the direction of the magnetic field.
- 2 No, the magnetic field slopes at different angles in different parts of the world.
- 3 The south end. The dip is down towards the north in the northern hemisphere, so the opposite end of the needle needs to be weighted to keep it level.
- 4 It will be weighted at the opposite end, the north end. A suitable diagram may reproduce the top figure on the worksheet, pointing out the dip in the northern and southern hemispheres.
- 5 The difference between magnetic north and the direction the compass is pointing.
- 6 **a** They do not normally have significant amounts of iron or steel/magnetic materials with them.
- b** If they are standing next to an iron gate or other large objects made of iron or steel.
- 7 Ships are often made from steel.
- 8 By placing magnets around the compass to cancel out the effects of the ship, or using a table of corrections.

**8Ld Gravity in space****Student Book****1: 8Ld Gravity in space**

- 1 It has a larger mass.
- 2 **a**  $\text{weight} = 2 \text{ kg} \times 10 \text{ N/kg} = 20 \text{ N}$   
**b**  $\text{weight} = 2 \text{ kg} \times 1.6 \text{ N/kg} = 3.2 \text{ N}$
- 3 The force of gravity on Callisto will be less than on Mercury because its mass is less (and it has the same diameter).
- 4 **a** the force of gravity between the Sun and the Earth  
**b** the force of gravity between the Earth and the Moon
- 5 If there was no gravity, the ISS would not stay in orbit around the Earth/would fly off into space.
- 6 If the Sun's gravitational field did not extend that far, Neptune would fly off into space instead of staying in orbit around the Sun.

**2: 8Ld Making comparisons**

- 1 Either answer is acceptable, as long as it is accompanied by a sensible reason, e.g. the models in the photograph are a better comparison because you can see the relative sizes; the ratio calculation is a better comparison because it gives you a number to compare the two sizes.
- 2  $g$  for Mars  $\div$   $g$  for Earth =  $3.7 \div 9.8 = 0.377$
- 3  $0.377 \times 100 = 37.7\%$
- 4 **a** diameter of Mercury  $\div$  diameter of Jupiter =  $4880 \text{ km} \div 142838 \text{ km} = 0.034$   
**b**  $0.034 \times 100 = 3.4\%$
- 5 **a**  $g$  for Mercury  $\div$   $g$  for Jupiter =  $3.7 \div 23.2 = 0.159$   
**b**  $0.159 \times 100 = 15.9\%$
- 6  $35 \div 100 = 0.35$
- 7 1:290 000 000 (make sure you use the same units, 1 km = 100 000 cm)

**Activity Pack****8Ld-1 Gravity and the solar system**

The Moon is kept in its orbit ... by gravity.

The force of gravity between two objects ... is bigger if the objects have more mass.

If two objects are moved apart ... the force of gravity between them gets weaker.

The gravitational field of the Earth ... is the space around it where its gravity affects other things.

The gravitational field strength of Earth ... is 10 N/kg.

The gravitational field strength is ... the force of gravity on every kilogram of mass.

Gravitational field strength describes ... the force of gravity on every kilogram of mass.

If you take an object to the Moon ... its weight changes but not its mass.

Gravity on Earth pulls things ... towards the centre of the Earth.

**8Ld-4 Ratios and percentages**

- 1 **a** 1:1.5 (to 1 d.p)  
**b** 1:3.4 (to 1 d.p)
- 2 **a** Mars is 1.5 times further from the Sun than the Earth.  
**b** Jupiter is 3.4 times further from the Sun than Mars.
- 3 **a** 1:1.9  
**b** 1:6.2
- 4 A year on Mars is nearly twice as long as a year on Earth.  
A year on Jupiter is more than six times longer than a year on Mars.
- 5 **1 a** 0.65; **1 b** 0.29; **3 a** 0.53; **3 b** 0.16
- 6 **1 a** 65%; **1 b** 29%; **3 a** 53%; **3 b** 16%
- 7 Answers depend on planets chosen.

**8Ld-5 Solar System questions 1**

- 1 An arrow with each figure, pointing towards centre of Earth.
- 2 **a** W, they are closer together  
**b** Z, their masses are greater
- 3 **a** newtons (N)  
**b** kilograms (kg)
- 4 **a** Yes, because mass does not depend on gravity/measures the amount of substance in something.  
**b** No, weight depends on gravity, and gravity is different/less on the Moon.
- 5 the force of gravity on a kilogram of mass

**8Ld-6 The Vomit Comet**

- 1 **a** towards the centre of the Earth (accept 'down' for part **a** but not for parts **b** and **c**)  
**b** towards the centre of the Moon  
**c** towards (the centre of) the Earth
- 2 By flying in aircraft that can produce a feeling of weightlessness. (They also train in large tanks of water, but this does not produce the same feeling of weightlessness.)
- 3 Because most people feel sick when they ride in it!
- 4 **a**  $32800 \text{ ft} - 24000 \text{ ft} = 8800 \text{ ft}$   
**b**  $52 \text{ s} - 26 \text{ s} = 26 \text{ s} \times 10 = 260 \text{ s}$
- 5 **a** The Moon has a force of gravity/they are not in orbit around the Moon but on it.  
**b** The Moon's gravitational field is not as strong as the Earth's.

## Earth and space

6 a  $70 \text{ kg} \times 10 \text{ N/kg} = 700 \text{ N}$

b  $70 \text{ kg} \times 9 \text{ N/kg} = 630 \text{ N}$

7 a Because it looks (and feels) as though the astronauts have no weight.

b Weight is the force of gravity on something, and there is still a force of gravity between the astronauts and the Earth.

8 Because they are falling at the same speed as their spacecraft, so the floor does not push up on them.

9 Yes, because the Moon itself is kept in orbit around the Earth by the Earth's gravity (more correctly, by the gravitational force between the Earth and the Moon).

**8Ld-7 Solar System questions 2**

1 a Sun

b Earth

c the force of gravity between the Sun and the Earth

2 The string would need to be shorter, as Mercury is closer to the Sun than the Earth. Some students may also add that the wooden block should be smaller, as Mercury is smaller than the Earth.

3 a  $0.5 \text{ kg} \times 10 \text{ N/kg} = 5 \text{ N}$

b  $0.5 \text{ kg} \times 4 \text{ N/kg} = 2 \text{ N}$

4 a The Earth would have to be closer to the Sun (halving the distance would not halve the length of year, but accept answers that say the Earth should be half the distance to the Sun as students are not expected to know how distance and orbital period are related other than 'further out → longer year').

b The Earth's axis would not be tilted at all. A very good answer will also state that the Earth's orbit should be circular.

c The Moon would have to be closer to the Earth.

5 a No effect – the length of a day depends on how fast the Earth spins.

b A year would be longer (approximately twice as long) as it would take longer for the Earth to go around the Sun.

c There would be more days in a year, as day length does not change but the year is longer.

d It would be less, as the two bodies are further apart.

e It would be colder, as the Earth would get less energy from the Sun.

**8Ld-8 Kepler's model**

1 a They were circular.

b Each planet has a constant speed in its orbit.

2 a The speed of Mars at different places in its orbit.

b He did not assume a constant speed or a circular shape.

3 a Diagram with arrow pointing directly towards the Sun.

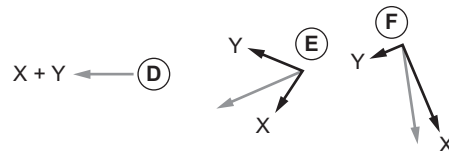
b Its orbit keeps it moving around the Sun.

c It changes the direction of its movement. (At A it only changes the direction, because at A the planet is actually moving at right angles to the direction of the Sun's pull, so the Sun's gravity cannot change its speed.)

4 It is further away from the Sun.

5 a It will tend to slow it down.

b



c The component of the Sun's gravity along the direction of the orbit is against the direction of motion, so the planet will slow down.

d The component of the Sun's gravity along the direction of the orbit is in the same direction as the planet's motion, so the planet will speed up.

**8Le Beyond the Solar System****Student Book****1: 8Le Beyond the Solar System**

1 a huge ball of gas that gives off large amounts of energy

2 It is much closer.

3 They are not bright enough compared with the Sun.

4 The Earth is spinning on its axis.

5 distance

6 a He could only see 100 objects with the telescopes/instruments available at the time.

b Astronomers today have much more powerful telescopes than Messier had, so they can see many more galaxies.

7 It is our galaxy – a collection of millions of stars. We cannot see its shape directly because we are inside it.

**2: 8Le Studying space**

1 a a star gives out a lot of energy/shines, a planet does not; a planet orbits around a star

b a planet orbits around a star, a moon orbits around a planet

2 only the Moon (and Earth!)

3 a their position in the sky, the appearance of their surface, whether or not they have moons

b any two sensible suggestions, e.g. better telescopes to make more detailed observations;



sending space probes to other planets to get more detailed images/make other measurements; returning rock samples from the Moon

**4 a** the masses of the objects and the distance between them

**b** It keeps them orbiting around the Sun instead of them flying off into space.

### Activity Pack

#### 8Le-1 Beyond the Solar System

- 1 a star, a huge ball of gas that gives out energy
- 2 a pattern of stars in the sky
- 3 millions of stars together
- 4 the name of our galaxy, the name for a bright band of stars in the sky
- 5 distance
- 6 it is much closer
- 7 the Sun appears much brighter than the other stars.
- 8 we are inside it

#### 8Le-2 Sizes in space

F, C, B, A, D, H, E, G, I

#### 8Le-3 What can we find out?

Non-scientific questions: E (although science can inform the discussion), H, M, R

Scientific questions:

Can be answered now: A, B, C (although a suitable probe would have to be built and sent), D, F (for the larger ones), G (for large planets), K, O (if they would put the money in to sending a probe).

Can be answered in the future: F (for smaller ones), G (for smaller ones that are harder to detect), L, N.

Will never be answered completely: I, J, Q, P, S, T (although scientists do have a pretty good idea how many of them formed, by analogy with similar features on the Earth).

#### 8Le-4 Spending – for or against?

1

**For:** A, B, E, F, G, J

**Against:** C, D, H, I

**2 & 3** *Students' own answers.*

#### 8Le-5 Starry questions

1 **a** a pattern of stars in the sky

**b** millions of stars grouped together

**c** all the galaxies

2 third box ticked

3 Milky Way

4 The Earth spins on its axis, so the stars appear to move around the sky.

5 planet, star, galaxy, Universe

6 Two from: stars are bigger than planets, stars make their own light/give off energy, planets orbit around stars.

7 10 million million km

#### 8Le-6 Constellations and star names

1 **a** To help them find a particular star they needed for navigation.

**b** To divide up the sky into different areas.

2 Betelgeuse, Rigel, Bellatrix, Mintaka

3 **a** Aldebaran, Elnath, Ambrosia

**b** Castor, Pollux, Alhena

4 C – the Greek letters only tell you about the brightness of the stars in that constellation. They don't tell you how bright the stars in one constellation are compared to another.

#### 8Le-7 The Milky Way

1 The ancient Greeks had a story that it was milk from a goddess.

2 No one has travelled outside the Milky Way to take a photo.

3 **a** 4

**b** Sketches of two different galaxy shapes (spiral – similar to drawing on worksheet, or without the central bar; elliptical – ellipse shaped; lenticular – like a convex lens; irregular – any irregular shape)

4 No, some will be hidden behind nearer stars. (There is also a lot of dust which can block the view, but students are not expected to know this.)

5 *Students' own diagrams*, showing that if you look in the direction of the spiral arm you see lots of stars. But, if you look in other directions away from the spiral arm then you only see the stars between you and the edge of the arm.

6 Stars would be more evenly spread across the whole sky.