1 Cell biology

Test yourself on prior knowledge

1 They provide structure for the plant.

2 Plant cells contain chloroplasts, vacuoles and a cell wall, whereas animal cells do not.

3 Leaves contain chloroplasts, which are green and are where photosynthesis occurs.

Test yourself

1 As a single (main) loop and one or more plasmids.

2 They are the site of protein synthesis.

3 Any two from: chloroplast, cell wall or vacuole

4 Eukaryotic plant and animal cells

5 It supports the nucleus and other cell organelles in the cell and is the site of many chemical reactions.

6 They transmit electrical impulses.

7 They are biconcave in shape to maximise their surface area to absorb more oxygen.

8 The root hairs increase the surface area in contact with the soil to absorb more water.

9 Electron microscopes have a much higher resolution.

Show you can

Page 8

1 Mitochondria are the site of the cell's respiration.

Page 11

2 Specialised cells allow organisms to develop tissues and organs. This means they can become more complex.

Required practical 1

Pages 7–8

1 Answers are based on the student's own work.

2 Answers are based on the student's own work.

3 Answers are based on the student's own work.

Chapter review questions

1 Any two from:
- they do not have a nucleus
- they are usually smaller than eukaryotic cells
- they usually have plasmids (small rings of DNA)

2 dissolved sugars and minerals

3 They contain chloroplasts, which contain a green substance called chlorophyll and are where photosynthesis occurs.

4 They have a tail to propel them towards the ovum and a relatively large number of mitochondria to release the energy from glucose during respiration.

5 The sample is placed in a drop of water or stain on a microscope slide. A thin coverslip is placed on top of this. The slide is then placed onto the stage.

6 Prokaryotic cells do not have a nucleus whereas eukaryotic cells do, they are single celled and they are smaller than eukaryotic cells.

7 It is the site of chemical reactions and is mainly water.

8 They are where proteins are made.

9 Only plant cells have chloroplasts, which are the site of photosynthesis. Only plant cells have a vacuole in which dissolved sugars and minerals are stored. Plant cells have a wall to provide structure, which is not seen in animal cells.

10 A nerve cell has a long section called an axon down which electrical impulses move. This cell is insulated by a myelin sheath to make this movement faster.

11 The shortest distance between two points that a microscope can determine as two separate points.

12 **a)** around 20 micrometres (μm)

b) Sperm cells need to be able to swim long distances to reach the ovum and so need the energy released from glucose during respiration in mitochondria.

13 Cells with more mitochondria are able to release more energy from glucose in respiration. Cells with more mitochondria are usually more active, like sperm or muscle cells.

14 'Turgid' is used to describe swollen cells.

15 Xylem cells are long and have thick, reinforced walls to allow water to move up by transpiration.

16 **a)** It is 2.6 cm long in the image and so has been magnified 20 times.

b) It has a large surface area to speed up osmosis.

17 They are very small (microscopic) structures.

Practice questions

1 **a)** B Chlorophyll [1 mark]

b) To maximise the light their leaves receive. [1 mark]

c) They are green because they contain chlorophyll in their chloroplasts. [1 mark] These are present in the roots of some orchids because they grow on trees and are able to receive sunlight. [1 mark] This means these cells can photosynthesise. [1 mark]

d) They possess a long extension called a hair. [1 mark] This increases the surface area in contact with water in the soil. [1 mark] This means that the plant can absorb more water. [1 mark]

2 **a)** A Plasmid DNA; B Cell wall [2 marks]

b) C Nucleus; D mitochondria [2 marks]

3 **a)** A Eyepiece lens; B Fine focus; C Stage [3 marks]

b) B Objective lens [1 mark]

c) total magnification = magnification of eyepiece lens × magnification of objective lens [1 mark]

d) Any two of: Light microscopes use magnifying lenses. The light passes through the objective lens and then the eyepiece lens before entering your eyes. Electron microscopes are more recently invented and more complicated machines. They use beams of electrons, not light, to magnify images. The wavelength of electrons is shorter than light so high resolution and great magnification are seen. [2 marks]

4

Level 3:	A clear description covering the key differences and similarities between prokaryotic cells and eukaryotic plant and animal cells	[5–6 marks
Level 2:	A number of relevant points made, but not precisely	[3–4 marks]
Level 1:	Fragmented points	[1–2 marks]
	No relevant content	[0 marks]

Indicative content: None can be seen without a microscope.

Prokaryotes:

- are single celled
- do not have a nucleus containing their genetic material (DNA)
- are smaller than eukaryotic cells
- may also have small rings of DNA called plasmids.

Eukaryotes:

- almost always have a nucleus
- are larger than prokaryotic cells
- have membrane-bound organelles
- often make up large multicellular organisms.

Plant and animal similarities:

- nucleus
- cell membrane
- cytoplasm
- mitochondria
- ribosomes.

Plant cells have in addition:

- a cell wall
- chloroplasts
- a (permanent) vacuole.

Working scientifically: Dealing with data

Pages 15–17

1 $1.8 \times 12.5 = 22.5$ mm

2 22.5/7.5 = 3 cm

3 13 mm approx.

4 Allow 5.5–5.8 µm, do not accept answer in mm.

Test yourself on prior knowledge

1. A short section of DNA that carries information about inherited characteristics.
2. DNA exists in a double helix shape, which is coiled into chromosomes.
3. chromosome > gene > DNA

Test yourself

1. 46
2. A haploid cell (nucleus) has half the normal number of chromosomes (one from each pair of chromosomes).
3. A diploid cell (or nucleus) has paired chromosomes (the normal number).
4. Chromosomes are made up from genes, which are made from DNA.
5. daughter cells
6. Growth and repair / replacing damaged or old cells.
7. A cell that can divide into any other kind of cell.
8. embryonic and adult
9. Some people disagree with it for religious or moral reasons.
10. They can grow into any cell types and possibly be able to treat paralysed patients, replace defective organs and treat conditions such as diabetes by replacing cells that are no longer working properly.

Show you can

Page 20

1. Saying '23 pairs' reminds us that half come from one parent and the other half come from the other parent.

Page 22

2. Chromosomes make copies of themselves and the nucleus disappears. The original and copied chromosomes line up. They move to opposite ends of the cell. The cell divides. Two new nuclei form in each of the two new cells.

Page 24

3. It could be used to grow nerve cells to help paralysed individuals. It could be used to grow brain cells to help after injury or with diseases like Parkinson's. It could eventually be used to grow tissues or organs.

Activity

Page 22

1 Task – no answer needed.

2 Task – no answer needed.

3 Task – no answer needed.

Activity

Page 24

1 Task – no answer needed.

2 Task – no answer needed.

3 Task – no answer needed.

Chapter review questions

1 gametes

2 23 pairs, or 46

3 1 at the start and 2 at the end

4 any two from: sperm cell, nerve cell, muscle cell

5 An organism produced asexually that has identical genetics to its parent.

6 They have the same genes as their one parent.

7 Any cells except for sperm and ova

8 23

9 eggs

10 A section of a chromosome made from DNA that carries the code to make a protein.

11 Growth and repair/ replacing damaged or old cells.

12 Because they have half the DNA of each parent and come together to form the one diploid set of DNA of a new organism.

13 The process of a stem cell turning into a specialised cell.

14 meristem

15 They believe that an embryo is a life.

Practice questions

1 B 46 [1 mark]

2 C Sperm cell [1 mark]

3 **a)** chromosome [1 mark]

b) Six chromosomes should be drawn [1 mark] showing six different sizes [1 mark].

4 **a)** mitosis [1 mark]

b) growth / repair [1 mark]

c) It is replicated / copied. [1 mark]

5 **a)** Cells that can develop into one or more types of specialised cell. [1 mark]

b) bone marrow, brain, blood, fat cells [1 mark]

c) They can grow into any specialised cell found in the adult organism. [1 mark]

d) Any two from: embryonic stem cells come from human embryos, the idea that embryos have a right to life, idea that people have religious views against it; idea the treatments are not fully tested or may have side effects. [2 marks]

Working scientifically: Experimental skills

Page 27

1–4 There are no specific answers as all are predictions.

5 There is an inactivated centromere present, the two telomere sequences are joined.

Test yourself on prior knowledge

1 root hair cell

2 Particles spread out from an area of high concentration to an area of low concentration.

3 Breathing is getting gases into and out from the lungs. Respiration is a cellular reaction that releases energy.

Test yourself

1 the net movement of particles from an area of high to lower concentration

2 They have moist, thin walls, a large surface area and rich blood supply to increase diffusion of gases.

3 The particles in solids are fixed and cannot move.

4 The net movement of water from an area of high concentration of water to an area of lower concentration of water across a partially permeable membrane.

5 root hair cell

6 Osmosis is the movement of water particles only.

7 The net movement of particles from an area of low concentration to an area of higher concentration using energy.

8 Sugars are absorbed into the blood by active transport (and diffusion) in the small intestine.

9 Active transport occurs from low to higher concentration.

Show you can

Page 32

1 Diffusion is the net movement of particles from an area of high to low concentration. When you inhale the oxygen is in a higher concentration in your lungs than in your blood so diffuses into the blood. This changes the concentration of oxygen in your blood to high. It reaches your tissues, where it is needed in the cells, so it diffuses from a high concentration in the blood to the lower concentration in your cells.

Page 35

2 Osmosis is the net movement of water from an area of high concentration of water to an area of lower concentration of water across a partially permeable membrane. When it rains the water is in a high concentration in the soil. This water therefore moves by osmosis into the plant through the membranes of the root hair cells.

Page 37

3 Active transport is the net movement of particles from an area of low concentration to an area of higher concentration using energy. Because plants absorb mineral ions from the soil they are present in higher concentrations in the plant than the soil. So plants must absorb them using active transport, which requires energy.

Activity

Page 31

1 The scent particles diffused through the wall of the balloon from an area of high concentration to an area of low concentration.

2 Heating the oil, cotton wool or balloon or increasing the concentration of oil used.

3 In the alveoli, oxygen moves into the blood down a concentration gradient from where there is a high concentration of oxygen in the alveoli to where there is a lower concentration of oxygen in the blood.

Activity

Page 31

This is a model of increased surface area due to villi.

Activity

Page 33

1 Any two from: sample equipment used, same volume of dye, same soaking time, cubes all made form agar.

2–4

Cube	Total surface area cm^2 (2)	Total volume in cm^3 (2)	Surface area/ volume (3)	SA:V (4)
A	6	1	6	6:1
B	24	8	3	3:1
C	96	64	1.5	1.5:1

5 Cube A

6 Dye would have entered by diffusion (down a concentration gradient).

Required practical 2

Page 35–36

1–3 Answers are based on the student's own work.

4 To remove excess water.

5 It took into account starting mass or removed any variation in starting mass.

6 Answer is based on the student's own results.

7 Answer is based on the student's own work.

Chapter review questions

1 The net movement of particles from an area of high concentration to an area of lower concentration.

2 smelling someone's deodorant or perfume

3 from the lungs into the blood

4 from the blood into the lungs

5 capillaries

6 ventilation

7 diffusion

8 the net diffusion of water from an area of high concentration to an area of lower concentration across a partially permeable membrane

9 When it rains and there is a higher concentration of water in the soil, water will move by osmosis into the plant cell.

10 stomata

11 the net movement of particles from an area of low concentration to an area of higher concentration using energy

12 from low to high

13 tea spreading out from a teabag, or juice being diluted with water

14 They have a large surface area, moist thin membranes, a rich blood supply and breathing provides them with a regular supply of fresh air.

15 a membrane in which only small molecules can pass though

16 because osmosis only involves water

17 It would remain the same size.

18 It would swell up, because water would move into it.

19 It would shrink, because water would move out of it.

20 Plant mineral ions exist in low concentration in the soil and in high concentration in the plant. Because the plants need to move the mineral ions from low to high concentrations, against the concentration gradient, they need to use energy. This is active transport.

21 Sugars can be in a low concentration in your digestive system and in high concentration in your blood. Therefore, because you need to move the glucose from low to high concentration, against the concentration gradient, you need to use energy. This is active transport.

22 Because some of the particles may naturally diffuse back to the area of high concentration they have just come from.

23 The size of insects is limited by the distance that oxygen can diffuse.

24 Wrap a piece of string around your clenched hand and measure the length of string that it takes to go round the largest part. Now do the same with your hand unclenched and your fingers straight.

25 As the temperature increases so does the rate of diffusion. Particles have more energy and so move faster.

26 The larger the surface area, the greater the rate of diffusion through it.

27 Make a series of salt solutions of different concentrations and place into beakers. Cut out potato chips to fit inside the beakers. Weigh all the potato chips before soaking in salt. Then, weigh them all again and calculate the percentage change in mass for each solution.

Practice questions

1 **a)** A [1 mark]

b) **i)** Diffusion is the movement of gas particles from a high concentration to a low concentration [1 mark] down a concentration gradient [1 mark].

ii) Diffusion is a passive process. This means it does not require additional energy. [2 marks]

2 **a)** Cell A [1 mark]

b) **i)** It would increase the rate. [1 mark]

ii) The particles would have more (kinetic) energy so move faster. [1 mark]

c) **i)** B [1 mark]

ii) idea that concentration / number of particles are the same inside and outside the cell [1 mark]

d) Cell A [1 mark]

3 **a)** vacuole larger, cell larger / fuller / turgid [1 mark]

b) **i)** It would burst / lyse. [1 mark]

ii) There is no cell wall in an animal cell. [1 mark]

c) **i)** Drawing should show a smaller vacuole [1 mark], cell membrane not fully against the cell wall [1 mark], cell wall the same size [1 mark].

ii) Any three from: water left the cells by osmosis , moved from a solution with a high concentration of water (dilute) to a solution with a low concentration of water (concentrated) down a concentration / water potential gradient through a partially permeable membrane , so the membrane came away from the cell wall, the cytoplasm took up less volume / the cell vacuole shrunk. [3 marks]

4

Level 3:	More than one improvement described and includes collection of more data involving range of salt concentrations and / or recording a change in mass	[5–6 marks]
Level 2:	More than one improvement described	[3–4 marks]
Level 1:	An improvement described	[1–2 marks]
	No relevant content	[0 marks]

Indicative content:

- Leave loner than 10 minutes.
- Control other factors, such as temperature of solutions.
- Repeat for each concentration of salt solution.
- Increase range of salt concentrations.
- Use pure water or a 0 M salt solution.
- Repeat investigation with other potato varieties.
- Control volume salt solutions used.
- Record change of mass rather than length.
- Record volume rather than length.

Working scientifically: Dealing with data

Pages 40–41

1 No units in headers, units in table, variables in the wrong column, mixed units, inconsistent use of decimal places, no increasing trend in independent variable.

2

Room temperature (°C)	Time taken to smell the deodorant (s)
10	105
15	90
20	60
25	54
30	42

3

Beaker	Volume of squash (cm^3)	Volume of water (cm^3)	Total volume (cm^3)
A	100	0	100
B	75	25	100
C	50	50	100
D	25	75	100
E	0	100	100

4

Solution / beaker	Starting mass (g)	Mass after 5 minutes (g)	Mass after 10 minutes (g)	Mass after 15 minutes (g)	Mass after 20 minutes (g)
A					
B					
C					
D					
E					

4 Animal tissues, organs and organ systems

Answers

Test yourself on prior knowledge

1 the large intestine

2 They can digest some substances that we can't and they stop harmful bacteria surviving there.

3 Any excess sugar in a person's diet is stored as fat, which can make them obese.

4 organism : organ system : organ : tissue : cell

Test yourself

1 bile

2 Muscles along the length of the outside of your small intestine contract behind lumps of food to move it along.

3 They have a large surface area and rich blood supply to absorb as much digested food as possible.

4 amylase

5 amino acids

6 Breakdown enzymes break substrates down. Synthesis enzymes join substrates together.

7 extremes of temperature and pH

8 away from the heart

9 atria and ventricles

10 They have one-way valves to reduce backflow of blood.

11 It has to pump blood further to the rest of the body.

12 phagocytes and lymphocytes

13 straw-coloured, or yellow

14 Haemoglobin reacts with oxygen to form oxyhaemoglobin.

15 They have a biconcave shape, which increases their surface area to absorb more oxygen and they have no nucleus, which also enables them to carry more oxygen.

16 to generate an electrical impulse to coordinate the pumping of the heart's chambers

17 by eating a balanced diet, not smoking, not drinking too much and taking regular exercise

18 physical and mental wellbeing

19 Speak to an adult (preferably your parents, a teacher or your doctor).

20 balanced diet, regular exercise, reduce stress, seeking medical help

21 breast, lung, prostate, bowel

22 Men: prostate or testicular cancer; women: cervical or uterine cancer (do not accept breast only for women)

23 Malignant describes a cancerous tumour that spreads; benign describes a tumour that is not cancerous and does not spread.

24 Many cancers can be prevented by living as healthy a lifestyle as possible. This means not smoking, drinking alcohol in moderation, eating a healthy diet and exercising regularly.

25 cancer

26 liver and brain

27 Cells stop responding to insulin. So excess glucose is not absorbed by the liver cells.

Show you can

Page 46

1 Mouth: food is broken down by teeth and mixed with saliva. Oesophagus: food moves to the stomach. Stomach: food is mixed with acid and lipase enzymes. Small intestine: nutrients are absorbed into the blood. Large intestine: water is absorbed into the blood. Anus: undigested food passes from the anus.

Page 50

2 Carbohydrase enzymes are produced in the mouth. Protease enzymes are produced in the stomach. Carbohydrase, lipase and protease enzymes are produced in the pancreas and small intestine.

Page 54

3 Blood is forced from the left ventricle when it contracts. The blood is pumped into the aorta, which takes it to the rest of the body. After moving through the body's tissues it returns to the right atrium of the heart in the vena cava. It is pumped into the right ventricle and then into the pulmonary artery to the lungs. It returns from the lungs to the heart in the pulmonary vein and enters the left atrium.

Page 56

4 Red blood cells carry oxygen from the lungs to the cells. White blood cells fight off infection from pathogens. Platelets form scabs. Plasma is the liquid in which the cells are held and substances like glucose are dissolved.

Page 58

5 Stents are small mesh devices that hold open arteries. A bypass is when a section of artery is moved to the heart. It is used to allow blood to flow around a blockage. Stents are less damaging and so preferred by doctors.

Page 59

6 Stress is the feeling of being under too much mental or emotional pressure. Anxiety is a feeling of unease, which might be worry or fear. Depression can lead to feelings of sadness and hopelessness, and losing interest in things you used to enjoy.

Page 62

7 Causation is the act of causing an outcome. Correlation is when an action and outcome are linked but when the action does not cause the outcome. Lung cancer is caused by smoking. There is a correlation between increasing age and illness.

Required practical 3

Pages 48–49

1 Answer will depends on the teacher's choice.

2 Starch test – iodine solution remains orangey brown.

Glucose – Benedict's reagent remains light blue.

Protein – biuret solution remains pale blue.

Lipids – no emulsification seen.

3 As they deal with perceptions of colour, something that cannot be empirically measured and different people will have different views on them.

4 Task – no answer is required.

Required practical 4

Page 50

1 To allow time for the tubes to reach the required temperature.

2 Task – no answer is required.

3 Answer is based on the student's graph.

4 amylase / other appropriate response

5 Increase the frequency at which the samples are taken and tested.

Chapter review questions

1 to lubricate food as it is swallowed

2 the gall bladder

3 carbohydrase, lipase and protease

4 absorption of water

5 the heart

6 away from the heart

7 Blood passes through it twice on every circuit of the body.

8 Malignant tumours are cancerous and spread, benign tumours are not cancerous and do not spread.

9 Stents are less invasive and less dangerous. It is faster to recover from an operation in which they are inserted.

10 to break it down into small enough pieces to be absorbed into our blood

11 a biological molecule that speeds up a reaction

12 protease; amino acids

13 carbohydrase; sugars

14 lipase; fatty acids and glycerol

15 Add a small volume of boiled and unboiled amylase to two test tubes of starch and incubate at room temperature. Several minutes later, check for the presence of glucose using the Benedict's test. The unboiled amylase will break down the starch into glucose. The boiled amylase is denatured and so no glucose will be produced.

16 extremes of temperature and pH

17 the pH at which the enzyme works most effectively

18 left atrium, left ventricle, rest of body, right atrium, right ventricle, lungs, left atrium

19 They are extremely thin to allow as much oxygen to diffuse from the blood into the cells and as much carbon dioxide to diffuse the opposite way.

20 They engulf pathogens and destroy them with enzymes.

21 coronary arteries

22 breathlessness, tiredness, dizziness and chest pain

23 Screening can be feeling a bump to see if it is a tumour, and taking blood tests, urine tests or X-ray images. Doctors can also use monoclonal antibodies.

24 Anxiety is a feeling of unease, which might be worry or fear.

25 The enzyme is specific for the substrate and fits into it to break it down just like a key is specific for a lock and fits into it.

26 the active site

27 The lock has changed shape and the key will no longer fit it. So the enzyme's active site has changed shape and will no longer fit the substrate.

28 The blood does not clot as quickly as it should do.

29 High levels of cholesterol lead to fatty substances building up in the walls of the coronary arteries. The arteries get narrower reducing the amount of oxygen getting to the cells of the heart.

30 Inserting a stent is less dangerous and faster to recover from.

Practice questions

1 **a)** **i)** stomach [1 mark]

ii) small intestine [1 mark]

b) absorbing water and salts from the remaining digested food [1 mark]

c) **i)** B (small intestine) [1 mark]

ii) 1 mark for description, 1 mark for paired explanation. Description – good blood supply; explanation – quickly removes digested products/maintains the concentration gradient. Or: description – thin wall /wall only one cell thick; explanation – short diffusion distance / small distance for food to travel. [2 marks]

d) **i)** peristalsis [1 mark]

ii) (rhythmic) contraction [1 mark] of muscle (in the walls) [1 mark]

2 A Stent [1 mark]

3 **a)** too large to be absorbed / pass into the bloodstream or to make them soluble [1 mark]

b) the active site [1 mark]

4 **a)** A = artery, B = vein, C = capillary [3 marks]

b) (Deposits) slow or stop oxygen reaching heart cells, which causes the cells to die. [2 marks]

c) (from top) white blood cells, platelets, plasma, red blood cells [4 marks]

5

Level 3:	A correct description of what reagent is used and what positive results look like for each food test; also extra detail of how to carry out the test.	[5–6 marks]
Level 2:	A correct description of what reagent is used and what positive results look like for at least two food tests; may be extra detail of how to carry out one test.	[3–4 marks]
Level 1:	A correct description of what reagent is used or what positive results look like for one food test.	[1–2 marks]
	No relevant content	[0 marks]

Indicative content:

Glucose

- Use Benedict's reagent / solution.
- Positive result is brick red / red / orangey red.
- Around 10 drops or 1–2 cm^3 could be used.
- The solution needs to be heated.
- The solution is bright blue to begin with.

Starch

- Use iodine reagent / solution.
- Positive result is blue-black / dark blue.
- Around 5–10 drops could be used.
- The solution is orangey brown to begin with.

Protein

- Use biuret reagent / solution.
- Positive result is light purple / lilac / mauve.
- Around 10 drops or 1–2 cm^3 could be used.
- The solution is light blue to begin with.

Working scientifically: Scientific thinking

Pages 65–66

1 It shows the specificity of enzymes and how only one substrate can fit into a specific active site.

2 Enzymes are not rigid structures like a lock and key and the active site will change shape slightly to accommodate the substrate as it bonds.

3 It can represent that the substrate is changed in the active site as a reaction is catalysed.

4 Visking tubing represents the small intestine or villi, the water represents the blood.

5 Because the amylase enzyme has not digested the starch into glucose, as the experiment proceeds the starch is broken down into glucose by the action of the enzyme.

6 Starch is too large to pass through the Visking tube membrane.

7 The water does not move or circulate like blood, so there is no concentration gradient established. The digestive system is much more complex and the organs are not all represented, the Visking tube has no villi.

8 Task – no answer is required.

Test yourself on prior knowledge

1 Water is absorbed through roots and carbon dioxide through leaves.

2 Stomata open and close to regulate the volume of water vapour and oxygen lost and the volume of carbon dioxide absorbed.

3 Leaves have high numbers of chloroplasts in cells near their surface. They are large and flat to absorb as much sunlight as possible.

Test yourself

1 xylem and phloem

2 They are full of chloroplasts to maximise the amount of photosynthesis.

3 They have spaces between them to allow gases to diffuse into and out of the cells.

4 osmosis

5 to absorb water and minerals and to hold the plant in the soil

6 in the tip of the shoot

7 They are not usually exposed to the Sun so do not need to have green chloroplasts for photosynthesis.

8 the leaf

9 the transportation organ system

10 Oxygen is produced during photosynthesis and so moves from the inside of the leaf at high concentration to a lower concentration outside the leaf.

Show you can

Page 70

1 epidermis, palisade mesophyll cells, spongy mesophyll cells

Page 71

2 They are younger and so often have not grown tough secondary cell walls that would make them harder to digest.

Page 73

3 dry, warm and windy days

Practical

Page 69

1 Dependant on leaves chosen, but there is likely to be higher stomatal density on the lower side of the leaf as there is less evaporation because it tends to be cooler and receives less light.

2 In a wilted plant the stomata pores become smaller as the guard cells narrow the pore. In a watered plant there would be wide stomata pores as the guard cells are turgid.

Activity

Page 73

1 Allow 40–48 squares as the estimate.

2

Leaf	Change in mass in g
A	0.20
B	0.08
C	0.04
D	0.01

3 The leaf with no petroleum jelly lost the most mass as the stomata pores were not sealed, therefore water was lost through evaporation.

4 0.004 g / cm^2

5 the treatment of petroleum jelly

6 mass

7 Temperature, ideally the surface area of leaf (but this is impractical).

Chapter review questions

1 at the bottom below the palisade mesophyll

2 They contain many chloroplasts to complete a lot of photosynthesis.

3 xylem

4 They do not contain any chloroplasts because they cannot photosynthesise under the ground.

5 to provide water for the plant, to anchor it into the ground, to grow runners to make new plants or to store the glucose made during photosynthesis, usually as starch

6 meristem

7 active transport

8 leaf; root; stem

9 palisade mesophyll

10 roots, shoots and leaves

11 osmosis

12 Palisade mesophyll cells are long and thin and are tightly packed with no gaps. Spongy mesophyll cells are more circular and have gaps between them.

13 Guard cells sit around the edge of a stomata. They open and close to allow water vapour to evaporate out.

14 painting the surface of the leaf in clear nail varnish before peeling it off to count the bumps when it is dry

15 xylem and phloem

16 growing above the ground, for example on another plant

17 Water vapour constantly evaporates from stomata in the leaves, which pulls up more water from the roots.

18 because less water loss occurs from the bottom of leaves

19 when it has just rained and there is lots of water in the soil

20 If this did not continue the transpiration stream would stop.

21 The rate of transpiration would reduce because more humidity means a smaller concentration gradient. This means that diffusion of water out of the leaf by transpiration would happen less quickly.

22 The rate of transpiration would reduce because less heat means less diffusion of water out of the leaf by transpiration.

23 when it is hottest, often at midday

24 On a windy day the air surrounding the leaves is continually replaced. This keeps the concentration gradient steep and the rate of transpiration high.

25 Collect leaves of the same size from a plant. Spread petroleum jelly onto the stalks of the leaves to stop water loss there. Weigh the leaves and hang them up to dry for an hour. Reweigh the leaves to see the water loss through transpiration.

Practice questions

1 a) spongy mesophyll = C, epidermis = A, palisade mesophyll = B [3 marks]

b) i) water / dissolved minerals [1 mark]

ii) sugars / sucrose [1 mark]

2 a) i) guard cell [1 mark]

ii) to control the size of the stomata [1 mark]

b) B Because it has the lowest number of stomata [1 mark], which means there will be less water loss/transpiration. [1 mark]

c) any from: reduced surface area, thick cuticle, stomata close in the day [1 mark]

d) $(1/0.02) \times 12 = 600$. Allow 1 mark for working and 1 for correct answer. [2 marks]

3 a) anything below 250 g [1 mark]

b) as a control, to check the effect of the plant. Do not accept fair test. [1 mark]

c) to reduce / prevent evaporation of water from flask [1 mark]

d) D Transpiration [1 mark]

e) The evaporation of water or loss of water vapour; from the leaves; through the stomata; causing a pull, change in osmotic pressure or osmotic potential; so that water moves up the plant; through the xylem; as the transpiration stream; water absorbed by roots or root hairs. [3 marks]

f) C Hot and dry conditions [1 mark]

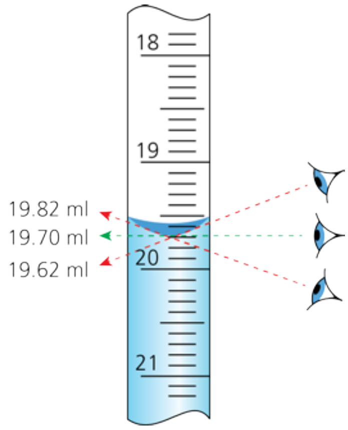
Working scientifically: Dealing with data

Pages 76–77

1 Kelly's – as the data for each repeat vary more.

2 Chris started from the bottom of the ruler, not at zero. This is a systematic error. Chris should repeat the experiment measuring correctly.

3 Kelly's method introduced errors because she was not measuring consistently (she was creating a parallax error). She should have measured consistently each time (with her eye in line with the bottom of the meniscus of the bubble).



4 To prevent evaporation of water. If the gaps were not sealed, this would have created higher readings as more water would be lost.

5 Accept any sensible suggestion related to random or systematic error.

6 a) High levels of evaporation as the lamp would heat the plant and increase the rate. Also, more photosynthesis would occur with light and the stomata would open to allow greater gaseous exchange.

b) High levels of evaporation, as the fan would increase the concentration gradient.

c) Low levels of evaporation as the humid environment would lower the concentration gradient.

Test yourself on prior knowledge

1 two from: cannabis, ecstasy, speed, cocaine

2 Recreational drugs are used for pleasure without a medical reason. Medicines are drugs that improve health.

3 because alcohol slows down your reaction times, which makes it more likely that you will have an accident

Test yourself

1 measles, HIV/AIDS, tobacco mosaic virus, mumps, colds and flu or other appropriate answer

2 athlete's foot, rose black spot or other appropriate response

3 A pathogen is highly infectious if it is easily spread from one organism to another.

4 It can then infect more hosts faster.

5 dirty water

6 vector (cattle), airborne (humans); some farmers believe the vector is badgers

7 measles, HIV/AIDS, tobacco mosaic virus, mumps, colds and flu or other appropriate answer

8 a fever and a red skin rash

9 human immunodeficiency virus

10 a fever and headache

11 *Salmonella*, gonorrhoea or other appropriate answer

12 by antibiotics

13 a fever, cramps, vomiting and diarrhoea

14 a painful burning sensation when urinating and a thick coloured discharge

15 athlete's foot, rose black spot or other appropriate response

16 People catch athlete's foot when they walk barefoot in communal areas where infected people have walked. Rose black spot is spread by wind or in water. Other answers if appropriate to answer to question 15.

17 malaria or other appropriate response

18 a fever, tiredness, vomiting and headaches

19 The blood of an infected organism is sucked by a mosquito. This contains the protist, which is transferred to the next organism that the mosquito drinks blood from.

20 skin, lysozymes, hairs, cilia or stomach acid

21 phagocytes and lymphocytes

22 As it is hydrochloric acid, it kills pathogens.

23 Chemical barriers have a chemical compound involved, such as stomach acid or the lysozyme enzymes in tears. Physical barriers such as skin do not.

24 measles, mumps and rubella

25 B cells

26 a small quantity of a dead, inactive or genetically modified version of a pathogen

27 Antibodies are produced by lymphocytes. Antigens are proteins on the pathogen itself. Antibodies recognise antigens.

28 penicillin

29 the willow tree

30 to reduce the chance of heart attacks

31 computer modelling

Show you can

Page 79

1 A pathogen infects a host. It then reproduces (or replicates if it is a virus). It then spreads from its host and infects other organisms.

Page 80

2 The four types of pathogen are viruses, bacteria, fungi and protists. An example of a viral pathogen is HIV. This could be spread by sexual contact. An example of a bacterial infection is *Escherichia coli*. This could be spread through uncooked food. An example of a fungal infection is athlete's foot. This could be spread by direct contact. An example of an infection by protist is malaria. This is spread by the mosquito as a vector.

Page 82

3 HIV infection leads to the condition AIDS. At this point HIV attacks the sufferer's immune system, which is then not so effective at killing pathogens. The AIDS patient is then more likely to catch another infection such as tuberculosis, which they cannot fight off.

4 Many bacteria are pathogens and cause illness. These include *Salmonella* and gonococci which cause gonorrhoea. Others, including those that live in our digestive system, are important and actually help us.

Page 84

5 Fungi are eukaryotic organisms. This means they have a nucleus. Bacteria are prokaryotic and so do not. Viruses are neither eukaryotic nor prokaryotic. They are not alive.

6 Travellers can take antimalarial tablets, which kill the parasite when infection has occurred. They can also stop infection in the first place by using mosquito nets and sprays.

Page 88

7 The second time an organism is infected antibodies are produced faster and in higher volumes. This stops an infection.

Page 90

8 Fleming made a mistake in his method. His bacterial plates became infected by a fungus. Rather than just throwing these away, Fleming noticed that the fungus stopped the bacterium growing. From here he found the first antibiotic.

Page 91

9 The first stage is computer modelling. The second stage of drug development involves laboratory on live cells or animals. The third and final stage involves clinical trials on humans. The drug is tested on a small number of healthy volunteers, then a small numbers of sick patients and finally it is given to a large number of patients to finalise safe doses and efficacy.

Activity

Page 83

A. *Streptococcus pneumonia*
B. *Streptococcus pyogenes*
C. *Treponema pallidum*
D. *Salmonella typhi*
E. *Staphylococcus aureus*
F. *Helicobacter pylori*

Chapter review questions

1 a disease that can be spread from one organism to another
2 viruses, bacteria, fungi and protists
3 athlete’s foot, rose black spot or other appropriate response
4 malaria or other appropriate response
5 human immunodeficiency virus/acquired immune deficiency syndrome
6 Alexander Fleming
7 viruses
8 Drug companies are companies and need to make money but also the process of drug testing is long and expensive.
9 in uncooked food

10 a painful burning sensation when urinating and the production of a thick yellow or green fluid (discharge) from the vagina or penis

11 a fever, tiredness, vomiting and headaches

12 by using mosquito nets and insect repellent sprays containing insecticides and medicines such as Malarone

13 It contains hydrochloric acid, which kills many bacterial pathogens.

14 The T and B cells form 'memory' cells, B cells produce larger numbers of antibodies more quickly on subsequent infection.

15 A vaccine is a medicine containing an antigen from a pathogen that triggers a low level immune response so that subsequent infection by that pathogen is dealt with more effectively.

16 If the vast majority of people in a population has a vaccination, then even if a small number of people becomes infected the disease is not likely to spread through the population.

17 Booster injections 'remind' your immune system and refresh the memory of your 'memory' lymphocytes.

18 One of Alexander Fleming's Petri dishes was mistakenly left open and had accidently been contaminated by a fungus called *Penicillium notatum*. Where the fungus grew, the *Staphylococcus* bacteria did not. Fleming realised that the fungus was naturally producing a chemical that killed bacteria. Fleming then isolated the first antibiotic drug, and it was called penicillin after the fungus.

19 Cilia are tiny hair-like projections that protrude into the airway. Goblet cells produce mucus, which they pump into the airway and in which pathogens get stuck. The ciliated cells waft the mucus back up their airway to the back of the throat, where it is swallowed.

20 They engulf (take in) pathogens and destroy them using enzymes.

21 They produce antibodies, which help clump pathogens together. The pathogens can then be engulfed and destroyed by phagocytes.

22 computer modelling

23 how effective a drug is

24 A trial in which neither the doctors nor the patients know who has received the drug and who has received the placebo.

Practice questions

1 **a)** to check work, to find best dose, to ensure safe to trial on people [1 mark]

b) **i)** fake drug/drug with no active ingredient [1 mark]

ii) to see if the drug works rather than the process of taking a drug itself/comparison [1 mark]

iii) in the trial neither the doctor nor the volunteers know which is the drug and which is the placebo [1 mark]

- **c)** age, sex, number in each group, other medical issues, size because lung capacity measured [1 mark]
- **d)** 19% [1 mark]

2 **a)** pathogen [1 mark]

b) They produce toxins, damage cells, reproduce rapidly or reproduce in cells. [1 mark]

c) **i)** Antibiotics don't kill viruses. [1 mark]

ii) painkillers: Allow name of painkiller. Allow any mention of antivirals. [1 mark]

d) idea that: antibodies produced [1 mark] by white blood cells, [1 mark] allows quick response to produce white blood cells with subsequent infection [1 mark]

3 **a)** D Protist [1 mark]

b) A Fever and B Vomiting [1 mark]

4 **a)** **i)** any two from the following (or specific types of any of the following): bacteria, fungi, protists [2 marks]

ii) any two from: airborne, through dirty water, by direct physical contact (sexual or non-sexual), through eating contaminated food, through a vector animal [2 marks]

iii) washing hands, using tissues [1 mark]

b) from top: stomach; skin; lungs, trachea or bronchi [3 marks]

c) **i)** White blood cells (lymphocytes and phagocytes) [1 mark]

ii) Lymphocytes produce antibodies that attach onto the pathogens [1 mark] and clump them together [1 mark]. Phagocytes engulf and break down pathogens [1 mark]

Working scientifically: Scientific thinking

Page 94

1 Some examples can be seen in the table below, although this is not exhaustive as it depends on what the sources the students use.

	Positive	**Negative**	**Risk**
Vaccination compulsory	• Prevention is better than cure; • Improves overall public health; • Natural way to strengthen the immune system; • Can and has eradicated diseases.	• Side effects; • Other alternatives might be available; • Some concern over ingredients and toxicity; • Efficacy is not always proven; • Ethical issues;	• Side effects; • Disease.

	Positive	Negative	Risk
		• Cost.	
Vaccination voluntary	• Allow people the freedom to choose ; • Does not impact religious beliefs.	• Many may not have vaccination programmes; • Only successful if enough people are vaccinated.	• Too low vaccination rate, so diseases still spread in the population.

2 Dependent on students' responses.

3 Allow any sensible diagrams or flowcharts that show the basic idea of vaccination. Key points to be included are:

- Vaccination involves exposing the body's immune system to a weakened or harmless version of the pathogen.
- This causes the white blood cells to produce antibodies specific to it.
- The antibodies remain in the blood in case of exposure by the pathogen.

Test yourself on prior knowledge

1 glucose and oxygen

2 because they are the only organisms that can capture the Sun's energy and convert it into glucose

Test yourself

1 chlorophyll (not chloroplasts)

2 $C_6H_{12}O_6$ and $6O_2$

3 It is an endothermic reaction and so requires energy (which it gets from light) to work.

4 a variable that reduces and then completely stops a process

5 temperature, light, carbon dioxide, chlorophyll

6 to make chlorophyll

7 They can optimise light and temperature levels. They can also add carbon dioxide.

Show you can

Page 97

1 Plants only photosynthesise during the day but they respire throughout the day and night. So oxygen levels would increase during the day and reduce again at night.

Page 100

2 There is more energy in the products glucose and oxygen than the reactants water and carbon dioxide. Energy from the Sun is used to break the bonds in the reactants and re-form them in the products.

Required practical 5

Page 99

1

Distance (cm)	Light intensity A.U
10	0.01000 or 0.0100
20	0.00250 or 0.0025
30	0.00110 or 0.0011
40	0.00063 or 0.0006
50	0.00040 or 0.0004

2 Task – no answer is required.

3 Answer is based on the student's own results.

4 To act as a heat shield.

5 To allow pondweed time to adjust to the new light intensity.

6 Use a gas syringe to measure the volume of oxygen produced.

Chapter review questions

1 carbon dioxide and water

2 leaves

3 chloroplast

4 light energy from the Sun

5 almost all animals eat them or eat other animals that have eaten them

6 carbon dioxide and water [and light] $\rightarrow$ glucose and oxygen

7 chlorophyll

8 palisade mesophyll

9 palisade mesophyll

10 root hair cell

11 $C_6H_{12}O_6$

12 anything that reduces or stops the rate of a reaction

13 active transport

14 magnesium

15 The crops are more protected from the wind and pests in polytunnels and greenhouses, but this also allows farmers to control the temperature, carbon dioxide and light needed for maximum photosynthesis.

16 It is used in respiration, converted into insoluble starch and stored, converted into fats and oils and stored, used to make cellulose cells walls for growth, and, along with nitrate ions absorbed from the soil, makes proteins.

17 cellulose

18 It requires light energy from the surroundings (Sun).

19 $6CO_2 + 6H_2O$ [+ light] $\rightarrow C_6H_{12}O_6 + 6O_2$

20 temperature, carbon dioxide, light, chlorophyll

21 because the reactant molecules have less kinetic energy, so collide less, and so react less

22 because it is one of the two key reactants

23 because light provides the energy necessary for this reaction, so reduced levels mean reduced photosynthesis

24 Put a small length of pondweed into a boiling tube of water and position a short distance from a lamp. After 2 minutes, record the number of bubbles of oxygen produced. Move the tube

progressively further away from the lamp and repeat. (More bubbles of oxygen means more photosynthesis.)

25 the amount of an agricultural product

26 keep the temperature at an optimum, have burners near their plants to produce carbon dioxide for optimal growth and provide their plants with maximum light

27 because the plant has used light energy to make glucose

28 nitrate ions

Practice questions

1 a) X = water, Y = oxygen [2 marks]

b) diffusion, through the leaf, through pores or stomata [1 mark]

c) i) leaf [1 mark]

ii) light [1 mark]

iii) chlorophyll [1 mark]

iv) chloroplasts [1 mark]

2 a) starch present in A and C [1 mark] but not present in B [1 mark]

b) i) C Iodine solution [1 mark]

ii) B Blue-black [1 mark]

3 a) i) 25 °C [1 mark]

ii) 0.11% [1 mark]

iii) 232 arbitrary units [1 mark]

b) light intensity [1 mark]

4

Level 3:	There is a clear description of how the investigation would be carried out and what measurements would be taken. There is a description of what steps would be taken to make it a fair test, including mention of controls and controlled variables.	[5–6 marks]
Level 2:	There is a description of a method involving how a change in light intensity may effect pond weed. A description of what is measured or at least one mention of how the experiment will be a fair test in included.	[3–4 marks]
Level 1:	There is a basic description of a simple method involving light and pond weed.	[1–2 marks]
	No relevant content	[0 marks]

Indicative content:

- Description of what apparatus is needed and how it is used.
- Description of how light intensity would be changed.
- Description of how the rate of photosynthesis would be measured.
- Use of ruler to measure distance of light from beaker / pond weed.
- Higher-tier students may also reference calculating light intensity using 1/d.

- Reference to counting the numbers of bubbles / measuring the volume of gas produced.
- Reference to using beaker of water as a heat shield / another method of maintaining the temperature of the water surrounding the pond weed.
- Reference to using the same piece of pond weed throughout.
- Reference to controlling the concentration of carbon dioxide in the water.
- Reference to allowing the pond weed to acclimatise for the same amount of time before starting the experiment.

Working scientifically: Experimental skills

Page 103

1 Time for leaf disc to reach the surface.

2 concentration of sodium hydrogen carbonate

3 volume of sodium hydrogen carbonate, number of leaf discs, age of leaf discs, distance from lamp, temperature, size of syringe

Test yourself on prior knowledge

1 carbon dioxide and water

2 Aerobic respiration happens in the presence of oxygen. Anaerobic doesn't.

3 Yeast respires anaerobically, which we call fermentation. We use this to make bread and beer.

Test yourself

1 exothermic

2 mitochondria

3 'with oxygen'

4 $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ [+ energy]

5 carbon dioxide and water

6 carbon dioxide and water

7 Energy enters photosynthesis from the Sun. It is stored in glucose. This is then released in respiration to be used for the seven life processes.

8 It is converted into thermal energy or a chemical stored of energy called adenosine triphosphate (ATP).

9 5%

10 in the liver

11 in the lactic acid

12 'without oxygen'

13 glucose $\rightarrow$ ethanol and carbon dioxide [and energy]

14 Bread is baked, which kills the yeast, and beer isn't.

Show you can

Page 106

1 They require more energy to function. They need to complete more respiration to release this energy from glucose. They have more mitochondria to do this.

Page 108

2 The reactants and products are opposite. The products of photosynthesis are glucose and oxygen. These are the reactants of respiration. The reactants of photosynthesis are carbon dioxide and water. These are the products of respiration. Energy enters from the Sun in photosynthesis and exits from respiration. Photosynthesis occurs in the day, whereas respiration occurs at all times.

Page 109

3 At the end of a run your cells lack oxygen. They start to respire anaerobically. This means lactic acid is produced and less energy is released. After you finish the race your body pays the oxygen debt by breathing deeply and quickly. You break down your lactic acid and return to aerobic respiration.

Page 110

4 They complete fermentation to produce energy for them to complete the seven life processes. Ethanol and carbon dioxide are produced instead of water and carbon dioxide in aerobic respiration of many other organisms like us. Ethanol is a by-product of yeast.

Activity

Page 106

1 **a)** carbon dioxide

b) It is absorbed by the soda lime.

2 **a)** They move left towards the tube.

b) The invertebrates are using up the oxygen in respiration, therefore the volume of gases in the equipment reduces.

3 The cricket's respirometer, as its scale has a higher resolution.

Activity

Page 107

1 To allow oxygen to get into the flask for respiration.

2 **a)** Over time the temperature readings would increase.

b) As respiration occurs heat is released as waste energy.

3 Boiled yeast is a suitable control. Having a control allows you to compare your results.

Chapter review questions

1 Respiration is a chemical reaction that releases energy and ventilation is the process of breathing.

2 glucose and oxygen

3 'in the presence of oxygen'

4 glucose and oxygen → carbon dioxide and water [and energy]

5 when cells do not have enough oxygen

6 glucose → lactic acid [and energy]

7 muscle fatigue and cramp

8 diffusion

9 glucose → ethanol and carbon dioxide [and energy]

10 Anaerobic respiration in microorganisms (fermentation) produces alcohol, which people consume.

11 mitochondria

12 the seven life processes: movement, reproduction, sensitivity, nutrition, excretion, and growth

13 It releases energy.

14 5%

15 the temporary shortage of oxygen in respiring tissues and organs

16 Your body needs to respire more to provide the energy for your muscle cells to keep on exercising. This means you need to breathe faster and deeper to provide oxygen and increase your heart rate to pump this oxygen and more glucose to your muscle cells.

17 the chemical breakdown of glucose into ethanol and carbon dioxide by respiring microorganisms such as yeast

18 the sum of all the chemical reactions that happen in an organism

19 Heat 200 cm^3 of 10% glucose solution to 35°C and add 20 g of baker's yeast. Place in a thermos flask with a thermometer held by a tightly fitting bung. A second hole in the bung relieves pressure inside the flask. Monitor the temperature for the following hour.

20 Photosynthesis is an endothermic reaction, which requires light energy from its surroundings to occur. Respiration is an exothermic reaction, which releases energy to its surroundings.

21 ATP (adenosine triphosphate)

22 in the chemical bonds of the lactic acid

23 It diffuses into your blood and is carried to your liver, where is broken down by an oxidation reaction.

24 any reaction in which a substance gives up electrons, as when reacting with oxygen

25 Place a grasshopper (or similar small invertebrate) into a boiling tube. Use a cotton wool stopper half way down to trap the grasshopper. Place a small amount of soda lime after the cotton wool. Place a bung with a capillary tube running through it into the boiling tube. Insert a small droplet of water into the tube. Observe the position of the droplet in the tube as the grasshopper respires. Repeat using another small invertebrate such as a cricket. Release the insects safely at the end of the experiment.

Practice questions

1 a) i) to provide, release or transfer energy [1 mark]

ii) A Carbon dioxide, C Water [2 marks]

iii) D $C_6H_{12}O_6$ [1 mark]

b) i) B [1 mark]

ii) to absorb carbon dioxide produced [1 mark], so the gas does not affect the movement of the liquid [1 mark]

2 a) 60 beats per minute [1 mark]

b) any three from: to carry the oxygen and glucose; to cells quicker; so more respiration can occur; to release more energy; to allow more muscle contractions, to remove the waste products faster. [3 marks]

c) 125 × 145 = 18 125 [2 marks, 1 for working, 1 for correct answer]

d) two of: increased breathing rate, increased depth for breathing, increased body temperature, dilation of blood vessels [2 marks]

3 a) 'without oxygen' [1 mark]

b) i) C Glucose $\rightarrow$ ethanol and carbon dioxide [1 mark]

ii) humans make lactic acid not alcohol/ethanol [1 mark]

c) increased, fast initially between 0 and 12 hours [1 mark], then slowed production between 12 and 24 hours [1 mark]

4 a) $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$; [2 marks, 1 for molecules correct and 1 for balanced equation]

b) i) lactic acid [1 mark]

ii) The lactic acid is carried back to the liver [1 mark], and oxygen is used to oxidise the lactic acid to produce glucose. [1 mark]

5

Level 3:	A clear description covering the key differences and similarities between aerobic and anaerobic respiration in humans	[5–6 marks]
Level 2:	A number of relevant points made, but not precisely	[3–4 marks]
Level 1:	Fragmented points	[1–2 marks]
	No relevant content	[0 marks]

Indicative content:

- Both designed to release energy.
- Both convert chemical energy.
- Both use glucose as a reactant.
- Both occur in cells.

Aerobic respiration

- requires oxygen
- produces carbon dioxide and water
- releases more energy
- glucose + oxygen $\rightarrow$ carbon dioxide + water
- $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$.

Anaerobic respiration

- occurs without oxygen
- glucose → lactic acid
- produces lactic acid
- releases less energy
- creates an oxygen debt.
- Lactic acid must be later broken down using oxygen.
- Lactic acid is broken down into carbon dioxide and water.

Working scientifically: Dealing with data

Pages 114–115

1–2

Temperature in °C	**Range (1)**	**Mean (2)**
20	345–400	362
35	623–682	651
50	302–520	474
65	105–203	159
80	1–4	2

3 Anomalous results are at temperature 50 °C for Repeat 3: at 65 °C for Repeat 4 and at 55 °C for Repeat 5.

4 Afreen's data

Temperature in °C	**Range**	**Mean**
20	14–20	16.6
35	43–45	44.2
50	4–55	36
65	24–28	25.8
80	1–5	2.6

5 In both students' data the volume of gas produced over 10 minutes increases from 20 °C to 35 °C. It then decreases from 35 °C to 80 °C. This is because 35 °C is closest to the optimal temperature for yeast.

6 Afreen's equipment allowed for more accurate data to be collected because she collected the volume of gas rather than counting the number of bubbles.

7 To allow time for the yeast to adjust to the conditions.

8 To prevent oxygen from reaching the solution, so anaerobic respiration was occurring.

9 Carbon dioxide. Lime water could be used to test for its presence. It would go cloudy if carbon dioxide was present.

Test yourself on prior knowledge

1 A substance made from only one type of atom/a substance that cannot be broken down into simpler substances

2 A substance made from atoms of different elements chemically joined/bonded together

3 In a compound the atoms have been chemically bonded together to make a new substance

4 Metals: conduct heat, conduct electricity, high melting points, shiny when polished, malleable; Non-metals: do not conduct heat, do not conduct electricity, low melting points, dull, brittle

5 In a mixture the substances are not chemically joined; in a compound the elements are chemically joined together

6 Four of: filtration, decanting, crystallisation, distillation, fractional distillation, evaporation, centrifugation, chromatography

Test yourself

1 7.0×10^{-11} m

2 0.025 nm

3 Chlorine

4 1.8×10^{-5} nm; 1.8×10^{-14} m

5 **a)** atom = 2.56×10^{-10} m, wire = 4.40×10^{-4} m

b) 1.72×10^{6} atoms (3 sf)

6 1.69×10^{9} atoms (3 sf)

7 Protons, neutrons, electrons

8 Neutron

9 There is an equal number of protons and electrons

10 15 protons, 16 neutrons, 15 electrons

11 That it has 19 protons

12 Similarities: have 17 protons; have 17 electrons; have same chemical properties

Differences: different mass numbers; ^{35}Cl has 18 neutrons but ^{37}Cl has 20 neutrons

13 $A_r = \frac{[(69 \times 63) + (31 \times 65)]}{69 + 31} = 63.6$

14 $A_r = \frac{[(79 \times 24) + (10 \times 25) + (11 \times 26)]}{79 + 10 + 11} = 24.3$

15 Mass number is the number of protons plus the number of neutrons in an atom so is an integer; relative atomic mass is an average mass taking into the mass and abundance of all the isotopes

16 ^{16}O = 2,6; ^{23}Na = 2,8,1; ^{40}Ca = 2,8,8,2

17 The first shell can only hold two electrons

18 1+

19 3−

20 2,8,8

21 Protons = 9, neutrons = 10, electrons = 10

22 Ions have the same electron structure as Group 0 elements

23 The discovery of the electron

24 The discovery of the nucleus

25 Positive alpha particles would be repelled by positive nucleus

26 a) Non-metal

b) Metal

c) Non-metal

d) Non-metal

e) Non-metal

27 a) Yes – ionic

b) Yes – molecular

c) Yes – molecular

d) Yes – ionic

e) No

f) Yes – molecular

28 Atomic number order

29 a) Group 4

b) Group 1

c) Group 3

30 The properties repeat at regular intervals

31 They have a stable electron structure (so have no need to gain/lose electrons)

32 Although most elements have 8 electrons in their outer shell, helium only has 2 electrons in its outer shell

33 Unreactive, colourless gas, non-metal, non-conductor

34 They have one electron in their outer shell which is easy to lose when they react

35 Potassium + water → potassium hydroxide + hydrogen; $2K + 2H_2O \rightarrow 2KOH + H_2$

36 Potassium hydroxide is formed, which dissolves in water forming an alkaline solution

37 Potassium atoms lose one electron to get a noble gas electron structure and chlorine atoms gain one electron to get a noble gas electron structure

38 Potassium atoms are bigger so the outer shell electron is further from the nucleus. Therefore the attraction between the nucleus and outer electron is weaker, and as a result the outer electron is lost more easily

39 Soft grey metal, low melting point, low density, very reactive, react with non-metals to form ionic compounds, forms 1+ ions, forms white compounds that dissolve in water to give colourless solutions

40 They have seven electrons in their outer shell and it is easy to gain one more when they react

41 Molecules containing two atoms

42 Fluorine will displace chlorine because fluorine is more reactive than chlorine

43 Bromine atoms share electrons with chlorine atoms to get noble gas electron structures – they form molecules when they share electrons

44 Chlorine atoms are smaller so the electron gained is closer to the nucleus. Therefore the attraction between the nucleus and electron gained is greater, and as a result the electron is gained more easily

45 Order of atomic weight

46 To ensure that elements were in groups with other elements with similar properties

47 He predicted that some elements had yet to be discovered

48 He predicted that some new elements would be discovered as well as predicting their properties. These elements were later discovered and their properties closely matched his predictions

49 a) Fractional distillation

b) Filtration

c) (Simple) Distillation

d) Separating funnel

e) Chromatography

Show you can

Page 120

Element	**Atomic number**	**Mass number**	**Number of protons**	**Number of electrons**	**Number of neutrons**
$^{7}_{3}Li$	3	7	3	3	4
$^{24}_{12}Mg$	12	24	12	12	12
$^{27}_{13}Al$	13	27	13	13	14
$^{39}_{19}K$	19	39	19	19	20
$^{107}_{47}Ag$	47	107	47	47	60

Page 121

a) Boron

b) 2,3

c) 11

d) Nucleus

Page 122

a)

Particle	Atomic number	Mass number	Number of protons	Number of neutrons	Number of electrons	Electronic structure
A	18	40	18	22	18	2,8,8
B	13	27	13	14	10	2,8
C	20	40	20	20	20	2,8,8,2
D	17	35	17	18	17	2,8,7
E	16	32	16	16	18	2,8,8
F	17	37	17	20	17	2,8,7

b) There is an equal number of protons and electrons.

c) 2-

d) D and F

Page 124

Plum-pudding model	Nuclear	Modern theory
Ball of positive charge	Nucleus of positive charge	Nucleus with protons and neutrons
Electrons embedded throughout	Electrons in shells	Electrons in shells

Page 126

a) Magnesium: solid, conducts heat, conducts electricity, ductile, malleable; oxygen: gas, insulator, not ductile, not malleable

b) Magnesium oxide

c) Basic

d) Ions

Page 127

a) A

b) B, D

c) C

d) B and C or B and E or D and C or D and E

e) C and E

Page 128

a) It has one electron in the outer shell and hence must be in Group 1. Elements in Group 5 have 5 electrons in their outer shell

b) 11

Page 129

Element	He	Ar
Reactive or unreactive?	Unreactive	Unreactive
Metal or non-metal?	Non-metal	Non-metal
Solid, liquid or gas at room temperature?	Gas	Gas
Electronic structure	2	2,8,8

Page 134

a) E

b) B

c) A

d) D

e) B

Page 136

No noble gases; spaces for undiscovered elements; no lanthanides or actinides; fewer elements

Page 137

A: compound; B: compound; C: mixture of two elements; D: mixture of element and compound

Page 140

	Filtration	Distillation	Fractional distillation
Type of mixture separated	Insoluble solid and liquid	Soluble solid dissolved in liquid	Miscible liquids
Important word and definition	Filtrate – liquid passing through filter paper	Condenser – apparatus used to cool gases to turn them back into liquids	Miscible – liquids that mix
Important word and definition	Residue – solid left in filter funnel	Distillate – the product collected at end of condenser	Fractionating column – keeps different liquids apart as they boil/condense

Practical

Page 134

1 a) Fume cupboard – chlorine is toxic

b) Chlorine is more reactive than iodine so displaces it

c) Potassium chloride and iodine

d) Colourless to brown

e) $Cl_2 + 2KI \rightarrow 2KCl + I_2$

f) Colourless to yellow

2 a) Liquid in which a substance dissolves

b) Hydrocarbon turns purple

Practical

Page 140

1 a) It is soluble (in water)

b) Heat to produce hot water

c) Land may collapse

d) Evaporation

2 A: I; B: iv; C: v

3 a) Contains salt, clay and sand which are not chemically combined

b) Increase the surface area to speed up dissolving

c) To speed up dissolving

d) Salt dissolved in water

e) Clay and sand

f) Some finer sand may have passed through filter paper, or paper may have ripped; refilter (use finer filter paper)

Chapter review questions

1 a) Potassium

b) Nickel

c) Krypton

d) Bromine

e) Silicon

2 a) Group 7

b) Group 1

c) Group 4

d) Group 0

e) Transition metals

f) Group 7

g) Group 7

h) Transition metals

i) Group 1

j) Group 6

k) Group 2

l) Group 0

m) Transition metals

3 a) Example for distillation, e.g. water from salt water

b) Example for filtration, e.g. sand from sand and water

c) Example for crystallisation, e.g. copper sulfate crystals from copper sulfate solution

d) Example for evaporation, e.g. salt from salt water

e) Example for chromatography, e.g. mixture of dyes/food colourings

f) Example for fractional distillation, e.g. alcohol and water

4 a) ${}^{12}_{6}C$ and ${}^{14}_{6}C$

b) ${}^{19}F^{-}$

c) ${}^{16}_{8}O^{2-}$, ${}^{19}_{9}F^{-}$, ${}^{20}_{10}Ne$

d) ${}^{19}_{9}F^{-}$, ${}^{20}_{10}Ne$

e) None

5 2.6×10^{-10} m

6 a) Transfer

b) Share

c) No reaction

d) No reaction

e) Share

f) Transfer

7 a) Group 1 = alkali metals, Group 7 = halogens

b) Electron is transferred from sodium to bromine so that both atoms form ions with noble gas electron structures

c) Potassium atoms are bigger so the outer shell electron is further from the nucleus; so the attraction between the nucleus and outer electron is weaker; so the outer electron is lost more easily

8 a) Iodine was formed

b) $Br_2 + 2I^- \rightarrow 2Br^- + I_2$

c) Bromine is more reactive than iodine. Bromine atoms are smaller than iodine so the electron gained when bromine reacts is closer to the nucleus. Therefore the attraction between the nucleus and electron gained is stronger, and as a result the electron is gained more easily than it is in iodine

9 Step 1: Use a separating funnel to separate the mixture of salt in water from the mixture of cyclohexane and diethyl ether

Step 2: Separate salt from water by (simple) distillation

Step 3: Separate cyclohexane from diethyl ether by fractional distillation

(Steps 2 and 3 can be in either order)

Practice questions

1 A [1 mark]

2 B [1 mark]

3 a) [4 marks]

Particle	Relative charge	Relative mass
Proton	+1	1
Electron	−1	Very small
Neutron	0	1

b) i) Nucleus [1 mark]

ii) Atomic number [1 mark]

iii) Mass number [1 mark]

iv) 13 [1 mark]

4 a) Plum-pudding model – positive ball [1 mark]; with electrons embedded in it [1 mark]. Today's model – nucleus [1 mark]; containing protons and neutrons [1 mark]; electrons in shells [1 mark]

b) i) 11 [1 mark]

ii) 23 [1 mark]

iii) Nucleus [1 mark]

iv) 2,8,1 shown on diagram [1 mark].

c) [6 marks]

Atom/ion	**Number of protons**	**Electronic configuration**
N	7	2, 5
S^{2-}	**16**	**2,8,8**
Ca^{2+}	**20**	**2,8,8**
Mg^{2+}	12	2, 8

5 a) 1 = evaporation, 2 = filtration, 3 = (simple) distillation [3 marks]

b) 3 [1 mark]

c) 2 [1 mark]

d) A = filtrate [1 mark], B = residue [1 mark]

e) Copper(II) chloride is soluble and would pass through the filter funnel [1 mark]

6 a) Chromatography [1 mark]

b) i) There is a spot at the same height as the one for E102 [1 mark]

ii) E160 [1 mark]

iii) A spot drawn at the same height as E160 and directly above orange drink Y label [1 mark]

iv) The ink would separate in the solvent and ruin the chromatogram [1 mark]

7 a) To stop it reacting with water and air [1 mark]

b) Any two of the following: safety screen/use a large volume of water in a trough/use a small piece of the metal/use forceps to lift the metal [2 marks]

c) i) Reactivity increases [1 mark]

ii) Green – due to neutral water [1 mark]; purple due to hydroxide/alkali formed [1 mark].

iii) Fizzing/bubbles [1 mark]

iv) sodium + water → sodium hydroxide + hydrogen [1 mark]

v) $2Na + 2H_2O \rightarrow 2NaOH + H_2$ (correct formulae = 1 mark; balanced = 1 mark)

8 a) number [1 mark]; weight/mass [1 mark]

b) No gaps/more elements/noble gases present/lanthanides and actinides present/transition metal block [any for 1 mark]

c) [6 marks]

Group number	Name of group	Number of electrons in the outer shell of an atom	Reactive or non-reactive?
1	Alkali metals	1	Reactive
7	Halogens	7	Reactive

d) i) It decreases [1 mark]

ii) Lithium [1 mark]

iii) Solid [1 mark]

9 Level 3 answer: describes all key features of Mendeleev's table and clearly explains why his table was accepted [5–6 marks]

Level 2 answer: describes some key features of Mendeleev's table and explains why his table was accepted [3–4 marks]

Level 1 answer: describes a key feature of Mendeleev's table or explains why his table was accepted [1–2 marks]

Indicative content:

- Elements in order of atomic weight/mass
- But prepared to go out of order if properties fitted better
- Properties repeated at (regular) intervals
- Elements in the same group with similar (chemical) properties
- Left gaps for undiscovered elements
- Predicted the properties of undiscovered elements
- New elements were discovered that matched his predictions

Working scientifically: How theories change over time

Pages 145–46

1 A substance that cannot be broken down further by chemical reactions

2 Sulfur, phosphorus, carbon, oxygen, nitrogen, hydrogen, cobalt, mercury tin, copper nickel, iron, gold, lead, silver, zinc, manganese, tungsten, platinum

3 Metallic

4 They react to give oxides which are acidic

5 Calcium oxide, magnesium oxide, barium sulfate, aluminium oxide, silicon dioxide – he did not have equipment which would break them down

6 Group 1 (alkali metals), Group 2, Group 7 (halogens)

7 Yes: Cl = 35.5, Br = 80, I = 127, $\frac{1}{2}$ (35.5 + 127) = 81

8 It only contains genuine elements – no compounds or 'material' elements. It showed periodicity; the elements are in groups where some elements have similar properties

9 More elements in each group; in some groups there are both metals and non-metals, e.g. 5th column

10 It includes noble gases, more elements and no gaps

10 Bonding, structure and the properties of matter

Answers

Test yourself on prior knowledge

1 Solid, liquid, gas

2 a) Melting point

b) Boiling point

c) Melting point

3 a) Two substances with high melting points: e.g., iron, sodium chloride

b) Two substances with low melting points: e.g., iodine, wax

c) Two substances that conduct electricity as a solid: e.g., iron, copper

d) Two substances that do not conduct electricity as a solid: e.g., sodium chloride, sulfur

4 Forces between the particles in a solid are stronger

Test yourself

1 Electrically charged particles with a different number of protons and electrons

2 There is a strong electrostatic attraction between positive and negative ions

3 Ions can move in this state

4 Ions cannot move in this state

5 A regular structure with a massive number of particles that continues in all directions throughout the substance

6 Fe_2O_3, $MgBr_2$

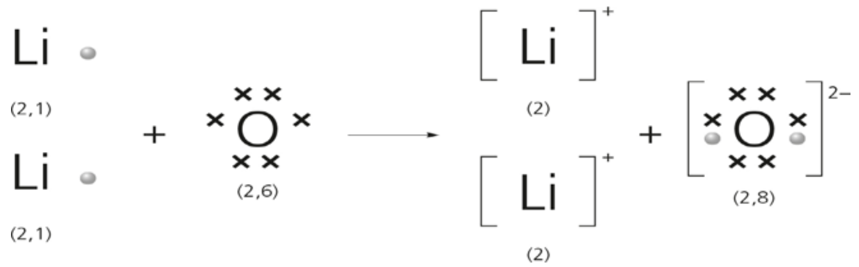
7 Sr^{2+}, At^-, Se^{2-}, Rb^+

8 The ratio of potassium ions to oxide ions is 2 : 1

9 Na_2S, CaF_2, $Mg(OH)_2$, K_2CO_3, $Ba(NO_3)_2$, Cs_2O

10 Electrons are transferred from metal atoms to non-metal atoms to form ions with group 0 electron structures

11



12 Particles containing atoms joined by covalent bonds

13 A covalent bond is two shared electrons that join atoms together

14 There are weak forces between molecules

15 Nothing

16 Molecules are neutral and there are no mobile electrons

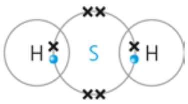
17 H_2S, CO, N_2H_4, C_2H_6O

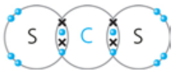
18 There are 6 C and 6 H atoms in each molecule

19 CH; the ratio of C : H is 1 : 1

20 A covalent bond (2 shared electrons)

21 Electrons

22 H—S—H 

23 S=C=S 

24 All the atoms are in a giant lattice with the atoms joined together by covalent bonds in a continuous network throughout the structure

25 Because there are lots of strong covalent bonds to break

26 They do not contain any delocalised electrons (except graphite that does)

27 The attraction between the nucleus of metals atoms and delocalised (outer shell) electrons

28 Strong attraction between nucleus of metals atoms and delocalised (outer shell) electrons/strong metallic bonding

29 The outer shell electrons are delocalised and can carry charge through the metal

30 Layers of atoms can slide over each other while maintaining the metallic bonding

31 Mixture of metals with small amounts of other elements

32 There are different sized atoms and so it is more difficult for layers to slide over each other

33 **a)** Ionic, ionic

b) Covalent, giant covalent

c) Ionic, ionic

d) Covalent, molecular

e) None, monatomic

f) Metallic, metallic

34 **a)** D

b) A

c) B, E

d) B

35 Lots of strong covalent bonds need to be broken

36 Diamond: has a rigid, continuous network of atoms linked by covalent bonds; graphite: atoms are arranged in layers – there are strong covalent bonds within the layers but the layers are not joined together

37 Diamond: has no delocalised electrons; graphite: has some delocalised electrons

38 Molecules of carbon atoms linked in rings to form a hollow sphere or tube

39 Due to structure composed of many atoms linked by strong covalent bonds

40 $0.12 / 1 \times 10^{-9} = 120\,000\,000 = 1.2 \times 10^{8}$

Show you can

Page 150

a) BA_2

b) Strong electrostatic forces of attraction between oppositely charged ions

c) Giant ionic lattice. Properties: high melting and boiling point, conducts electricity when molten or dissolved

Page 152

Name of compound	Formula of positive ion in compound	Formula of negative ion in compound	Formula of compound	What the numbers in the formula represent
Copper(II) carbonate	Cu^{2+}	CO_3^{2-}	$CuCO_3$	1 copper, 1 carbon, 3 oxygens
Copper(II) hydroxide	Cu^{2+}	OH^-	$Cu(OH)_2$	1 copper, 2 oxygens, 2 hydrogens
Copper(II) nitrate	Cu^{2+}	NO_3^-	$Cu(NO_3)_2$	1 copper, 2 nitrogens, 6 oxygens
Copper(II) oxide	Cu^{2+}	O^{2-}	CuO	1 copper, 1 oxygen
Copper(II) sulfate	Cu^{2+}	SO_4^{2-}	$CuSO_4$	1 copper, 1 sulfur, 4 oxygens
Copper(II) sulfide	Cu^{2+}	S^{2-}	CuS	1 copper, 1 sulfur

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a) Magnesium has two electrons in the outer shell which are lost, causing it to become Mg^{2+}. The electrons move to the oxygen atom which has six electrons in the outer shell, so it gains 2 electrons and becomes O^{2-}

b) Magnesium has two electrons in the outer shell which are lost, causing it to become Mg^{2+}. One electron moves to one fluorine atom which has seven electrons in the outer shell, so it gains 1 electron and becomes F^-. The other magnesium electron also moves to another fluorine atom forming a second F^-

c) Similarities – for both compounds magnesium loses two electrons and forms an Mg^{2+}. Differences – for each magnesium ion formed, one oxide ion is formed with 2– charge, but two fluoride ions are formed each with 1– charge

Page 155

Sulfur dioxide: made of molecules with weak intermolecular forces between the molecules which require little energy to break

Calcium oxide: made of ions with strong attraction between positive and negative ions which require a lot of energy to break

Page 156

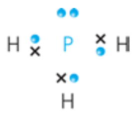
a)

Substance	**Empirical formula**
C_2H_6	CH_3
$C_{21}H_{22}N_2O_2$	$C_{21}H_{22}N_2O_2$
$C_2H_4O_2$	CH_2O

b) Sometimes they are the same (e.g. $C_{21}H_{22}N_2O_2$) as the ratio of atoms cannot be any simpler than what is in the molecular formula

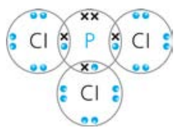
Page 157

a)



b) PCl_3

c)



d) There are three covalent bonds ×•; there is one non-bonding pair of electrons on P ××; there are three non-bonding pairs of electrons on each Cl ••. Covalent bonding electrons are shared between atoms (shown as within the overlapping sections). Non-bonding pairs are not involved in bonding and are not shared between atoms.

Page 160

a)

Substance	**Type of bonding**	**Structure**
Carbon dioxide	Covalent	Molecular
Silicon dioxide	Covalent	Giant covalent

b) SiO_2: All the atoms in silicon dioxide are linked to other atoms by strong covalent bonds in a giant structure. Many strong bonds must be broken to make it melt and this takes much energy

CO_2: In carbon dioxide the weak forces between molecules do not take much energy to overcome and so it has a low melting point

Page 162

a) Outer shell electrons are delocalised and so can move and carry charge

b) Low density, ductile

c) The layers of atoms can slide over each other while maintaining the metallic bonding and so it can be hammered into different shapes

d) In aluminium, the delocalised electrons move and carry charge. In aluminium oxide, the ions can only move and carry charge when it is molten

Page 164

a) E: high melting and boiling point, conducts when molten liquid but not as solid

b) B; low melting and boiling point, does not conduct

c) It conducts electricity and diamond is an insulator

d) C

Page 166

a)

Substance	**Melting point/°C**	**Boiling point/°C**	**Type of bonding present**
N_2	−210	−196	Covalent
CS_2	−112	46	Covalent
NH_3	−78	−34	Covalent
Br_2	−7	59	Covalent
LiCl	605	1137	Ionic
Cu	1084	2562	Metallic

b) **i)** Cu

ii) CS_2

iii) NH_3

iv) Br_2

v) NH_3

Page 169

	Graphite	**Diamond**	**Graphene**	**Fullerenes**	**Carbon nanotubes**
Description of structure	Each C forms three covalent bonds with three carbon atoms forming layers of hexagonal rings; one electron per carbon is delocalised. The layers are not bonded to each other	Each C forms four bonds to other C atoms in giant, continuous network	Single layer of graphite which is one atom thick	Molecules of C atoms with hollow shapes made from hexagonal rings of C atoms but also with some rings of 5 or 7 C atoms	Long tubes of C atoms joined by covalent bonds
Example of use	Pencils Electrodes	Saw tips Drills	Improving the performance of fuel cells	Drug delivery	Reinforcing sports equipment

Practical

Page 159

1 Place the sample to be tested in the beaker, ensure the electrodes do not touch. Switch on the power pack and record if the bulb lights up. Wash out the beaker thoroughly and repeat with the next solution.

2

Test solution	**Does the bulb light?**	**Does the substance conduct electricity?**	**Does the substance contain ionic or covalent bonding?**
Copper(II) sulfate	Yes	Yes	Ionic
Ethanol (C_2H_5OH)	No	No	Covalent
Magnesium sulfate	Yes	Yes	Ionic
Potassium iodide	Yes	Yes	Ionic
Glucose ($C_6H_{12}O_6$)	No	No	Covalent
Sodium chloride	Yes	Yes	Ionic

3 Ionic solutions conduct electricity because the ions can move and carry charge. Covalent substances do not conduct electricity as there are no free charge carriers.

4 Yes. Solid copper(II) sulfate would not conduct electricity and the bulb would not light up as the ions are held tightly by ionic bonds and cannot move.

5 Calcium nitrate solution conducts and the bulb lights as the ions can move.

6 Bromine cannot conduct and the bulb does not light as there are no charge carriers.

Activity

Page 162–63

1 Good electrical conductivity

2 Metallic bonding: strong attraction between the nucleus of metal atoms and delocalised electrons

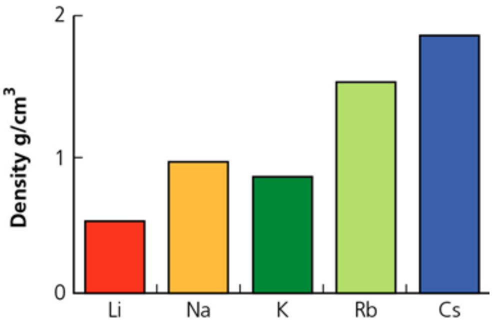
3 Change from solid to liquid on heating

4 Decreases

5 Li= 2,1, Na = 2,8,1, K = 2,8,8,1. The distance of the outer electron from the nucleus increases so the attraction between the delocalised electrons and the nucleus of the metal atoms decreases as the group is descended. As a result the metallic bond is weaker and less energy is needed to break it.

6 Increases

7



8 Li, Na, K will as their density is less than that of water.

Chapter review questions

1 a) Molecular

b) Metallic

c) Ionic, metallic

2 a) Weak forces between molecules

b) Molecules are neutral and there are no delocalised electrons

3 a) Strong attraction between nucleus of atoms and delocalised outer shell electrons

b) Outer shell electrons are delocalised and able to carry charge

c) Layers of atoms can slide over each other while keeping the metallic bonding

d) There are some different sized atoms that make it more difficult for the layers to slide over each other

4 a) 2,8,8

b) 2,8

c) KF

d) Strong attraction between positive and negative ions

e) Ions cannot move

f) Ions can move and carry charge through the substance in this state

5 a) Metallic

b) Molecular

c) Giant covalent

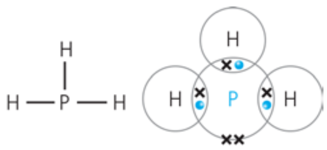
d) Ionic

e) Molecular

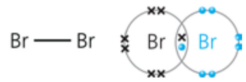
f) Ionic

6 A: ionic; B: molecular; C: metallic; D: ionic; E: giant covalent; F: metallic

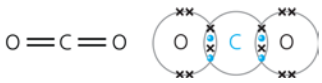
7 a)



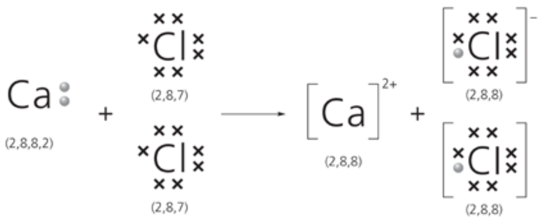
b)



c)



8



9 a) K_2O

b) MgF_2

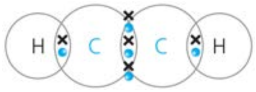
c) Li_2S

d) $Fe_2(SO_4)_3$

e) $Cu(OH)_2$

10 a) There are 2 C atoms and 2 H atoms in each molecule

b) 

c) 

11 a) 3

b) One electron on each C atom that is not used in bonding; these become delocalised and carry electric charge through the nanotube

c) Lots of strong covalent bonds would need to be broken to break the structure

Practice questions

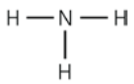
1 B [1 mark]

2 D [1 mark]

3 a) Ammonia [1 mark], NH_3 [1 mark]

b) i) Covalent bond is any ×• [1 mark]

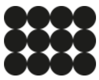
ii) Non-bonded pair is •• [1 mark]

c)  [1 mark]

d) Shared [1 mark] pair of electrons [1 mark]

4 a) A: melting; B: condensation; C: evaporation/boiling [3 marks]

b) B [1 mark]

c)  [1 mark]

d) No forces between the spheres [1 mark], atoms, molecules and ions are not solid spheres [1 mark]

e) The amount of energy needed to change from solid to liquid [1 mark] depends on the strength of the forces / bonds between particles [1 mark]

5 a) A, B [2 marks]

b) A: diamond; B, graphite; C: silicon dioxide; D: carbon dioxide [4 marks]

c) A: Covalent [1 mark], B: Covalent [1 mark], C: Covalent [1 mark], D: Covalent [1 mark]

d) A: giant covalent; B, giant covalent, C, giant covalent; D, molecular [4 marks]

6 a) Carbon atoms are in layers [1 mark], with weak forces between layers [1 mark], layers can slip off [1 mark]

b) One electron per carbon [1 mark] free to move/delocalised and carry charge [1 mark]

c) Electrons transferred from sodium to chlorine [1 mark], each sodium atom loses one electron and each chlorine atom gains one electron [1 mark], forms ions Cl^- and Na^+ [1 mark]

d) In solution ions can move and carry charge [1 mark]; in solid ions cannot move [1 mark]

7 Level 3 answer: describes and explains each of these three properties: high melting points, conductivity as solid and conductivity when molten [5–6 marks]

Level 2 answer: describes and explains two of these three properties: high melting points, conductivity as solid and conductivity when molten [3–4 marks]

Level 1 answer: describes and explains one of these three properties: high melting points, conductivity as solid and conductivity when molten [1–2 marks]

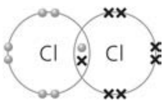
Similarities:

- Both have high melting points
- Due to strong bonds between positive and negative ions in magnesium chloride
- And between the nucleus of metal atoms and delocalised electrons in magnesium

Differences:

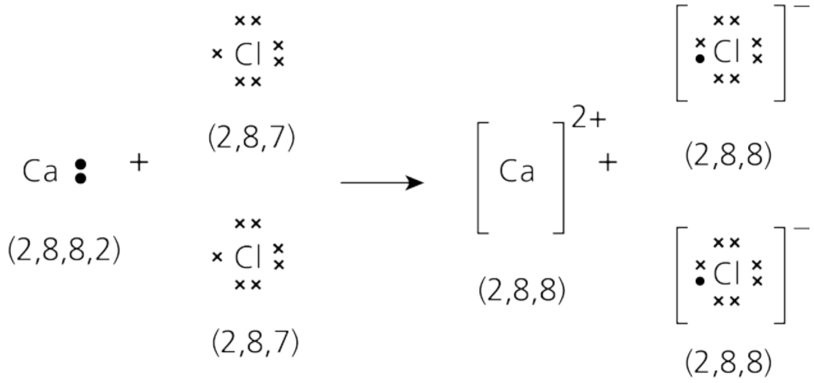
- Magnesium is a good conductor due to the delocalised electrons which can move and carry charge
- Magnesium chloride can only conduct when molten
- Because only then can the ions move and carry charge
- Mg conducts due to electron movement while magnesium chloride conducts due to ion movement

8 a) i) Two atoms covalently bonded together in a molecule [1 mark]

ii) 

[2 marks]

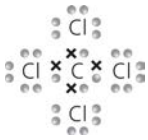
b) i)



[1 mark for Ca as 2,8,8,2 and Cl as 2,8,7; 1 mark for showing 1Ca and 2 Cl; 1 mark for showing Ca^{2+} as 2,8,8 and Cl^- as 2,8,8]

ii) Ionic [1 mark]

iii) Giant ionic lattice [1 mark]

iv)  [1 mark for four covalent bonds; 1 mark for rest of structure]

v) Covalent [1 mark]

c) [2 marks with 1 mark for each column]

Compound	Solubility in water	Relative melting point
Calcium chloride	Soluble	High
Tetrachloromethane	Insoluble	Low

d) Calcium: electrons in outer shell of metal atoms are delocalised [1 mark], strong attraction [1 mark], between the nucleus of metal atoms and delocalised electrons [1 mark]

Graphite: each carbon forms three covalent bonds [1 mark], to three carbon atoms [1 mark], one electron from each carbon is delocalised [1 mark]

e) Calcium is malleable [1 mark], calcium is ductile [1 mark]

f) B They are hollow [1 mark]

g) A They have a large surface area to volume ratio [1 mark]

Working scientifically: Units: Using prefixes and powers of ten for orders of magnitude

Page 174–75

1 a) 2.4×10^{-4}

b) 3.23×10^{9}

c) 2×10^{-2}

d) 7×10^{-9}

e) 2.4×10^{4}

2 a) 0.0023

b) 460 000

c) 0.000095

d) 53 400

e) 3300

3 a) 31 Mm

b) 1 mg

c) 9.7 km

d) 2 ns

Test yourself on prior knowledge

1 1 molecule of CH_4 reacts with two molecules of O_2 to make one molecule of CO_2 and two molecules of H_2O

2 The total mass of the reactants equals the total mass of the products

3 36 g

4 Protons = 19, neutrons = 20, electrons = 19

Test yourself

1 a) 17

b) 59

c) 58

d) 74

e) 213

2 a) 56 g

b) 32 g

c) 30 g

d) 74.5 g

e) 164 g

3 a) Same

b) Same

c) He atoms

4 a) 20 000 g

b) 0.005 g

c) 300 000 g

5 a) 96 g

b) 4.6 g

6 a) 25 mol

b) 40 mol

c) 0.000 50 mol

d) 35 700 mol

7 60

8 a) 35 (2 sf), 34.8 (3 sf), 34.82 (4 sf)

b) 29 000 000 (2 sf), 28 600 000 (3 sf), 28 550 000 (4 sf)

c) 0.023 (2 sf), 0.023 2 (3 sf), 0.023 19 (4 sf)

d) 0.000 63 (2 sf), 0.000 632 (3 sf), 0.000 6319 (4 sf)

9 a) 25.3 cm^3 (3 sf)

b) 170 (3 sf)

c) 1.68 g (3 sf)

10 a) Two molecules of H_2 react with one molecule of O_2 to form two molecules of H_2O

b) Sum of M_r of reactants = 2(2) + 32 = 36; sum of M_r of products = 2(18) = 36

11 a) Gains/combined with oxygen

b) The total mass of the reactants equals the total mass of the products

c) Total mass of copper plus oxygen = total mass of copper oxide produced

12 0.44 g of carbon dioxide given off into the air as the nickel carbonate decomposes

13 a) 5 mol

b) 6 mol

c) 0.15 mol

d) 5 mol

14 a) 16 mol

b) 2.5 mol

c) 2 mol

d) 0.65 mol

15 a) 10 mol

b) 6 mol

c) 0.5 mol

d) 4.5 mol

16 80 g

17 14 g

18 5 g

19 0.2 g

20 529 g (to 3 sf)

21 2.26 g (to 3 sf)

22 $2H_2O_2 \rightarrow 2H_2O + O_2$

23 $Ca + F_2 \rightarrow CaF_2$

24 $2Ni + O_2 \rightarrow 2NiO$

25 $2Ca(NO_3)_2 \rightarrow 2CaO + 4NO_2 + O_2$

26 $2K + Br_2$

27 $TiCl_4 + 4Na$

28 a) 5 mol

b) 2 mol

c) 0.3 mol

29 a) 2 mol

b) 2 mol

c) 8 mol

30 a) 1.5 mol

b) 0.15 mol

c) 0.5 mol

31 14.4 g

32 0.48 g

33 7.12 g

Show you can

Page 178

a) 2 oxygens, relative formula mass = 44

b) $Ca(NO_3)_2$, 6 oxygens, relative formula mass = 164

c) 54 = 16 + 2x, therefore x = 19, F

Page 180

Moles $= \frac{\text{mass}}{M_r}$; mass = M_r × moles; $M_r = \frac{\text{mass}}{\text{moles}}$

a) $\frac{9.8}{98} = 0.1$

b) 0.5 × 74 = 37 g

c) $\frac{6.9}{0.05} = 138$, 138 = 2Y + 12 + (3 × 16), 2Y = 78, Y = 39, K

Page 186

a) In the equation $C + O_2 \rightarrow CO_2$ 1 mole of C <u>atoms</u> reacts with 1 mole of O_2 <u>molecules</u> to form 1 mole of CO_2 <u>molecules</u>

b) **i)** In the equation $C_2H_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ 1 mole of C_2H_4 molecules reacts with 2 moles of O_2 molecules to form 1 mole of CO_2 molecules and 2 moles of H_2O molecules

ii) In the equation $Be + Cl_2 \rightarrow BeCl_2$ 1 mole of Be atoms reacts with 1 mole of Cl_2 molecules to form 1 mole of $BeCl_2$ molecules

iii) In the equation $C_xH_y + 3O_2 \rightarrow 2CO_2 + 2H_2O$ 1 mole of C_xH_y molecules reacts with 3 moles of O_2 molecules to form 2 moles of CO_2 molecule and 2 moles of H_2O molecules

c) $x = 2$, $y = 4$

Page 188

a) 84

b) $\frac{4.2}{84} = 0.05$

c) 0.025 mol

d) 0.025 × 106 = 2.65 g

Page 192

Moles CaO = $\frac{84}{56}$ = 1.5

Moles C = $\frac{48}{12}$ = 4

Reagent in excess = CaO

Moles CaC_2 formed = 1.33

Moles CaC_2 = 1.33 × 64 = 85.3 g

Practical

Page 182

1 a) 17.36 − 16.34 = 1.02 g

b) 18.04 − 16.34 = 1.70 g

c) 1.70 − 1.02 = 0.68 g

2 The law of conservation of mass states that no atoms are lost or made in a chemical reaction so the mass of products (1.70 g) equals the mass of reactants (1.02 + 0.68 = 1.70 g)

3 To allow oxygen in to react with the titanium

4 Mass of container, mass of container and titanium

5 Mass would increase due to titanium oxide forming/oxygen combining with titanium

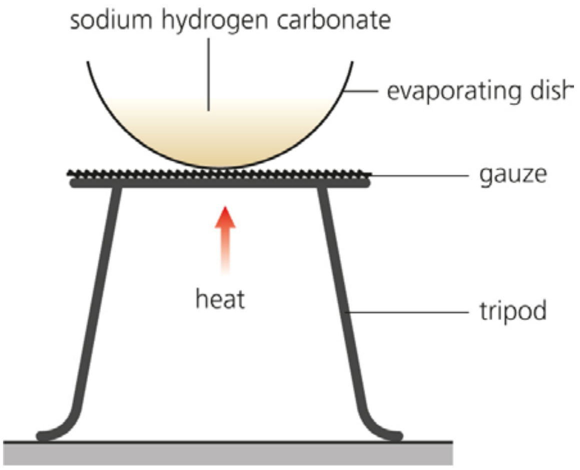
6 Allow the container to cool before weighing and so prevent burns, wear eye protection

7 Repeat the experiment or get someone else to do the experiment

Practical

Page 189

1



2 Moles $NaHCO_3 = \frac{8.01}{84} = 0.0954$

3 a) Moles NaOH = 0.0954

b) Moles Na_2CO_3 = 0.0477

c) Moles Na_2O = 0.0477

4 a) $0.0954 \times 40 = 3.81$ g

b) $0.0477 \times 106 = 5.05$ g

c) $0.0477 \times 62 = 2.96$ g

5 The correct equation is equation 2

6 Carbon dioxide gas and water vapour have been lost

Chapter review questions

1 a) 32

b) 44

c) 120

d) 164

2 a) M_r of reactants = 4(23) + 32 = 124; M_r of products = 2(62) = 124

b) 15.5 g

3 Given off as (carbon dioxide) gas.

4 a) 39 g

b) 28 g

c) 342 g

5 a) 198.8 g

b) 1.6 g

6 a) 0.075 mol

b) 62.5

c) 6250 mol

d) 1.28×10^{-4} mol

7 a) 36 g

b) 8 g

8 30 g

9 2960 g (to 3 sf)

10 mol $NaNO_3$ = 0.02, mol $NaNO_2$ = 0.02, mol O_2 = 0.01; $2NaNO_3 \rightarrow 2NaNO_2 + O_2$

11 a) 5 mol

b) 7.5 mol

c) 10 mol

12 20.8 g (to 3 sf)

Practice questions

1 A [1 mark]

2 B [1 mark]

3 a) PbS = 239, Fe_2O_3 =160, $CaMg(CO_3)_2$ = 184 [3 marks]

b) 27 [1 mark], Al [1 mark]

c) i) No atoms are lost or made during a chemical reaction so the mass of the products equals the mass of the reactants [1 mark]

ii) M_r Fe_2O_3 = 160, CO = 28, Fe = 56, CO_2 = 44

reactants = 160 + 3(28) = 244

products = 2(56) + 3(44) = 244 [2 marks]

4 a) 152 [1 mark]

b) 152 g [1 mark]

c) $\frac{200}{1000}$ = 0.200 g [1 mark] moles = $\frac{0.200}{152}$ = 0.00132 [1 mark]

5 a) moles = $\frac{4780}{239}$ = 20

Ratio 1 : 1; moles PbO = 20

Mass PbO = 20 × 223 = 4460 g [3 marks]

b) Moles Pb = 20

Mass Pb = 20 × 207 = 4140 g [2 marks]

6 a) M_r = 84 [1 mark], $\frac{3.36}{84}$ = 0.04 [1 mark]

b) 0.02 [1 mark]

c) M_r = 106 [1 mark], 0.02 × 106 = 2.12 g [1 mark]

7 Moles $ZnCO_3$ = $\frac{2.5}{125}$ = 0.02

Moles $ZnSO_4$ = 0.02

Mass $ZnSO_4$ = 0.02 × 161 = 3.22 g [3 marks]

8 a) M_r = 138 [1 mark], $\frac{4}{138}$ = 0.0290 [1 mark]

b) M_r = 102 [1 mark], $\frac{6.5}{102}$ = 0.0637 [1 mark]

c) 0.0290 [1 mark]

d) M_r = 180 [1 mark], 0.0290 × 180 = 5.22 g [1 mark]

Working scientifically: Interconverting units

Pages 197–98

1 a) 0.025 dm^3

b) 0.1 dm^3

c) 10 000 cm^3

d) 0.020 m^3

e) $24\ dm^3$

2 a) 0.025 kg

b) 1.032 tonnes

c) 10 000 kg

d) 0.043 g

e) 6 130 000 g

f) 300 g

3 a) $0.05\ dm^3$

b) 0.032 tonnes

c) $22\ dm^3$

d) 700 g

e) 2 450 000 g

f) $0.012\ dm^3$

Test yourself on prior knowledge

1 Two reactive metals, e.g. sodium, calcium, magnesium

2 Two unreactive metals, e.g. copper, silver, gold

3 Electrolysis

4 a) Hydrogen

b) Carbon dioxide

5 a) Alkaline

b) Acidic

c) Neutral

d) Acidic

Test yourself

1 a) calcium + oxygen → calcium oxide

b) gold + oxygen *no reaction*

c) copper + water *no reaction*

d) lithium + water → lithium hydroxide + water

e) calcium + nitric acid → calcium nitrate + hydrogen

f) copper + sulfuric acid *no reaction*

g) zinc + hydrochloric acid → zinc chloride + hydrogen

h) iron + sulfuric acid → iron sulfate + hydrogen

i) tin + magnesium chloride *no reaction*

j) zinc + lead nitrate → zinc nitrate + lead

k) magnesium + aluminium sulfate → magnesium sulfate + aluminium

2 a) Magnesium + oxygen → magnesium oxide

b) $2Mg + O_2 \rightarrow 2MgO$

c) Mg atoms lose electrons to form Mg^{2+} ions

3 a) Fizzing and white solid forms

b) Calcium + water → calcium hydroxide + water

c) $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$

d) Ca atoms lose electrons to form Ca^{2+} ions

4 a) i) Magnesium

ii) Greater tendency to form ions/loses electrons more easily

b) i) Magnesium + sulfuric acid → magnesium sulfate + hydrogen

ii) $Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$

5 a) Aluminium is more reactive than chromium

b) Aluminium

c) Chromium oxide

6 a) Rubidium + water → rubidium hydroxide + water

b) $2Rb + 2H_2O \rightarrow 2RbOH + H_2$

c) Rb atoms lose electrons to form Rb^+ ions

d) Oxidised as they lose electrons

7 a) Mg gains oxygen

b) $Mg - 2e^- \rightarrow Mg^{2+}$ or $Mg \rightarrow Mg^{2+} + 2e^-$

c) Mg loses electrons

d) CuO loses oxygen

e) $Cu^{2+} + 2e^- \rightarrow Cu$

f) Cu^{2+} gains electrons

8 a) $Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$

$Cu^{2+} + 2e^- \rightarrow Cu$

$Zn - 2e^- \rightarrow Zn^{2+}$ (or $Zn \rightarrow Zn^{2+} + 2e^-$)

b) $Zn + 2Ag^+ \rightarrow Zn^{2+} + 2Ag$

$Ag^+ + e^- \rightarrow Ag$

$Zn - 2e^- \rightarrow Zn^{2+}$ (or $Zn \rightarrow Zn^{2+} + 2e^-$)

c) $2Al + 3Cu^{2+} \rightarrow 2Al^{3+} + 3Cu$

$Cu^{2+} + 2e^- \rightarrow Cu$

$Al - 3e^- \rightarrow Al^{3+}$ (or $Al \rightarrow Al^{3+} + 3e^-$)

9 a) Zinc + iron sulfate → zinc sulfate + iron

b) $Zn + FeSO_4 \rightarrow ZnSO_4 + Fe$

c) $Zn + Fe^{2+} \rightarrow Zn^{2+} + Fe$

d) $Fe^{2+} + 2e^- \rightarrow Fe$ and $Zn - 2e^- \rightarrow Zn^{2+}$ (or $Zn \rightarrow Zn^{2+} + 2e^-$)

e) $Fe^{2+} + 2e^- \rightarrow Fe$

f) $Zn - 2e^- \rightarrow Zn^{2+}$ (or $Zn \rightarrow Zn^{2+} + 2e^-$)

g) Both reduction and oxidation take place

10 a) Magnesium + silver nitrate → magnesium nitrate + silver

b) $Mg + 2AgNO_3 \rightarrow Mg(NO_3)_2 + 2Ag$

c) $Mg + 2Ag^+ \rightarrow Mg^{2+} + 2Ag$

d) $Ag^+ + e^- \rightarrow Ag$ and $Mg - 2e^- \rightarrow Mg^{2+}$ (or $Mg \rightarrow Mg^{2+} + 2e^-$)

e) $Ag^+ + e^- \rightarrow Ag$

f) $Mg - 2e^- \rightarrow Mg^{2+}$ (or $Mg \rightarrow Mg^{2+} + 2e^-$)

g) Both reduction and oxidation take place

11 a) Low reactivity

b) Rock from which a metal can be extracted for profit

12 a) Heat with carbon

b) Electrolysis

c) Electrolysis

d) Found as an element

e) Heat with carbon

13 a) Tin oxide + carbon → tin + carbon monoxide/dioxide

b) Tin oxide loses oxygen (or tin ions gain electrons)

14 a) Alkaline

b) Acidic

c) Acidic

d) Neutral

15 a) 13

b) 1

16 a) Universal indicator solution, pH probe

b) pH probe

17 a) H^+

b) OH^-

18 a) C

b) B has a concentration of H^+ ions that is 10 times greater than A

c) C has a concentration of H^+ ions that is 1000 times greater than A

19 Concentration of H^+ ions = concentration of OH^- ions

20 a) An acid where all the molecules break down into ions when added to water

b) An acid where only a small fraction of the molecules break down into ions when added to water

21 a) calcium + hydrochloric acid → calcium chloride + hydrogen

b) tin + sulfuric acid → tin sulfate + hydrogen

c) barium hydroxide + nitric acid → barium nitrate + water

d) lithium hydroxide + hydrochloric acid → lithium chloride + water

e) nickel oxide + nitric acid → nickel nitrate + water

f) magnesium oxide + sulfuric acid → magnesium sulfate + water

g) potassium carbonate + nitric acid → potassium nitrate + water + carbon dioxide

h) zinc carbonate + hydrochloric acid → zinc chloride + water + carbon dioxide

22 a) Hydrogen

b) Carbon dioxide

23 a) Aqueous/dissolved in water

b) $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

c) Produces OH^- in water

24 $Ca + 2HCl \rightarrow CaCl_2 + H_2$

$LiOH + HCl \rightarrow LiCl + H_2O$

$MgO + H_2SO_4 \rightarrow MgSO_4 + H_2O$

$K_2CO_3 + 2HNO_3 \rightarrow 2KNO_3 + H_2O + CO_2$

25 a) Hydrochloric acid + calcium/calcium oxide/calcium hydroxide/calcium carbonate

b) Nitric acid + copper oxide/copper hydroxide/copper carbonate

c) Sulfuric acid + aluminium/aluminium oxide/aluminium hydroxide/aluminium carbonate

26 a) As people are going to take the tablets

b) To use up all the acid

c) Filter

d) Iron + sulfuric acid → iron sulfate + hydrogen

e) $Fe + H_2SO_4 \rightarrow FeSO_4 + H_2$

27 a) Solution in which no more solute can be dissolved at that temperature

b) Nickel nitrate becomes less soluble as it cools and so it cannot all stay dissolved

28 a) Copper does not react with hydrochloric acid acid / copper has low reactivity / copper is less reactive than hydrogen

b) i) copper oxide + hydrochloric acid → copper chloride + water

copper hydroxide + hydrochloric acid → copper chloride + water

copper carbonate + hydrochloric acid → copper chloride + water + carbon dioxide

ii) $CuO + 2HCl \rightarrow CuCl_2 + H_2O$

$Cu(OH)_2 + 2HCl \rightarrow CuCl_2 + H_2O$

$CuCO_3 + 2HCl \rightarrow CuCl_2 + H_2O + CO_2$

29 a) Because the ions can move in this state

b) Because the ions cannot move in this state

30

Ionic compound (molten)	**Product at the negative electrode (cathode)**	**Product at the positive electrode (anode)**
Potassium iodide (KI)	Potassium	Iodine
Zinc bromide ($ZnBr_2$)	Zinc	Bromine
Magnesium oxide (MgO)	Magnesium	Oxygen

31 a) Lose electrons

b) Gain electrons

c) Ions

d) Electrons

32 a) Liquid or solution that conducts electricity

b) Electrode where oxidation takes place (positive electrode in electrolysis)

c) Electrode where reduction takes place (negative electrode in electrolysis)

33 a) $Cu^{2+} + 2e^- \rightarrow Cu$, reduction

b) $2I^- - 2e^- \rightarrow I_2$, oxidation

c) $2F^- \rightarrow F_2 + 2e^-$, oxidation

d) $Fe^{3+} + 3e^- \rightarrow Fe$, reduction

34 a) $2O^{2-} - 4e^- \rightarrow O_2$

b) $K^+ + e^- \rightarrow K$

35 a) Metal is more reactive than carbon; metal may react with carbon

b) Two reactive metals, e.g. sodium, potassium, calcium, magnesium, lithium

c) Heat energy for high temperature to melt mixture, electricity for electrolysis

36 a) Aluminium oxide

b) To lower its melting point and lower heat energy costs

c) Oxide ions lose electrons to form oxygen

d) Aluminium ions gain electrons to form aluminium

e) Graphite/carbon

f) Reacts/burns with the oxygen to form carbon dioxide

37

Ionic compound (aqueous)	**Product at the negative electrode (cathode)**	**Product at the positive electrode (anode)**
Potassium iodide (KI)	Hydrogen	Iodine
Copper(II) chloride ($CuCl_2$)	Copper	Chlorine
Magnesium sulfate ($MgSO_4$)	Hydrogen	Oxygen
Copper(II) nitrate ($Cu(NO_3)_2$)	Copper	Oxygen
Zinc bromide ($ZnBr_2$)	Hydrogen	Bromine

38 a) $2Br^- - 2e^- \rightarrow Br_2$, oxidation

b) $2H^+ + 2e^- \rightarrow H_2$, reduction

39 a) $4OH^- - 4e^- \rightarrow 2H_2O + O_2$, oxidation

b) $Cu^{2+} + 2e^- \rightarrow Cu$, reduction

Show you can

Page 204

a) Mg, Zn, Ni, Cu

b) $NiO + Mg \rightarrow MgO + Ni$

c) i) Nickel + hydrochloric acid → nickel chloride + hydrogen

$Ni + 2HCl \rightarrow NiCl_2 + H_2$

ii) Zinc + water *no reaction*

iii) Nickel + water *no reaction*

iv) Zinc + sulfuric acid → zinc sulfate + hydrogen

$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

v) Magnesium + zinc oxide → magnesium oxide + zinc

$Mg + ZnO \rightarrow MgO + Zn$

Page 207

a) CH_4

b) CuO is reduced as it has lost oxygen

c) H_2 is oxidised as it has gained oxygen

d) $Cu^{2+} + Mg \rightarrow Cu + Mg^{2+}$

$Mg \rightarrow Mg^{2+} + 2e^-$

Magnesium is oxidised as it has lost electrons to form magnesium ions

Page 209

a) Gold

b) Two of: sodium, zinc, copper

c) Carbon or hydrogen

d) Sodium

Page 210

a) pH meter probe

b) 4 minutes

c) 8 minutes

Page 212

a) Compare the colour with the universal indicator colour chart

b) A = acidic, B = acidic

c) More H^+ ions in solution so a lower pH. Indicator colours would be the same

d) Gives the pH rather than just whether a solution is acidic or alkaline

Page 215

a) Sodium hydroxide + sulfuric acid → sodium sulfate + water

$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$

b) A, contains sodium carbonate which reacts with acid

c) Carbon dioxide

d) Bubble into limewater – colourless to cloudy

e) Na_2SiO_3

Page 217

a) A Magnesium + hydrochloric acid → magnesium chloride + hydrogen

B Magnesium oxide + hydrochloric acid → magnesium chloride + water

C Magnesium hydroxide + hydrochloric acid → magnesium chloride + water

D Magnesium carbonate + hydrochloric acid → magnesium chloride + water + carbon dioxide

b) Bubbles, magnesium carbonate used up/disappears

Page 220

	Anode	**Cathode**
Product	Chlorine	Lithium
Observation	Bubbles	Molten grey solid
Half equation	$2Cl^- - 2e^- \rightarrow Cl_2$ or $2Cl^- \rightarrow Cl_2 + 2e^-$	$Li^+ + e^- \rightarrow Li$
Oxidation or reduction	Oxidation	Reduction

Page 221

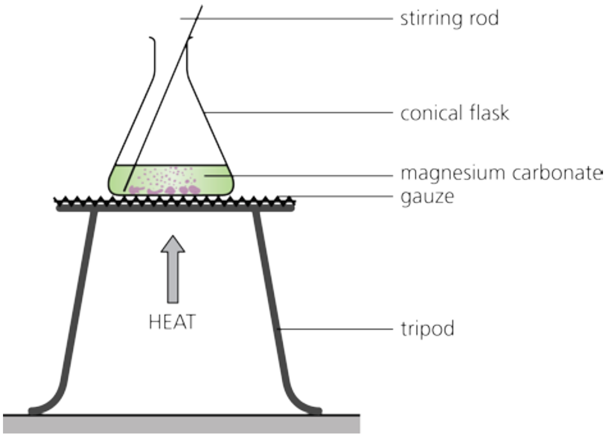
	Anode	**Cathode**
Product	Oxygen (and carbon dioxide)	Aluminium
Half equation	$2O^{2-} - 4e^- \rightarrow O_2$ or $2O^{2-} \rightarrow O_2 + 4e^-$	$Al^{3+} + 3e^- \rightarrow Al$
Oxidation or reduction	Oxidation	Reduction
Conditions for the electrolysis	950°C molten (mixture of bauxite and cryolite)	

Required practical 8

Page 218

1 Measuring cylinder

2



3 To ensure all acid reacted

4 Solid remaining/no more gas evolved

5 Residue

6 To remove some water (and to prevent splitting)

7 As there is water (of crystallisation) in the salt

8 Solubility decreases on cooling

9 Between two pieces of filter paper or in a low temperature oven

10 Magnesium carbonate + sulfuric acid→ magnesium sulfate + carbon dioxide + water;

$MgCO_3 + H_2SO_4 \rightarrow MgSO_4 + H_2O + CO_2$

Required practical 9

Page 223

1 Graphite conducts electricity and is unreactive/inert

2 To avoid adding any extra ions

3 Lamp/ammeter

4 Some products are toxic/chlorine and bromine are toxic

5 From left to right: copper; hydrogen; silver; hydrogen; hydrogen; hydrogen

6 Hydrogen is produced unless the metal ions are from a metal that is less reactive than hydrogen, then the metal is produced

7 From left to right: chlorine; oxygen; oxygen; bromine; iodine; oxygen

8 Yes, oxygen is produced unless the solution contains halide ions, when the halogen is produced

Chapter review questions

1 a) C

b) A

c) E

2 a) iron + oxygen → iron oxide

b) zinc + sulfuric acid → zinc sulfate + hydrogen

c) magnesium oxide + hydrochloric acid → magnesium chloride + water

d) sodium carbonate + nitric acid →sodium nitrate + water + carbon dioxide

e) potassium hydroxide + sulfuric acid → potassium sulfate + water

f) gold + magnesium nitrate *no reaction*

g) iron + copper sulfate → iron sulfate + copper

h) zinc + iron nitrate → zinc nitrate + iron

3 a) Electrolysis

b) Electrolysis

c) Heating with carbon

d) Electrolysis

e) Found as an element

4 a) $2Ca + O_2 \rightarrow 2CaO$

b) $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$

c) $Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$

5 a) Sodium hydroxide + nitric acid → sodium nitrate + water

b) $NaOH + HNO_3 \rightarrow NaNO_3 + H_2O$

c) $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

d) Neutralisation

6 a) To use up all the acid

b) To remove excess magnesium oxide

c) Heat the solution until crystals start to form; allow solution to cool; filter off crystals

d) magnesium oxide + sulfuric acid → magnesium sulfate + water

e) $MgO + H_2SO_4 \rightarrow MgSO_4 + H_2O$

7

Ionic compound	**Product at the negative electrode (cathode)**	**Product at the positive electrode (anode)**
Molten magnesium bromide ($MgBr_2$)	Magnesium	Bromine
Aqueous magnesium bromide ($MgBr_2$)	Hydrogen	Bromine
Molten potassium oxide (K_2O)	Potassium	Oxygen
Molten sodium iodide (NaI)	Sodium	Iodine
Aqueous calcium nitrate ($Ca(NO_3)_2$)	Hydrogen	Oxygen
Aqueous copper(II) chloride ($CuCl_2$)	Copper	Chlorine

8 a) Aluminium is more reactive than zinc

b) Al, gains oxygen (or loses electrons)

c) ZnO, loses oxygen (or gains electrons)

9 a) i) Positive = chlorine; negative = sodium

ii) $Na^+ + e^- \rightarrow Na$, reduction

iii) $2Cl^- - 2e^- \rightarrow Cl_2$, oxidation

b) i) Positive = chlorine, negative = hydrogen

ii) $2H^+ + 2e^- \rightarrow H_2$, reduction

iii) $2Cl^- - 2e^- \rightarrow Cl_2$, oxidation

c) In aqueous solution there are H^+ and OH^- ions present as well

10 a) $Fe + 2Ag^+ \rightarrow Fe^{2+} + 2Ag$

b) $Fe - 2e^- \rightarrow Fe^{2+}$, $Ag^+ + e^- \rightarrow Ag^+$

c) Fe oxidised, loses electrons

d) Both oxidation and reduction take place

11 a) $2K + 2H_2O \rightarrow 2KOH + H_2$

b) $CuCO_3 + 2HCl \rightarrow CuCl_2 + H_2O + CO_2$

c) $MgO + H_2SO_4 \rightarrow MgSO_4 + H_2O$

d) $Zn + 2AgNO_3 \rightarrow Zn(NO_3)_2 + 2Ag$

e) $2Al + 3O_2 \rightarrow 2Al_2O_3$

12 Solution is 100 times more dilute ($10 \rightarrow 1000\,cm^3$) and so pH rises from 2 to 4

Practice questions

1 B [1 mark]

2 C [1 mark]

3 D [1 mark]

4 B [1 mark]

5 D [1 mark]

6 A [1 mark]

7 a) i)

	Ion present in all acids	**Ion present in all alkalis**
Name	Hydrogen [1 mark]	Hydroxide [1 mark]
Formula	H^+ [1 mark]	OH^- [1 mark]

ii) $H^+ (aq) + OH^- (aq) \rightarrow H_2O (l)$ [1 mark for equation, 1 mark for state symbols]

b) i) $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$ [1 mark for formulae, 1 mark for balanced equation]

ii) $CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$ [1 mark for formulae, 1 mark for balanced equation]

c) Evaporate off some of the solution, cool and crystallise, filter, dry between filter paper [4 marks]

8 a) Conducts electricity [1 mark]

b) Two of: silver coloured, reacts with acid, burns to give a white powder [2 marks]

c) Oxygen [1 mark]

d) Magnesium [1 mark]

e) magnesium + sulfuric acid $\longrightarrow$ magnesium sulfate + hydrogen [1 mark]

9 Level 3 answer: A detailed and coherent answer giving correct observations and names of products. There must be correct comparisons and contrasts made between both reactions [5–6 marks]

Level 2 answer: A number of observations and products considered and a clear comparison has been made between either the observations or the names of products. There may be some detail missing but all observations given are correct [3–4 marks]

Level 1 answer: Simple statements but disjointed with vague observations given. There has been no attempt at a comparison [1–2 marks]

Indicative content

- Same salt in both/calcium chloride in both
- Calcium chloride and water products for first reaction
- Calcium chloride and hydrogen products for second reaction
- *Observations reaction with calcium hydroxide:*
  - test tube gets warm/heat released (any extra incorrect observation loses this mark)
- *Observations reaction with calcium* (any 2):
  - bubbles/effervescence/gas produced
  - test tube gets warm/heat increased
  - solid disappears
  - colourless solution formed

10 a) Decomposition of an ionic compound using electricity [1 mark]

b) Bauxite [1 mark]

c) i) Z = anode (positive electrode), X = cathode (negative electrode) [2 marks]

ii) Aluminium oxide [1 mark], cryolite [1 mark]

iii) So that it is molten [1 mark], so that it conducts electricity [1 mark]

iv) Anode = oxygen, cathode = aluminium [2 marks]

v) Anode = $2O^{2-} \rightarrow O_2 + 4e^-$ or $2O^{2-} - 4e^- \rightarrow O_2$

Cathode = $Al^{3+} + 3e^- \rightarrow Al$ [2 marks]

vi) Anode, $C + O_2 \rightarrow CO_2$ [2 marks]

d) Al^{3+} gains electrons [1 mark]

11 a) A: anode/positive electrode; B: cathode/negative electrode; C: evaporating basin [3 marks]

b) Lamp/ammeter [1 mark]

c)

Electrode	Name of product	Half equation
A	Bromine [1 mark]	$2Br^- - 2e^- \rightarrow Br_2$ or $2Br^- \rightarrow Br_2 + 2e^-$ [1 mark]
B	Lead [1 mark]	$Pb^{2+} + 2e^- \rightarrow Pb$ [1 mark]

d) Bromine is toxic [1 mark]

e) Copper conducts by delocalised electrons, molten lead bromide conducts by ions moving [2 marks]

f) Anode = chlorine, cathode = hydrogen [2 marks]

Working scientifically: Measurements and uncertainties

Pages 228–29

1 A: 10 cm^3; B: 15 cm^3; C: 15 cm^3; D: 40 cm^3

2 E: 26.8 cm^3; F: 20.4 cm^3; G: 29.5 cm^3

3 H: 67°C; I: 13°C; J: 16°C; K: 3°C; L: 24.4°C; M: −6°C

4 **i)** 2.04 g

ii) 4.36 g

5 124 ± 2°C

6 0.36 ± 0.04 g (0.18 is anomalous)

7 26 ± 1 cm^3 (20 is anomalous)

Test yourself on prior knowledge

1 Three of: kinetic (movement) energy, sound energy, light energy, elastic (potential) energy, gravitational (potential) energy, nuclear energy

2 Energy cannot be made or destroyed – it can only be transferred from one form to another

Test yourself

1 a) Exothermic

b) Endothermic

c) Exothermic

2 a) Exothermic

b) Endothermic

c) Endothermic

d) Exothermic

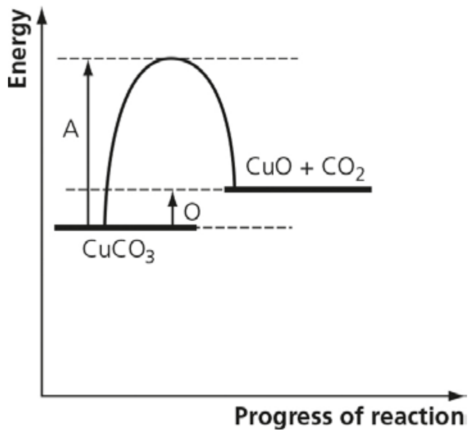
3 a) Thermal energy transferred from chemicals to the surroundings

b) Thermal energy transferred from the surroundings to the chemicals

4 a) Reactions 2 and 3 are exothermic

b) Reaction 1 is endothermic

5



6 a) −103 kJ; exothermic as more energy is released making bonds than is needed to break bonds

b) −76 kJ; exothermic as more energy is released making bonds than is needed to break bonds

c) −95 kJ; exothermic as more energy is released making bonds than is needed to break bonds

d) −1690 kJ; exothermic as more energy is released making bonds than is needed to break bonds

Show you can

Page 233

	Combustion	Decomposition	Neutralisation	Oxidation	Respiration	Exothermic	Endothermic
P		✓					✓
Q			✓			✓	

Page 235

a) Exothermic

b) A

Page 237

Bonds broken = 150 + 242 = 392

Bonds made = 2*x* (where *x* = I–Cl bond energy)

$392 - 2x = -30$

$392 + 30 = 2x$

$2x = 422$

$x = 211$ kJ

Required practical 10

Page 234

1 **a)** Independent = volume of HCl added

b) Dependent = temperature

c) Control = volume of sodium hydroxide solution, concentration of hydrochloric acid, concentration of sodium hydroxide

2 To check results are repeatable

3 To minimise heat loss

4 To ensure the solutions mix and react

5 The *x*-axis is volume of acid added in cm^3; *y*-axis is temperature in °C; the best-fit line should be drawn or two lines could be extrapolated to find the highest temperature

6 As the volume of acid increases, so the temperature increases to a maximum and then decreases

7 Add a few drops of indicator to the sodium hydroxide solution and repeat the experiment noting the volume at which the indicator changes colour – if it is the same volume as the highest temperature then neutralisation has occurred at this point

8 a) Independent = type of acid
b) Dependent = temperature
c) Control = volume and concentration of sodium hydroxide solution, volume and concentration of acid

9 Any two of the following: strong acids/hydrochloric and sulfuric have a similar highest temperature/temperature rise; strong acids/sulfuric and hydrochloric have a higher temperature rise (at neutralisation) than weaker acids/ethanoic acid; neutralisation gives out heat/has a temperature increase and so is exothermic

Chapter review questions

1 Reaction 1: endothermic; reaction 2: exothermic; reaction 3: exothermic

2 Rises/increases, endothermic, falls/decreases

3 Collide, activation

4 a) C
b) F
c) Exothermic

5 a) Exothermic
b) Endothermic
c) Endothermic
d) Exothermic
e) Exothermic
f) Endothermic

6 a) −184 kJ
b) Exothermic, more energy is released making bonds than is needed to break bonds

7 −590 kJ

Practice questions

1 B [1 mark]

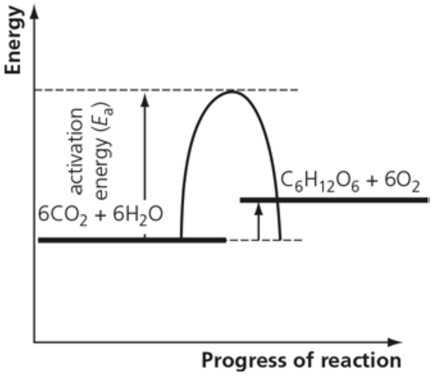
2 B [1 mark]

3 a) A: decomposition; B: neutralisation; C: combustion/oxidation; D: combustion/oxidation; E: neutralisation [5 marks]
b) An exothermic reaction is one that transfers thermal energy to the surroundings so the temperature of the surroundings increases [1 mark]; an endothermic reaction is one that takes in thermal energy from the surroundings so the temperature of the surroundings decreases [1 mark]
c) A: endothermic; B: exothermic; C: exothermic; D: exothermic; E: exothermic [5 marks]
d) Measure a volume of hydrochloric acid [1 mark], into a polystyrene beaker [1 mark], measure the temperature [1 mark], add magnesium [1 mark], measure the temperature [1 mark], if the temperature increases the reaction is exothermic [1 mark]

4 a) An endothermic reaction is one that takes in thermal energy from the surroundings so the temperature of the surroundings decreases [1 mark]

b) The minimum amount of energy which particles must have in order to react [1 mark]

c) [4 marks]



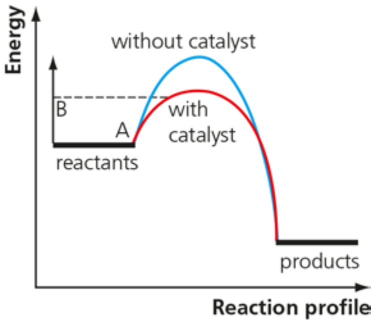
Axis labelled correctly [1 mark], products above reactants [1 mark], activation energy indicated and labelled [1 mark], energy change indicated and labelled [1 mark]

d) The energy needed to break the bonds in the reactants is greater than the energy released from forming new bonds in the products [2 marks]

5 a) Exothermic [1 mark]

b) No effect [1 mark]

c) [2 marks]



d) The presence of a catalyst lowers the activation energy. [1 mark]

6 436 + 158 − (2 × 568) = −542 kJ [2 marks]

Exothermic [1 mark]; more energy released making bonds than is needed to break bonds [1 mark]

7

Bonds broken	Bonds made
5C–H = 5(412)	4C=O = 4(743)
C–C = 348	6O–H = 6(463)
C–O = 360	
O–H = 463	
3O=O = 3(496)	
Total = 4719 kJ [1 mark]	Total = 5750 kJ [1 mark]

Energy change = energy needed to break bonds − energy released making bonds

= 4719 − 5750

= −1031 kJ [1 mark]

Working scientifically: Identifying variables when planning experiments

Pages 241–42

1 a) Continuous

b) Categoric

c) Continuous

d) Categoric

e) Continuous

f) Continuous

g) Continuous

h) Categoric

i) Categoric

j) Continuous

2 a) Independent: volume of hydrochloric acid

Dependent: temperature

Control: mass of magnesium, surface area of magnesium, concentration of acid

b) Independent: mass of copper carbonate

Dependent: time taken to react

Control: surface area of copper carbonate, volume of acid, concentration of acid, temperature

c) Independent: concentration of copper sulfate

Dependent: temperature

Control: mass of magnesium, surface area of magnesium, volume of copper sulfate

d) Independent: stirring/no stirring

Dependent: time to dissolve

Control: mass of copper sulfate, surface area of copper sulfate, volume of water, temperature

e) Independent: mass of calcium carbonate

Dependent: volume of carbon dioxide

Control: surface area of calcium carbonate, volume of HCl, concentration of HCl, temperature

f) Independent: type of acid

Dependent: temperature

Control: volume of acid, concentration of acid, volume of NaOH, concentration of NaOH

Test yourself

1 **a)** Cu

b) H_2

c) CO_2

d) Ar

e) Ag

f) O_2

g) NH_3

h) Cl_2

i) C

j) C_{60}

k) SO_2

l) CH_4

2 **a)** K_2O

b) Na_2SO_4

c) AlF_3

d) Fe_2S_3

e) $Cu(NO_3)_2$

f) Li_2CO_3

g) NH_4Br

h) $Ba(OH)_2$

i) $AgNO_3$

j) $Al_2(SO_4)_3$

k) SrO

l) K_2Se

3 **a)** Bromine

b) Sodium

c) Copper

d) Carbon monoxide

e) Sulfur trioxide

f) Calcium oxide

g) Aluminium fluoride

h) Copper sulfide

i) Potassium nitrate

j) Ammonium carbonate

k) Iron(II) oxide

l) Iron(III) oxide

4 a) Metallic

b) Monatomic

c) Ionic

d) Molecular

e) Giant covalent

f) Molecular

g) Molecular

h) Ionic

i) Metallic

j) Giant covalent

k) Molecular

l) Ionic

5 a) Base

b) Salt

c) Alkali and base

d) Base

e) Acid

f) Salt

g) Alkali and base

h) Base

i) Acid

j) Salt

k) Salt

l) Acid

6 a) Acidic

b) Basic

c) Basic

d) Acidic

7 a) Magnesium + oxygen → magnesium oxide

b) Hydrogen sulfide + oxygen → water + sulfur dioxide

c) Phosphorus + oxygen → phosphorus oxide

d) Silane + oxygen → water + silicon dioxide

e) Propane + oxygen → carbon dioxide + water

f) Methanol + oxygen → carbon dioxide + water

8 a) Potassium + water → potassium hydroxide + hydrogen

b) Nitric acid + zinc → zinc nitrate + hydrogen

c) Sulfuric acid + nickel oxide → nickel sulfate + water

d) Hydrochloric acid + potassium hydroxide → potassium chloride + water

e) Nitric acid + sodium carbonate → sodium nitrate + water + carbon dioxide

f) Hydrochloric acid + ammonia → ammonium chloride

g) Magnesium hydroxide + sulfuric acid → magnesium sulfate + water

h) Calcium + water → calcium hydroxide + hydrogen

i) Copper carbonate + nitric acid → copper nitrate + water + carbon dioxide

j) Ammonia + sulfuric acid → ammonium sulfate

k) Magnesium oxide + nitric acid → magnesium nitrate + water

l) Cobalt + hydrochloric acid → cobalt chloride + hydrogen

9 Transfer of electrons = b, d; sharing of electrons = c; transfer of protons = a, e

10 a) Solid

b) Aqueous/dissolved in water

c) Gas

11 a) $2K + I_2 \rightarrow 2KI$

b) $2Na + 2H_2O \rightarrow 2NaOH + H_2$

c) $CuCO_3 \rightarrow CuO + CO_2$

d) $4Al + 3O_2 \rightarrow 2Al_2O_3$

e) $Ca + 2HCl \rightarrow CaCl_2 + H_2$

f) $2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$

g) $C_5H_{12} + 8O_2 \rightarrow \rightarrow 5CO_2 + 6H_2O$

h) $H_3PO_4 + 3NaOH \rightarrow Na_3PO_4 + 3H_2O$

i) $2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

j) $4NO + 2H_2O + 3O_2 \rightarrow 4HNO_3$

12 a) $4Na + O_2 \rightarrow 2Na_2O$

b) $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

c) $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$

d) $Cl_2 + 2NaBr \rightarrow 2NaCl + Br_2$

e) $MgO + 2HNO_3 \rightarrow Mg(NO_3)_2 + H_2O$

13 a) $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

b) $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

c) $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

d) $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

14 a) $Cu^{2+}(aq) + Mg(s) \rightarrow Cu(s) + Mg^{2+}(aq)$

b) $2Ag^+(aq) + Mg(s) \rightarrow 2Ag(s) + Mg^{2+}(aq)$

c) $3Zn^{2+}(aq) + 2Al(s) \rightarrow 3Zn(s) + 2Al^{3+}(aq)$

15 a) $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

b) $2Ag^+(aq) + Zn(s) \rightarrow 2Ag(s) + Zn^{2+}(aq)$

c) $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

d) $Ni^{2+}(aq) + Zn(s) \rightarrow Ni(s) + Zn^{2+}(aq)$

16 a) $Mg^{2+} + 2e^{-} \rightarrow Mg$

b) $Se^{2-} - 2e^{-} \rightarrow Se$ (or $Se^{2-} \rightarrow Se + 2e^{-}$)

c) $K^{+} + e^{-} \rightarrow K$

d) $2Br^{-} - 2e^{-} \rightarrow Br_2$ (or $2Br^{-} \rightarrow Br_2 + 2e^{-}$)

e) $2O^{2-} - 4e^{-} \rightarrow O_2$ (or $2O^{2-} \rightarrow O_2 + 4e^{-}$)

f) $2H^{+} + 2e^{-} \rightarrow H_2$

17 a) $Cu^{2+} + 2e^{-} \rightarrow Cu$ and $Mg - 2e^{-} \rightarrow Mg^{2+}$ (or $Mg \rightarrow Mg^{2+} + 2e^{-}$)

b) $Ag^{+} + e^{-} \rightarrow Ag$ and $Mg - 2e^{-} \rightarrow Mg^{2+}$ (or $Mg \rightarrow Mg^{2+} + 2e^{-}$)

c) $Zn^{2+} + 2e^{-} \rightarrow Zn$ and $Al - 3e^{-} \rightarrow Al^{3+}$ (or $Al \rightarrow Al^{3+} + 3e^{-}$)

Test yourself on prior knowledge

1 There are many possibilities, e.g.:

going for a walk

boiling water in an electric kettle

going to school in a bus.

2 Coal, oil, gas.

3 Metals have free electrons which are able to move quickly and transfer thermal energy as they move from a hot part of a metal to a colder part.

Test yourself

1 **a)** Kinetic energy.

b) Elastic potential energy.

c) Chemical.

d) Gravitational potential energy.

2 The battery stores chemical energy. The battery does electrical work to light the bulb when a current flows from the battery.

3 **a)** An elastic potential energy store transfers energy to a kinetic energy store.

b) A kinetic energy store transfers energy to a thermal energy store.

c) A chemical energy store transfers energy to thermal energy stores (in the pan and in the surroundings).

d) A gravitational potential energy store transfers energy into a kinetic energy store. Then when the putty hits the ground it warms up. Then energy is transferred to a thermal energy store.

4 B 60 J

C 60 J

D 90 J

5
$$E_k = \frac{1}{2}mv^2$$
$$= \frac{1}{2} \times 0.015 \times (240)^2$$
$$= 432\text{ J } (430\text{ J to 2 sf})$$

6
$$E_p = mgh$$
$$= 50 \times 9.8 \times 440$$
$$= 215\,600\text{ J}$$

or 220 kJ (to 2 sf)

7 Increase in $E_k = \frac{1}{2}mv_2^{\ 2} - \frac{1}{2}mv_1^{\ 2}$

$$= \frac{1}{2} \times 1500 \times 20^2 - \frac{1}{2} \times 1500 \times 15^2$$

$$= 131\ 250\,\text{J}$$

or 130 kJ (to 2 sf)

8 $E_e = \frac{1}{2}ke^2$

$$= \frac{1}{2} \times 2000 \times (0.08)^2$$

$$= 6.4\,\text{J}$$

9 $E_k = \frac{1}{2}mv^2$

$$= \frac{1}{2} \times 0.05 \times (30000)^2$$

$$= 22\ 500\ 000\,\text{J}$$

or 22.5 MJ

10 a) $E_e = \frac{1}{2}ke^2$

$$= \frac{1}{2} \times 200 \times (0.01)^2$$

$$= 0.01\,\text{J}$$

b) i) The elastic energy store in the ball is transferred to the gravitational energy store of the ball. So the ball has 0.01 J of E_p.

ii) $E_p = mgh$

$0.01 = 0.0005 \times 9.8 \times h$

$$h = \frac{0.01}{0.0049}$$

$$= 2.0\,\text{m (to 2 sf)}$$

11 a) $E_e = \frac{1}{2}ke^2$

$$= \frac{1}{2} \times 80 \times (0.15)^2$$

$$= 0.9\,\text{J}$$

b) i) The elastic potential energy stored in the spring is transferred to the kinetic energy store of the trolley. So the trolley has 0.9 IJ of E_K

ii) $E_k = \frac{1}{2}\text{mv}^2$

$0.9 = \frac{1}{2} \times 0.8 \times v^2$

$0.9 = 0.4\,v^2$

$$v^2 = \frac{0.9}{0.4}$$

$$= 2.25$$

$v = 1.5\,\text{m/s}$

12 a) $E_p = mgh$

$= 0.2 \times 9.8 \times 0.9$

$= 1.76\,\text{J}$

b) i) Gravitational potential energy stored in the mass is transferred to kinetic energy stored in the trolley and the mass. So they have a combined E_k of 1.76 J.

ii) $E_k = \frac{1}{2}(M + m)v^2$

$1.76 = \frac{1}{2} \times 1 \times v^2$

$1.76 = 0.5\,v^2$

$v^2 = \frac{1.76}{0.5}$

$= 3.52$

$v = 1.9\,\text{m/s}$

13 watt

14 $\text{power} = \frac{\text{energy transferred}}{\text{time}}$

15 $P = \frac{\text{work done}}{\text{time}}$

$= \frac{12\,000 \times 30}{90}$

$= 4\,000\,\text{W or } 4\,\text{kW}$

16 $\text{Peter: power} = \frac{\text{work done}}{\text{time}}$

$= \frac{760 \times 4.5}{3.80}$

$= 900\,\text{W}$

$\text{Hannah: power} = \frac{608 \times 4.5}{3.04}$

$= 900\,\text{W}$

17 a) work done = force × distance moved (in 1 second)

$= 150\,000 \times 80$

$= 12\,000\,000\,\text{J}$

or 12 MJ

b) power = work done in 1 second

$= 12\,\text{MW}$

18 J/kg°C

19 $\Delta E = mc\Delta\theta$

$= 80 \times 1000 \times 12$

$= 960\ 000\,J$

or $960\,kJ$

20 **a)** $\Delta E = mc\Delta\theta$

$= 60 \times 800 \times 30$

$= 1\ 440\ 000\,J$

or $= 1.4$ MJ (to 2 sf)

b) $P = \frac{E}{t}$

$200 = \frac{1\ 440\ 000}{t}$

$t = \frac{1\ 440\ 000}{200}$

$= 7\ 200\,s$ or $2\,h$

21 **a)** $P = \frac{E}{t}$

$E = P \times t$

$= 700 \times 60$

$= 42\ 000\,J$

b) $E = mc\Delta\theta$

$42\ 000 = 0.3 \times 3800\ \Delta\theta$

$\Delta\theta = \frac{42\ 000}{1140}$

$= 36.8\ °C$

final temperature $= 42.8\,°C$ ($43\,°C$)

22 Dissipate means to spread energy out and to use wastefully.

23 Engineers streamline cars to reduce drag; engines are designed to be efficient in the use of fuel; moving parts are oiled to reduce friction.

24 Here are two more examples:

We put a hat on when it is cold.

We can use petrol efficiently by driving at a steady speed without rapid acceleration.

25 Here are some examples:

Loft insulation

Cavity wall insulation

Double-glazing

Carpets

Draft excluders

26 $\text{efficiency} = \frac{\text{useful output energy transfer}}{\text{total input energy transfer}}$

27 A

28 a) $E_p = mgh$

$= 72 \times 9.8 \times 0.5$

$= 353\ \text{J}$

b) $\text{Efficiency} = \dfrac{353}{1500}$

$= 0.24$ or 24%

29 $\text{efficiency} = \dfrac{\text{output energy (work)}}{\text{input energy}}$

$0.36 = \dfrac{\text{output work}}{45\ \text{MJ}}$

$\text{output work} = 0.36 \times 45\,\text{MJ}$

$= 16.2\,\text{MJ}$, or $16\,\text{MJ}$ (to 2 sf)

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

If the frictional force is reduced by streamlining, less work is done against drag forces

31 a) Without the machine, the men would have to carry the bricks up the ladder in small loads. Then they have to lift their own body weight up the ladder too.

b) A lot of machines dissipate energy, e.g., a petrol driven lawn mower dissipates energy as it cuts the lawn. If we tried to cut the lawn as neatly by hand, we would dissipate more energy as we would get hot and sweaty in the process.

32 a) One that is used up and cannot be replaced, e.g. coal, oil, gas.

b) One that is replaced after it has been used, e.g. wind or wave power, wood, biofuels.

33 Uranium or plutonium; non-renewable

34 a) Coal is relatively cheap, we can use it when we want to and can control the output of a power station.

b) Coal produces greenhouse gases which contribute to global warming, e.g. CO_2. Coal burning also produces sulfur dioxide (SO_2) which can make acid rain.

35 a) Forests and farmland can be lost. The habitats of wildlife can be destroyed. People might have to move home, as a large lake will cause extensive flooding.

b) Hydroelectric power is renewable and it is non-polluting.

36 Tides occur at regular times, twice a day; we cannot predict when the wind will blow.

37 If wind turbines are spread across the whole of Britain, we can generate some electricity when the wind is blowing in Scotland, but not in Cornwall.

38 The average power from a wind turbine is 0.4 MW

number of turbines (N) × 0.4 MW = 2000 MW

$N = \dfrac{2000}{0.4}$

$= 5000$

39 a) Pumped storage is useful because extra electricity can be produced at short notice when there is a need.

b) i) No, because no waste products are produced as the water falls down the mountain.

ii) This power station does not produce pollution or greenhouse gases as water is pumped up the hill; but if the electricity to do this work is generated by a coal fired power station, then that power station produces pollution and greenhouse gases.

c) $E_p = mgh$

$= 50\,000 \times 9.8 \times 200$

$= 98\,000\,000\,\text{J}$

or 98 MJ

d) power output $= 0.8 \times 98\,\text{MJ/s}$

$= 78\,\text{MW}$

e) i) In the evening.

ii) In the morning.

The station generates electricity at times of peak demand (evening) and uses electricity from other stations to pump water upwards at times of low demand (early morning).

Show you can

Page 261

Stores of energy: kinetic; chemical; internal (or thermal); gravitational potential; magnetic; elastic potential; nuclear.

Examples of transfer of energy include: chemical energy stored in a battery transferred to a light, and the light striking an object and increasing its internal energy; dropping a bunch of keys onto a table, which makes a sound wave which transfers energy to the air and surrounding objects causing an increase in their store of internal energy.

Page 265

The principle of conservation of energy states that the total amount of energy always remains the same. Energy can be transferred from one store to another, but energy cannot be created or destroyed.

There are many demonstrations, for example:

- An object falls – energy is transferred from the gravitational potential energy store to the kinetic energy store.
- A torch cell can be used to drive a current through an electrical resistor; energy in the chemical store in the cell is transferred into the thermal energy store in the resistor and the surroundings.

- Also the Test yourself questions 10, 11 and 12 on page 265 give numerical examples of energy conservation.

Page 268

You need to design an experiment similar to the practical shown in Figure 15.11 page 267.

For examples: Choose a weight you can lift reasonably easily (2–5 kg). Time how long it takes you

To lift it, and measure the distance lifted, *h*.

Then $P = \frac{mgh}{t}$

This gives you the **useful** power of your arm but remember you have also lifted the arm itself.

Page 271

Apparatus required:

insulated beaker
measuring beaker or cylinder
heater of known power, *P*, when connected to a 12 V supply
stop watch or clock
thermometer
power pack

Method

1 Measure 100 ml of water and pour into the insulated beaker. It is important that the beaker is insulated so that when the water is heated, the beaker does not absorb any energy. The mass of 100 ml of water is 0.1 kg.
2 Connect the heater to the power supply and place in the water. Wait for a minute and measure the temperature of the water, θ_1.
3 Turn on the power supply for 5 minutes, 300 s. Energy supplied to the water is $E = P \times t$.
4 Stir the water and measure the temperature, θ_2.
5 Now calculate the specific heat capacity using the equation:
energy supplied = mass × specific heat capacity × temperature rise
$E = m \times c \times (\theta_2 - \theta_1)$

Page 273

Calculations on the principle of energy conservation. Three examples of calculations are given in Test yourself questions 10, 11 and 12 Page 265.

Page 276

Connect a power supply (6 V d.c.) through a joulemeter to a 6 V d.c. motor. Turn the supply on to lift a load of mass, *m*. Turn off the supply when the mass has been lifted through your measured height, *h*.

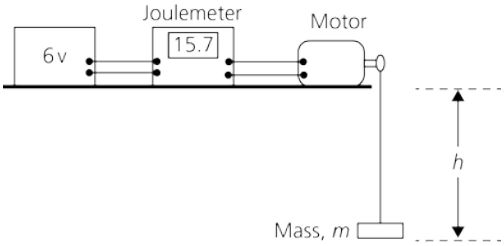
Then energy supplied is measured by the joulemeter, E_{in}.

Energy to lift the load is:

$$E_p = mgh$$

$$\text{efficiency} = \frac{\text{useful output energy transfer}}{\text{total input energy transfer}}$$

$$= \frac{mgh}{E_{in}}$$



Page 281

This is an open-ended question with a variety of answers, and can provide stimulus for research. By 2050 the UK government plans to reduce our CO_2 emissions by 80%. So any answer needs to include this goal. A good answer will need to consider these points, and students will be able to include many more too.

The elimination of coal fired power stations.

The use of gas only to boost electricity production at peak times.

Should we use more nuclear power? What safety concerns are there here?

How can we boost renewable energy supplies? More wind turbines? Will people protest about wind turbines on the landscape. Should we build tidal barrages? Can we boost hydroelectric power?

Should we have solar panels on all houses or across the countryside?

How much land should we use for growing crops to burn for bioelectricity production.

Will there be new technologies for electricity production?

Will we be able to capture carbon dioxide from power stations?

Teachers can direct students towards the government's 2050 pathways website, which allows models for an electricity generation strategy – but this provides more than is intended for this discussion question.

Required practical 14

Page 269–70

1 At the moment the heater is switched off, not all of the energy transferred to the heater has then been transferred to the block.

2 Not all of the energy transferred to the heater will result in an increase in the temperature of the block:

- some of the energy is used to warm up the heater itself
- some of the heater is in contact with the air so will transfer energy to the air and not to the block
- as the block warms up it will also transfer some energy to the air.
- All of these factors mean that the temperature rise is not a high as it would have been had all of the energy transferred to the heater been transferred to the block. Dividing by $\Delta\theta$ means that the calculated value for *c* will be greater than the true value.

Chapter review questions

1 The stores are:

a) chemical

b) kinetic

c) elastic potential

d) gravitational potential.

2 a) A chemical store in the battery transfers thermal energy to the surroundings.

b) A thermal store in the soup transfers thermal energy to the surroundings.

c) A chemical store in the battery transfers thermal energy to the surroundings and to a gravitational potential energy store in the load.

d) A chemical store in the firework transfers energy to a thermal store in the surroundings and into potential energy and kinetic energy stores in the firework.

3 The carpet is a poor conductor of heat, so not much heat is transferred from your feet. A kitchen tile conducts heat much better than the carpet, so your feet transfer thermal energy to the floor, and your feet feel cold.

4 a) $E_k = \frac{1}{2}mv^2$

$= \frac{1}{2} \times 1400 \times 25^2$

$= 437\ 500\,\text{J}$

$= 440\,\text{kJ}$ (to 2 sf)

b) $E_e = \frac{1}{2}ke^2$

$= \frac{1}{2} \times 40\ 000 \times 0.05^2$

$= 50\ \text{J}$

c) $E_p = mgh$

$= 18 \times 9.8 \times 2.5$

$= 441\,\text{J}$

5 a) The potential energy store is transferred to a kinetic energy store.

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

$= 45 \times 9.8 \times 4 = \frac{1}{2} \times 45 \times v^2$

$v^2 = 78.4$

$v = 8.9\,\text{m/s}$ (to 2 sf)

b) A frictional force will slow the girl down.

6 The potential energy store is transferred to an elastic potential energy store.

$$mgh = \frac{1}{2}ke^2$$

$$= 55 \times 9.8 \times 5 = \frac{1}{2} \times 35\ 000 \times e^2$$

$$e^2 = \frac{55 \times 9.8 \times 5}{\frac{1}{2} \times 35000}$$

$$e^2 = 0.154$$

$$e = 0.39\ \text{m or } 39\ \text{cm}$$

7 a) Energy is transferred from the gravitational potential energy store to the thermal energy store of the shot.

b) $E_p = 50 \times m \times g \times h$

$= 50 \times 0.05 \times 9.8 \times 1$

$= 24.5\,\text{J}$

c) $\Delta E = mc\Delta\theta$

$24.5 = 0.05 \times 160 \times \Delta\theta$

$$\Delta\theta = \frac{24.5}{0.05 \times 160}$$

$= 3.1°C$

d) Some thermal energy will be transferred from the lead shot to the surroundings.

8 The work done on the ball is equal to the gain in its kinetic energy store.

$$F \times d = \frac{1}{2}mv^2$$

$$300 \times 0.2 = \frac{1}{2} \times 0.45 \times v^2$$

$$v^2 = \frac{300 \times 0.2}{\frac{1}{2} \times 0.45}$$

$v^2 = 267$

$v = 16.3$ m/s

9 $$\text{useful power out} = \frac{\text{work}}{\text{time}} = \frac{mgh}{\text{time}}$$

$$= \frac{80 \times 9.8 \times 3}{12}$$

$= 196\,\text{W}$

$$\text{efficiency} = \frac{\text{useful power out}}{\text{power input}}$$

$= 196/800$

$= 0.245$ or 24.5%

10 a) $$\text{density} = \frac{\text{mass}}{\text{volume}}$$

$$900 = \frac{mass}{200 \times 10^{-6}}$$

$\text{mass} = 900 \times 200 \times 10^{-6}$

$= 0.18\,\text{kg}$

b) $E = P \times t$

$= 24 \times 10 \times 60$

$= 14\,400\,\text{J}$

c) $\Delta E = mc\,\Delta\,\theta$

$14\,400 = 0.18 \times c \times 72$

$$c = \frac{14\,400}{0.18 \times 72}$$

$= 1110\,\text{J/kg°C}$

11 a) $E_k = \frac{1}{2}mv^2$

$= \frac{1}{2} \times 0.0015 \times 3^2$

$= 0.00675\,\text{J}$

b) $P = \frac{E}{t}$

$= \frac{0.00675}{0.025}$

$= 0.27\,\text{W}$

Practice questions

1 watts [1 mark]

2 J/kg°C [1 mark]

3 efficiency $= \frac{\text{useful power out}}{\text{power input}}$

$= \frac{600}{2000}$ [1 mark]

$= 0.3$ or 30% [1 mark]

4 Advantages:

- wind power is renewable and never runs out
- wind power is clean and non-polluting.

Disadvantages:

- wind power is unreliable and only works when it is windy
- sometimes the wind is so strong that the turbines have to be switched off.

[2 marks, 1 for an advantage and 1 for a disadvantage]

5 a) Carbon dioxide is thought to contribute to global warming. [1 mark]

b) i) Coal. [1 mark]

ii) These are categoric variables. There are three specific types of fuel, there is no reason to look for a trend in a line graph. [1 mark]

c) i) Tides, hydroelectric, wind, geothermal. [1 mark]

ii) Plants grow again and they absorb CO_2 to enable them to grow. [1 mark]

6 a) i) Categoric. [1 mark]

ii) The amount of water in the same beaker. [1 mark]

The distance of the firelighter below the beaker. [1 mark]

iii) Burning your fingers. Inhaling fumes from the firelighter. [1 mark]

iv) Use a longer thermometer with a more sensitive scale

Or: use an electronic thermometer. [1 mark]

b) i) It looks as if H&S Firelighter is better than brand X. [1 mark]

However, we need to check it again to be certain that it is better than brand Y – the temperature difference is only 2°C. [1 mark]

ii) Two of: Energy is used to warm up the glass beaker and thermometer.

Energy is dissipated to the surroundings including the support for the firelighter and the tripod.

Energy is also radiated away from the flame as electromagnetic radiation and light.

[2 marks

7 a) $E_p = mgh$

$= 60 \times 9.8 \times 495$ [1 mark]

$= 291060$ J or 291 kJ [1 mark for answer, 1 for unit]

b) $P = \frac{E}{t}$

$= \frac{291060}{35 \times 60}$ [1 mark for correct working, 1 for time in s]

$= 138$ W [1 mark]

c) $\text{efficiency} = \frac{\text{useful power out}}{\text{power input}}$

$0.2 = \frac{291060}{\text{input energy}}$ [1 mark]

$\text{input energy} = \frac{291060}{0.2}$

$= 1455300$ J [1 mark]

$= 1455$ kJ

So number of slices of bread $= 1455/400$

$= 3.6$

The tourist needs to eat four slices to make sure he gets there. [1 mark]

d) Most of the energy is transferred to the thermal stores of the surroundings. [1 mark]

8 a) $E_p = mgh$ [1 mark]

$= 40 \times 9.8 \times 5.8$ [1 mark]

$= 2274$ J [1 mark]

b) Useful energy delivered per second:

$= \frac{5 \times 2274}{60}$ [1 mark]

$= 189$ J/s or 189 W [1 mark]

c) $\text{efficiency} = \dfrac{\text{useful power out}}{\text{power input}}$

$$0.35 = \frac{189}{\textit{input power}} \text{ [1 mark]}$$

$$\text{input power} = \frac{189}{0.35} \text{ [1 mark]}$$

$$= 541\,\text{W or } 540\,\text{W (to 2 sf) [1 mark]}$$

9 Increase in $E_k = \frac{1}{2}mv_1^2 - \frac{1}{2}mv_2^2$ [1 mark]

$$\left(\frac{1}{2} \times 1500 \times 25^2\right) - \left(\frac{1}{2} \times 1500 \times 15^2\right) \text{ [1 mark]}$$

$$= 468\,750 - 168\,750$$

$$= 300\,000\,\text{J [1 mark]}$$

$$= \text{or } 300\,\text{kJ (to 2 sf)}$$

10 a) $E_k = \frac{1}{2}mv^2$

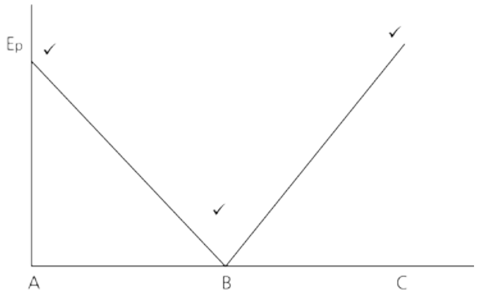
$$10\,830 = \frac{1}{2} \times 60 \times v^2 \text{ [1 mark]}$$

$$v^2 = \frac{10\,830}{30}$$

$$v^2 = 361 \text{ [1 mark]}$$

$$v = 19\,\text{m/s [1 mark]}$$

b) [3 marks]



c) Since energy is transferred from the child's potential energy story to the kinetic energy store as she falls, the original potential energy store is also 10 830 J.

So: $10\,830 = mgh$ [1 mark]

$$10\,830 = 60 \times 9.8 \times h \text{ [1 mark]}$$

$$h = \frac{10\,830}{588}$$

$$= 18.4\,\text{m or } 18\,\text{m (to 2 sf) [1 mark]}$$

11 a) work = force × distance [1 mark]

$$= 2000 \times 15 \text{ [1 mark]}$$

$$= 30\,000\,\text{J or } 30\,\text{kJ [1 mark]}$$

b) distance = speed × time

$50 = 5 \times t$ [1 mark]

$t = 10\,\text{s}$ [1 mark]

c) $\text{power} = \dfrac{\text{energy}}{\text{time}}$

$6000 = \dfrac{E}{10}$ [1 mark]

$E = 60\,000\,\text{J}$ or $60\,\text{kJ}$ [1 mark]

d) $\text{efficiency} = \dfrac{\text{useful power out}}{\text{power input}}$

$= \dfrac{30\,\text{kJ}}{60\,\text{kJ}}$ [1 mark]

$= 0.5$ or 50% [1 mark]

12 a) $E_p = mgh$ [1 mark]

$= 1 \times 9.8 \times 7$ [1 mark]

$= 68.6\,\text{J}$ [1 mark]

b) volume = area × height [1 mark]

$= 200 \times 10^6 \times 5$

$= 10^9\,\text{m}^3$ [1 mark]

c) mass $= 1.4 \times 10^9 \times 1000$ [1 mark]

$= 1.4 \times 10^{12}\,\text{kg}$ [1 mark]

d) E_p = energy per kg × mass [1 mark]

$= 68.6 \times 1.4 \times 10^{12}$ [1 mark]

$= 6.86 \times 10^{13}\,\text{J}$ [1 mark]

e) $\text{Power} = \dfrac{E}{t}$ [1 mark]

$= \dfrac{9.8 \times 10^{13}}{6 \times 3600}$ [1 mark]

$= 3.2 \times 10^9\,\text{W}$ or 3200 MW [1 mark]

but this power is only generated for half the day, because no energy is generated when the tide is rising.

f) Advantages:

- This is a lot of power.
- There is no pollution.
- Tides are predictable.

Disadvantages:

- It would be expensive to build the barrier.
- It would damage the environment for birds.

- Power can only be generated for half the day.

[1 mark for each of 2 advantages and disadvantages]

Working scientifically: Uncertainty, errors and precision

Pages 289–90

1 (14.8 + 15.3 + 14.9) ÷ 3 = 15.0

2 **a)** From 2 N to 7 N (or 5 N)

b) Weight lifted

c) Height the weight was lifted

3 When reset it showed a reading of zero.

4 15.1

5 Graph drawn, line of best fit a curve peaking at 5 N (or slightly greater).

6 The efficiency of the motor increases with the weight until it reached 5 N.

Increasing the weight beyond 5 N decreases the efficiency.

Test yourself on prior knowledge

1 They are in parallel – they can be turned on and off independently.

2 **a)** All metals, e.g. copper, silver, brass; carbon (graphite).

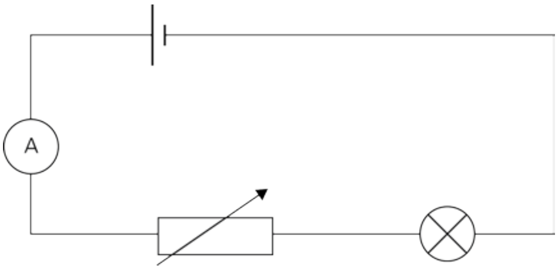
b) Plastic, china, glass, rubber, air.

Test yourself

1 (b)

2 A diode; B lamp; C cell; D switch

3



4 **a)** volt

b) amp

c) coulomb

5 Both 0.08 A

6 **a)** $Q = It$

$3 = I \times 2$

$I = 1.5\,\text{A}$

b) $Q = It$

$= 0.3 \times 20 \times 60$

$= 360\,\text{C}$

c) $Q = It$

$5 = I \times 2 \times 10^{-4}$

$I = 25\,000\,\text{A}$

d) $Q = It$

$= 10^{-4} \times 30 \times 60$

$= 0.18\,\text{C}$

7 You need to make the resistance smaller, to make the lamp brighter.

8 Resistor – 0.075 A

Lamp – 4600 Ω

Heater – 10 A

LED – 3 V

Motor – 1.5 Ω

9 **a)** 2200 Ω

b) 900 Ω

c) 300 Ω

10 In an ohmic resistor the current flowing through it is proportional to the p.d. across the resistor, provided the temperature remains constant.

11 **a)** **i)** $R = \frac{V}{I}$

$= \frac{1}{0.2}$

$= 5\,\Omega$

ii) $R = \frac{V}{I}$

$= \frac{3}{0.29}$

$= 10.3\,\Omega$

b) Resistance provided by the bulb.

12 **a)** $R = \frac{V}{I}$

$= \frac{2}{0.03}$

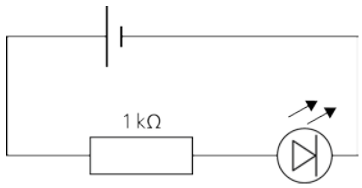
$= 67\,\Omega$

b)

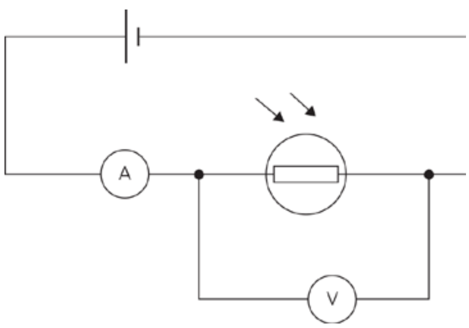
$R = \frac{4}{0.005}$

$= 800\,\Omega$

13 **a)**



b)



14 2 A

15 **a)** **i)** 35 Ω

ii) 2150 Ω

b) Less than 10 Ω

16 a) 9 V

b) 12 V

17 $A_1 = 3\,A$; $A_2 = 2\,A$; $A_3 = 1\,A$; $A_4 = 5\,A$

18 a) 18 V

b) 6 V

c) 27 V

19 a) $V = IR$

$4 = I \times 6$

$I = 0.67\,\text{A}$

b) $V = 4\,\text{V} + 8\,\text{V}$

$= 12\ \text{V}$

20 a) $V = IR$

$8 = I \times 24$

$I = 0.33\ \text{A}$

b) p.d. across R = 12 V – 8 V = 4 V

$$R = \frac{V}{I}$$

$$= \frac{4}{0.33}$$

$$= 12\,\Omega$$

21 p.d. across 10 Ω resistor = $IR = \frac{1}{4} \times 10 = 2.5\,\text{V}$

p.d. across R $= 10 - 2.5 = 7.5\,\text{V}$

$$R = \frac{V}{I}$$

$$= \frac{7.5}{0.25}$$

$$= 30\ \Omega$$

22 a) a.c. is an alternating current

d.c. is a direct current

b) A direct p.d. remains at a constant value in the same direction.

When an alternating p.d. is applied across a resistor, the p.d. switches direction many times per second.

23 In the UK, the supply is rated at 230 V and 50 Hz. Therefore the p.d. in the USA has half the value of the UK supply. At 60 Hz, the USA changes direction 60 times per second rather than 50, as in the UK.

24 a) $P = V \times I$

$= 12 \times 90$

$= 1080\,\text{W}$

b) $P = 230 \times 2.5$

$= 575\,\text{W}$

c) $P = 3 \times 0.0003$

$= 0.0009\,\text{W}$

or $0.9\,\text{mW}$

25 a) $W = VQ$

$= 12 \times 200$

$= 2400\,\text{J}$

b) $W = VIt$

$= 230 \times 0.2 \times 30 \times 60$

$= 82\,800\,\text{J}$

or 83 kJ (to 2 sf)

c) $W = VIt$

$= 6 \times 0.002 \times 2 \times 60 \times 60$

$= 86.4\,\text{J}$

or 86 J (to 2 sf)

26 a) i) $P = I^2R$

$= 100^2 \times 200$

$= 2\,000\,000\,\text{W}$

or $2\,\text{MW}$

ii) $P = I^2R$

$= 1000^2 \times 200$

$= 200\,000\,000\,\text{W}$

or $200\,\text{MW}$

b) The power dissipated by a current, I, flowing through a resistor, R, is $P = I^2R$. So when a low current flows less power is dissipated, which saves energy and money.

27 a) $I = 3\,\text{A}$

So $P = I^2R$

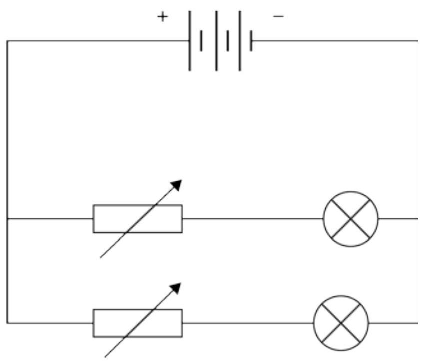
$= 3^2 \times 4$

$= 36\,\text{W}$

b) The two wires dissipate 36 W, so only $\frac{1}{3}$ of the power lights the lamp.

Show you can

Page 293



Page 295

Current = the rate at which charge flows or how much charge flows per second.

$$I = \frac{Q}{t}$$

Page 301

a) An LDR is a light dependent resistor. Its resistance depends on the light intensity; its resistance is high at low light intensity and low in bright light.

b) An LED is a light emitting diode. This is a diode that only allows current to flow one way. When there is a potential difference of about 0.8 V across the diode it emits light. [The colour of light and this p.d. depend on the diode.]

c) A thermistor is a thermally sensitive resistor. Its resistance depends on its temperature. Here you have met a thermistor whose resistance is high at low temperatures and low at high temperature.

Page 310

a) A step-up transformer at a power station steps up the potential difference to a very high level: 400 000 V. Though the p.d. is stepped up, the current carried by the lines is reduced. The power dissipated by heating the transmission lines depends on the current ($P = I^2R$). So a low current reduces waste.

b) A p.d. of 230 V is low enough to minimise the chance of electrocution, but high enough to power our kettles and heaters.

Required practical 15

Page 297

1 Resistance of the wire.

2 Using a low voltage power supply.

Switching the circuit on only when readings were being taken.

3 Systematic error.

Required practical 16

Page 300

1 The resistance does not depend on the direction of the current.

2 For a diode connected in the reverse direction (negative), there is zero current. For a filament, lamp, a current flows in both directions.

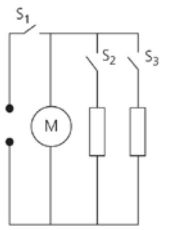
3 The plotted points will be closer together so it is easier to see the trend in the pattern.

4 0.5 V

Chapter review questions

1 Largest A; smallest B

2



(M) is the Symbol for a motor – fan in this case.

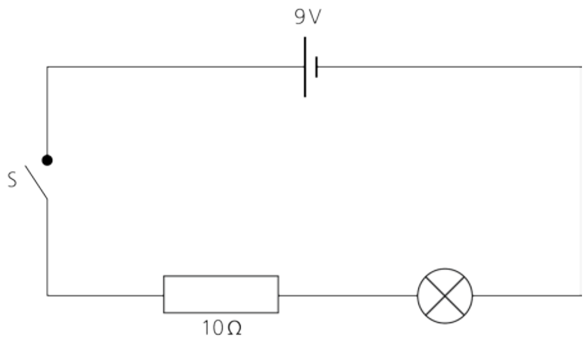
3 a) S1, but S2 also has to be closed for the headlights to work.

b) Yes, when S2 is closed current flows through the sidelights to the car body.

c) Yes, because current flows in parallel to the headlights.

d) Wiring would need to be added as plastic is an insulator.

4 a)



b) i) $P = VI$

$= 9 \times 0.3$

$= 2.7\,\text{W}$

ii) p.d. across resistor $= IR$

$= 0.3 \times 10$

$= 3\,\text{V}$

$= \text{so } P = VI$

$= 3 \times 0.3$

$= 0.9\,\text{W}$

or $P = I^2R$

$= 0.3^2 \times 10$

$= 0.9\,\text{W}$

iii) power in lamp $= 2.7\,\text{W} - 0.9\,\text{W}$

$= 1.8\,\text{W}$

or p.d. across lamp $= 9\,\text{V} - 3\,\text{V}$

$= 6\,\text{V}$

$P = VI$

$= 6 \times 0.3$

$= 1.8\,\text{W}$

5 a) 6 V

b) 6 V

c) 0.6 A

d) i) $R = V/I$

$= \frac{6}{0.2}$

$= 30\,\Omega$

ii) $R = V/I$

$= \frac{6}{0.4}$

$= 15\,\Omega$

6 p.d. across the 24 Ω resistor is:

$V = IR$

$= 0.2 \times 24$

$= 4.8\,\text{V}$

p.d. across X is 7.2 V

resistance of X is :

$$R = \frac{7.2}{0.2}$$

$$= 36\Omega$$

7 **a)** p.d. across each lamp is:

$$\frac{230}{115} = 2\text{V}$$

b) $R = V/I$

$$= \frac{2}{0.05}$$

$$= 40\Omega$$

c) $R = 115 \times 40$

$$= 4600\Omega$$

d) $P = VI$

$$= 230 \times 0.05$$

$$= 11.5\text{W}$$

Or $P = I^2R$

$$= (0.05)^2 \times 4600$$

$$= 11.5\text{W}$$

8 The resistance increases in a filament as the current rises because the filament gets hotter. As the atoms get hotter, their increased vibrations hinder the passage of electrons.

9 The component next to the lamp is a thermistor. At low temperatures the thermistor has a high resistance; at high temperatures the thermistor has a lower resistance. When the switch is closed, current flows; the thermistor beings to warm up. The resistance of the thermistor drops and the current rises, so the lamp gets brighter.

Practice questions

1 **a)** 1.5 V [1 mark]

b) 6 V [1 mark]

c) 0.25 A [1 mark]

d) greater than [1 mark]

The lamp and resistor have the same potential difference across them, so the lamp has a greater resistance as less current flows through it. $R = \frac{V}{I}$.[1 mark]

2 **a)** The resistance of an LDR gets less as the light intensity increases. [1 mark]

b) **i)** 8 mA (you must have the unit for the mark). [1 mark]

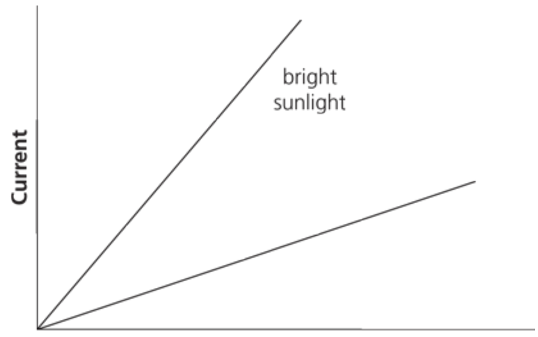
ii) $R = \frac{V}{I}$

$= \frac{3}{0.008}$ [1 mark]

$= 375\ \Omega$ [1 mark]

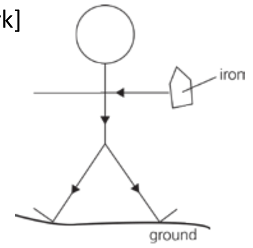
iii) It could be used as a lightmeter.

c) [1 mark]



3 In a direct current the current flows in the same direction all the time [1 mark]. An alternating current switches direction (50 times a second for mains electricity) [1 mark].

4 a) [1 mark]



b) $V = IR$

$230 = I \times 46\,000$ [1 mark]

$I = \frac{230}{46000}$ [1 mark]

$= 0.005$ A or 5 mA [1 mark]

5 a) A1 = 1.2 A [1 mark]

A2 = 0.7 A [1 mark]

b) Both resistors have the same potential difference across them. So R1 is bigger because there is a smaller current through it than through R_2. [2 marks]

c) $R = \frac{V}{I}$ [1 mark]

$= \frac{12}{0.3}$ [1 mark]

$= 40\ \Omega$ [1 mark]

6 a) The current rises quickly after the lamp is switched on, reaching a peak after about 0.1 s. After 0.8 s the current reaches a steady value. [2 marks]

b) i) 4.7 A [1 mark]

ii) 2.0 A [1 mark]

c) When the current is switched on the lamp is cold and the resistance is low.

Since $I = \frac{V}{R}$, the current is high. [1 mark]

As the lamp warms, resistance (*R*) increases so the current drops. [1 mark]

After 1 s the lamp has reached a steady temperature, so the current remains the same. [1 mark]

d) $P = VI$

$= 12 \times 2$ [1 mark]

$= 24\,\text{W}$ [2 marks, 1 for answer, 1 for unit]

7 a) $0.8\,\text{V}$ [1 mark]

b) $V = IR$

$= 20 \times 10^{-3} \times 260$ [2 marks]

$= 5.2\,\text{V}$ [1 mark]

c) $V = 5.2 + 0.8$

$= 6.0\,\text{V}$ [1 mark]

8 a) A thermistor. [1 mark]

b) 37 °C [1 mark]

c) $V = IR$

$12 = I \times 1000$ [1 mark]

$I = 0.012\,\text{A}$ or $12\,\text{mA}$ [2 marks, 1 for answer, 1 for unit]

d) As the temperature rises the resistance of X decreases and the current rises.

When the current rises the p.d. across the 750 Ω resistor rises, so the p.d. across X decreases and the voltmeter reading falls.

[3 marks, 1 for each good point]

9 a) i) The lamp has the greatest resistance, because the current through it is smaller. [1 mark]

$I = \frac{V}{R}$

All the appliances have the same p.d. across them. [1 mark]

ii) The cable needs to be thicker to carry a large current. If the cable is thin, a large current can heat it. [1 mark]

The kettle needs an earth wire. [1 mark]

b) $P = VI$

$= 230 \times 11.5$ [1 mark]

$= 2645\,\text{W}$ [1 mark for answer, 1 mark for unit]

c) **i)** $R = \frac{V}{I}$

$= \frac{230}{11.5}$

$= 20\,\Omega$ [1 mark]

$I = \frac{V}{R}$

$= \frac{115}{20}$ [1 mark]

$= 5.75\text{ A}$ [1 mark]

or you can say since the p.d. is halved, the current is halved: $\frac{11.5V}{2} = 5.75\,\text{A}$ [3 marks]

ii) $P = VI$

In USA, *V* is halved, *I* is halved so the power is reduced by 4 [2 marks]

Now the kettle boils in four times the time = 360 s [1 mark]

$P = \frac{E}{t}$

$t = \frac{E}{P}$

10 **a)** B (as this has the largest resistance) [1 mark]

b) D (as this has the least resistance) [1 mark]

Working scientifically: Units and calibration

Pages 316–17

1

Quantity	**Unit**	**Symbol**
charge	coulomb	C
current	ampere	A
energy	joule	J
frequency	hertz	Hz
potential difference	volt	V
power	watt	W
resistance	ohm	Ω
time	second	s

2 They share a common understanding

or

they can compare directly values measured in different places.

3 Draw a horizontal line from the voltmeter reading to the graph line; draw a vertical line down from this point on the graph line.

4 Because the calibration graph is not linear; joining only two data points would give a straight line and not a curve.

5 Between 8.4 and 8.6.

6 The resolution gets worse; a larger change in temperature is needed to produce the smallest measurable change in the voltmeter reading.

Test yourself on prior knowledge

1 Solid, liquid, gas.

2 There are fewer atoms (or molecules) in 1 m^3 of gas than 1 m^3 of solid. There is a lot of space between gas atoms; in a solid, atoms are packed closely together.

3 The molecules in steam are much more widely separated than the molecules in water.

Test yourself

1 A cork floats on water because it has a lower density than water. A stone sinks because it has a higher density than water.

2
$$\text{density} = \frac{\text{mass}}{\text{volume}}$$
$$= \frac{0.1732}{0.101 \times 0.048 \times 0.013}$$
$$= 2750\,\text{kg/m}^3$$

Note: it is easiest to turn the mass into kg first, and the lengths into m.

3 a) i) volume = 120 ml − 100 ml

= 20 ml

ii) volume = $20 \times 10^{-6}\,\text{m}^3$

b)
$$\text{density} = \frac{m}{v}$$
$$= \frac{0.09}{20 \times 10^{-6}}$$
$$= 4500\,\text{kg/m}^3$$

4 water – 1000 kg/m^3

alcohol – 4 m^3

titanium – 2250 kg

cork – 0.001 m^3

gold – 19 500 kg/m^3

5 Refer to Figure 17.6 page 323.

6 The molecules in gases are further apart than the molecules in liquids and solids, so gases have less mass in a given volume; therefore the density is lower.

7 a) A change of state occurs when a liquid changes to a solid or a gas, for example.

b) any two suitable examples such as: water freezing; alcohol evaporating

8 Melting snow; breaking a matchstick; mixing salt and sugar.

9 a) The internal energy rises.

b) There is a change of stage: melting or evaporating/boiling.

10 a) $\Delta E = mc\Delta\theta$

$= 60 \times 800 \times 25$

$= 1\,200\,000\,\text{J}$

or 1.2 MJ

b) $\Delta E = mc\Delta\theta$

$4180 = 0.5 \times 380 \times \Delta\theta$

$\Delta\theta = \frac{4180}{190}$

$= 22\,°\text{C}$

c) $\Delta E = mc\Delta\theta$

$21\,120 = m \times 880 \times 16$

$m = \frac{21120}{880 \times 16}$

$= 1.5\,\text{kg}$

11 a) $\Delta E = mc\Delta\theta$

$13\,500 = 1.2 \times c \times 45$ [Note the joulemeter is set to kJ]

$c = \frac{13500}{1.2 \times 45}$

$= 250\,\text{J/kg}\,^{\circ}\text{C}$

b) There will be heat losses to the surroundings.

Energy is used to warm up the heater itself and the thermometer.

12 a) $\Delta E = mc\Delta\theta$

$= 0.75 \times 4200 \times 80$

$= 252\,000\,\text{J}$

b) $P = \frac{\Delta E}{t}$

$2000 = \frac{252\,000}{t}$

$t = \frac{252\,000}{2000}$

$= 126\,\text{s}$

13 a) Energy is transferred from the body's thermal store to evaporate the sweat.

b) If you get out of the sea on a windy day, water from the skin evaporates quickly. This removes energy quickly from the body's thermal store and you cool down.

14 a) **i)** The substance melts over the period BC and **ii)** boils over the period DE.

b) 155 °C

c) Vaporisation – it takes longer for the substance to evaporate than to melt, so more energy is supplied to evaporate the substance than to melt it.

15 a) The specific latent heat of fusion is the energy required to turn 1 kg of ice at 0 °C to 1 kg of water at the same temperature. If you use ice at −18 °C, you also measure the energy required to warm it up.

b) $E = P \times t$

$= 50 \times 60$

$= 3000$ J (Remember to turn 1 minute into 60 s)

c) $E = mL$

$3000 = 0.008\ L$

$$L = \frac{3000}{0.008}$$

$= 375\ 000$ J/kg

d) Energy might be lost to the surroundings directly from the heater because the ice is not in contact with the heater. Some energy from the surroundings could melt the ice. The ice might be colder than 0 °C.

Show you can

Page 322

Measure the mass of a measuring beaker by placing it on an electronic balance. Record its mass in grams, m_1.

Fill the beaker with the liquid – to the 100 ml mark.

Measure the mass again, m_2.

Calculate the mass of the liquid, $m_2 - m_1$.

The density of the liquid is calculated using:

density = $(m_2 - m_1)$/volume

To calculate the density in kg/m^3, convert grams to kilograms (1 g = 10^{-3} kg) and remember that 1 ml = 10^{-6} m^3.

Page 330

Neither method of burning is to be recommended. Steam is much more dangerous because it releases latent heat when it condenses to water at 100 °C and the specific latest heat of steam is very high.

Required practical 17

Page 320

1 The percentage error in the measurement will be smaller

or

the error in the measurement will be less significant.

2 The smallest change in mass that can be measured is 0.1 g.

Page 321

1 The sides of the cuboid could be slightly worn away or rounded.

2 Stack 500 sheets of paper on top of each other. Measure the thickness of the stack and then divide by 500.

Page 322

1 A Mass of zero must have a volume of zero.

2 An anomalous data point will not be close to the line of best fit.

Chapter review questions

1 a) volume = 0.04 × 0.03 × 0.05

$= 6 \times 10^{-5}\,\text{m}^3$

b) $\rho = \dfrac{m}{v}$

$= \dfrac{0.03}{6 \times 10^{-5}}$

$= 500\,\text{kg/m}^3$

Hint: Work in m and kg from the start. Do not try to convert g/cm^3 to kg/m^3, which is the harder way to do the problem.

2 a) Mass – measure on an electronic balance.

Volume – measure the volume by displacing a volume of water.

b) $\rho = \dfrac{m}{v}$

$= \dfrac{0.32}{26 \times 10^{-6}}$

$= 12\,300\,\text{kg/m}^3$

c) A lead ornament with a gold cover?

3 When a liquid evaporates, energy must be supplied from the surroundings to cause the evaporation. When ether is on the skin, energy is supplied from the body for it to evaporate. The loss of energy makes the skin feel cold.

4 **a)** The molecules in ice are in fixed positions; the molecules in water are free to move past each other. (See Figure 17.6 parts a) and b) page 323 for an example of a diagram.)

b) Energy must be supplied to melt ice at 0 °C. Energy comes from the drink to melt the ice, so cooling the drink.

c) Ice is less dense than water.

5 **a)** $\Delta E = mc\Delta\theta$

$200 \times 10^3 = 40 \times 1000 \times \Delta\theta$

$$\Delta\theta = \frac{200\,000}{40\,000}$$

$$= 5\,°\text{C}$$

so the air temperature rises from 15 °C to 20 °C

b) $\Delta E = mc\Delta\theta$

$= 60 \times 800 \times (48 - 13)$

$= 60 \times 800 \times 35$

$= 1\,680\,000$ J or 1.68 MJ

6 **a)** Molecules are in a state of constant motion. The molecules hit the walls of the container and thereby exert a force on the walls. Pressure is a measure of that force per unit area.

b) At a higher temperature, the molecules move faster. Therefore, the molecules hit the walls harder and more often.

7 **a)** $P = \frac{E}{t}$

$$500 = \frac{E}{5 \times 60}$$

$E = 500 \times 300$

$= 150\,000$ J

b) $L = \frac{E}{m}$

$$2\,500\,000 = \frac{150\,000}{m}$$

$$m = \frac{150\,000}{2\,500\,000}$$

$= 0.06$ kg

Practice questions

1 kg/m^3 [1 mark]

2 **d)** X and Z [1 mark]

3 **a)** liquid [1 mark]

b) solid [1 mark]

c) liquid [1 mark]

d) gas [1 mark]

e) gas [1 mark]

f) solid [1 mark]

4 The substance could melt or boil (or evaporate). [1 mark]

The energy added provides the energy required to bring about the change of state [1 mark]

5 Atoms in a solid remains in fixed positions, but can vibrate about those fixed positions. [2 marks]

The atoms in a gas are separated and free to move around at random at large speeds. [2 marks]

6

Measure the mass, *M*, of the marbles using the balance. [1 mark]

Put some water in the cylinder and measure the volume V_1 [1 mark]

Put the marbles in and measure the new volume V_2. Volume of the marbles, V, is $V_2 - V_1$ [1 mark]

Calculate the density, ρ, using $\rho = \frac{\mathrm{m}}{\mathrm{v}}$ [1 mark]

7 **a)** $\Delta\theta = 70 - 30$

$= 40\,°\mathrm{C}$ [1 mark]

b) $\Delta E = mc\Delta\theta$

$48\,000 = 2 \times c \times 40$ [1 mark]

$c = \frac{48\,000}{80}$ [1 mark]

$= 600\,\mathrm{J/kg\,^{o}C}$ [1 mark for answer, 1 mark for unit]

c) $P = \frac{E}{t}$ [1 mark]

$= \frac{48\,000}{10 \times 60}$ [1 mark]

$= 80\ \mathrm{W}$ [1 mark]

8 **a)** $53\,°\mathrm{C}$ [1 mark]

b) The energy that is supplied by the heater is used to break the bonds which keep the wax as a solid. When the bonds break, the internal energy of the solid increases. [2 marks]

c) $L = \frac{E}{m}$ [1 mark]

$= \frac{4000}{0.05}$ [1 mark]

$= 80\,000\,\mathrm{J/kg}$ [1 mark for answer, [1 mark for unit]

Working scientifically: Physical models

Pages 335–36

1 A ball and spring model for the internal energy of a solid.

2 The acceleration would increase (in direct proportion to the increase in force); this could be tested experimentally by applying different forces to an object (e.g. laboratory trolley) and measuring the acceleration.

3 New evidence (observations or data) that support a prediction made by a model and cannot be explained by the other models.

Test yourself on prior knowledge

1 Proton, neutron.

2 Proton.

3 An atom is neutral; protons and electrons carry charges of the same size but opposite sign.

Test yourself

1 **a)** 10^{-10} m

b) 10 000

2 B and C. They each have four of the same type of particle – which must be a proton.

3 **a)** **i)** 7; the atomic number is the number of protons

ii) 14; the mass number is the number of protons and neutrons

b) It has seven protons and seven electrons. Since a proton has a positive charge and an electron a negative charge, of the same size, the atom is neutral.

4 **a)** 8 protons, 9 neutrons

b) 80 protons, 120 neutrons

c) 92 protons, 146 neutrons

d) 1 protons, 2 neutrons

5 **a)** 64 is the atomic number which tells us the number of protons in the nucleus.

156 and 158 are the mass numbers, which tell us the combined number of protons and neutrons in the nucleus.

b) **i)** number of protons – 64

ii) number of neutrons – 92 and 94

6 Elements can have more than one isotope. Each isotope has the same number of protons in the nucleus, but different numbers of neutrons.

7 $$\frac{\text{radius of atom}}{\text{radius of nucleus}} = \frac{1.5 \times 10^{-10}}{3.0 \times 10^{-15}}$$

$$= 50\,000 \text{ or } 5 \times 10^{4}$$

8 **a)** Uniformly throughout the atom.

b) In the nucleus.

9 The alpha particle is repelled by the charge on the nucleus. Like charges repel, so the alpha particles and nucleus carry the same sign of charge.

10 Because the radius of the nucleus is very small in comparison with the radius of the atom. So most alpha particles pass through without getting close enough to the nucleus to be deflected by the nuclear charge.

11 The plum pudding model describes the atom as a positive charge distributed through the atom. Then inside this solid substance there are small electrons, with a negative charge, which can move around.

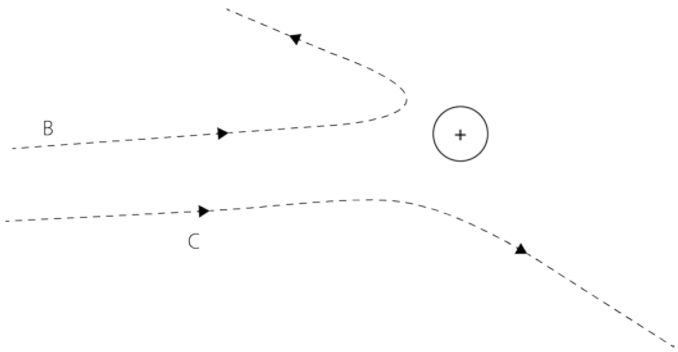
12 a) The Bohr model of the atom has a small nucleus with a positive charge e.g. + 8. Then outside the nucleus are eight electrons (with charge −1 each). These electrons orbit in fixed orbits/energy levels, like planets going round the Sun.

You could add a diagram like Figure 18.7 page 342 to help your answer.

b) i) The electron gains energy and, in an atom, the electron can jump up an energy level.

ii) The electron loses energy and, in an atom, the electron can fall from a high energy level to a lower one.

13



B is deflected more than A.

C is deflected less than A.

14 a) A helium nucleus.

b) An electron.

c) Electromagnetic radiation.

15 B

16 a) An atom or molecule is ionised when an electron is removed from it or added to it.

b) When an electron is removed from an atom or molecule, it leaves a positive ion behind. That free electron can be thought of as a negative ion, or the electron might attach itself to another atom or molecule, so making a negative ion.

17 a) ${}^{3}_{1}H \rightarrow {}^{3}_{2}He + {}^{0}_{-1}e$

b) ${}^{229}_{90}Th \rightarrow {}^{225}_{88}Ra + {}^{4}_{2}He$

c) ${}^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e$

d) ${}^{209}_{82}Pb \rightarrow {}^{209}_{83}Bi + {}^{0}_{-1}e$

e) ${}^{225}_{89}Ac \rightarrow {}^{221}_{87}Fr + {}^{4}_{2}He$

18 Thorium

19 The alpha particles create ions in the air – negative ions are repelled from the electroscope but positive ones attracted so charge is neutralised.

20 B It will travel through several metres of air.

21 a) alpha

b) beta

22 Radiation is dangerous to us, so the teacher keeps the source as far away as possible from his/her body.

23 Count rate.

24 a) C

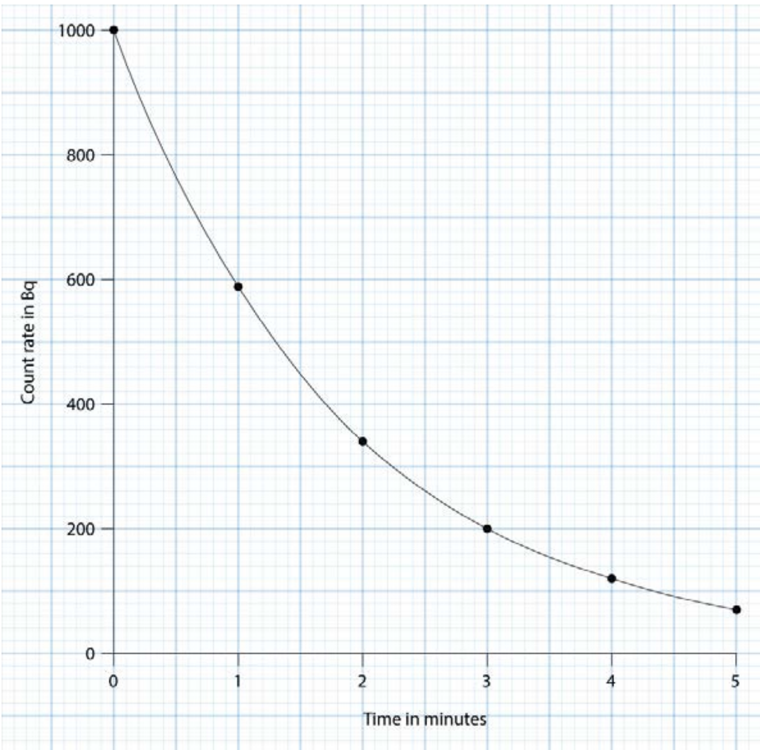
b) A

25 'Random' describes an occurrence which is unpredictable.

26 Over a period of 15 minutes, half of the radioactive material will decay.

60 minutes is four half-lives. So $\frac{1}{2}\times\frac{1}{2}\times\frac{1}{2}\times\frac{1}{2}=\frac{1}{16}$ of the material is left.

27



Half-life = 1.3 minutes

28 a) 12 noon on 2 March to 4.00 am on 3 March is a period of 16 h.

This is two half-lives, so the count rate reduces to $\frac{1}{4}\times 2400\ \text{Bq} = 600\ \text{Bq}$

b)

600 Bq	4.00 am on 3 March
300 Bq	12 noon on 3 March
150 Bq	8.00 pm on 3 March
75 Bq	4.00 am on 4 March

29 Alpha, beta, gamma, neutron.

30 a) It is difficult to say as we do not know the size of the doses. But $\frac{50}{800} = 1 \text{ in } 16$ people died after exposure to alpha particles; $\frac{20}{7000} = 1 \text{ in } 350$ people died after exposure to gamma rays. So on this limited evidence alpha particles seem much more dangerous.

b) If we assume that the two atomic bombs were of the same strength, then neutrons appear more dangerous than gamma rays.

Hiroshima: $\frac{100}{15000} = \frac{1}{150}$

Nagasaki: $\frac{20}{7000} = \frac{1}{350}$

c) Correct, we have no data about the size of the doses received.

31 Greater than

Show you can

Page 340

Atoms are very small with a radius of about 10^{-10} m. The atom has an even smaller nucleus with radius less than a $\frac{1}{10000}$ of the atom. The nucleus contains nearly all of the mass of the atom. Inside the nucleus are protons and neutrons. The proton has a positive charge; the neutron is neutral. Electrons with a negative charge orbit the nucleus. The mass number of the atom is the sum of the number of neutrons and protons. The atomic number is the number of protons. In a neutral atom, the numbers of protons and electrons are the same.

Page 343

Alpha particles, which are small energetic positively charged particles were aimed at a thin piece of gold foil. Most of the particles travelled through the foil without deflection. A small number underwent very large deflections. This led to the idea of a very small, massive, positively charged nucleus.

Page 346

The answers for this question are to be found on Page 344.

Page 347

Note, you are not allowed to do this experiment yourself.

You need a pure alpha source, e.g. Americium-241.

Place the source close to the GM tube. Move the source away until the count rate on the GM tube reduces to zero.

Place the source close to the GM tube. Insert a thin piece of tissue paper between the source and the GM tube. Observe the fall in count rate.

Continue inserting extra pieces of tissue paper until the count rate falls to zero. It is possible that one sheet will be sufficient to stop all the alpha particles.

Page 351

Radiation causes damage by two mechanisms:

- direct – an alpha or beta particle directly collides with a cell, tearing it apart
- indirect – ionisation produces acids which attack cells.

The amount of damage to our bodies depends on the exposure to radiation – the dose. By monitoring the dose, we can rest a radiation worker if they are exposed to too high a dose.

Chapter review questions

1 **a)** 3

b) 7

c) 3

2 **a)** **i)** Stable means that the isotope does not emit a radioactive particle and become another element.

ii) An isotope is one type of nucleus of a particular element. Different isotopes of the same element have the same number of protons but different numbers of neutrons.

b) Carbon-12, 6 protons, 6 neutrons; Carbon-13, 6 protons, 7 neutrons

3 They have different numbers of protons in the nucleus, and different numbers of electrons.

4 **a)** **i)** ${}^{241}_{94}\text{Pu} \rightarrow {}^{237}_{92}\text{U} + {}^{4}_{2}\text{He}$

ii) ${}^{229}_{90}\text{Th} \rightarrow {}^{225}_{88}\text{Ra} + {}^{4}_{2}\text{He}$

iii) ${}^{213}_{84}\text{Po} \rightarrow {}^{209}_{82}\text{Pb} + {}^{4}_{2}\text{He}$

b) **i)** ${}^{237}_{92}\text{U} \rightarrow {}^{237}_{93}\text{Np} + {}^{0}_{-1}\text{e}$

ii) ${}^{59}_{26}\text{Fe} \rightarrow {}^{59}_{27}\text{Co} + {}^{0}_{-1}\text{e}$

iii) ${}^{32}_{14}\text{Si} \rightarrow {}^{32}_{15}\text{P} + {}^{0}_{-1}\text{e}$

5 The plum pudding model assumed that the atom has a uniform density, with positive charge spread through the atom. Such an atom was not expected to deflect an alpha particle. Geiger and Marsden's work showed that alpha particles could be deflected by large angles by metal foils. This can only be explained by a model which places nearly all the mass and all the positive charge of an atom in a small nucleus.

6 a) More will bounce back when the foil is thicker, as the alpha particle has more chance of meeting a nucleus.

b) Fewer will bounce back, because the charge on the aluminium nucleus is much less than it is on a gold nucleus; there is a smaller force between the alpha particle and nucleus for a given separation.

7 a) A helium nucleus.

b) Alpha particles are strongly ionising. Inside the body, alpha particles can cause intense localised damage to tissues.

8 a) i) Time.

ii) Count rate.

b) Geiger-Muller tube.

9 a) A half-life is the time taken for a radioactive material to decay to half its original amount.

b) i) Ionising radiation is radiation that ionises material which it meets by knocking out electrons from atoms or molecules.

ii) Alpha

Practice questions

1 a) i) Number of electrons, 4 [1 mark]

Number of protons, 4 [1 mark]

Number of neutrons, 5 [1 mark]

ii) Atomic number 4 – the number of protons determines the atomic number. [2 marks]

b) i) Missing word: neutron. [1 mark]

ii) C [1 mark]

c) i) 4.2 million years. [1 mark]

ii) 1.4 million years. [1 mark]

2 a) i) C

ii) B [2 marks]

b) i) X [1 mark]

ii) Irradiation keeps them fresher, so they are better to eat. [1 mark]

3 a) i) Protons 15

Neutrons 16

Electrons 15 [2 marks for all 3, 1 mark for 2 correct]

ii) Phosphorus-32 has 17 neutrons so it is heavier than phosphorus-31. [1 mark]

iii) ${}^{32}_{15}\mathrm{P} \rightarrow {}^{32}_{16}\mathrm{S} + {}^{0}_{-1}\mathrm{e}$ [1 mark]

b) i) A Geiger-Muller tube (or GM tube). [1 mark]

ii) Cancer. [1 mark]

4 a) β and γ [1 mark]

b) γ [1 mark]

5 **a)** Caesium-137 has three more neutrons than caesium-134. [1 mark]

b) A beta particle is an electron. [1 mark]

Gamma radiation is electromagnetic radiation [1 mark]

(or an electromagnetic wave).

c) To reduce to ¼ of the count rate will take 2 half-lives – 16 days. [2 marks]

d) Caesium-137 – after 50 years there will be only a very small amount of caesium-134 and iodine-131. [1 mark]

6 **a)** An electron. [1 mark]

b) Half-life is the time taken for half of a radioactive source to decay. [1 mark]

c) Putting the waste into drums sounds safe, but these are some of the concerns:

- after many years, the drums could leak and radioactive waste could get into water
- the drums have to be transported to the caverns – there could be a road accident on the way that spills waste
- unlikely – but an earthquake or collapse of the cavern could fracture the drums and spill the waste.

[2 marks for the first well-explained answer, plus a third mark for a second relevant idea.]

7 **a)** ${}^{11}_{5}\mathrm{B} \rightarrow {}^{7}_{3}\mathrm{Li} + {}^{4}_{2}\mathrm{He}$ [1 mark for each]

b) Both are positively charged and like charges repel. [1 mark]

c) Because radiation can actually cause cancer – this is a risky procedure but the benefits outweigh the risks. [1 mark]

8 Include a diagram like Figure 18.4 page 341. [2 marks]

A very small number of nuclei are deflected back by 180°. This shows that the nucleus is very small in comparison with the atom. [2 marks]

The nucleus must be massive to repel the alpha particle and be positively charged, because the alpha particle is positively charged. [2 marks]

Working scientifically: Risk and perception of risk

Page 356

1 Handle the source with tongs.

Wear disposable plastic gloves.

Do not point the source at anyone.

When not in use keep the source in a lead lined box.

2 a), b), d)

19 Homeostasis and the human nervous system

Answers

Test yourself on prior knowledge

1 A specialised cell that conducts nerve impulses.

2 Coordinates voluntary and involuntary actions.

Test yourself

1 blood glucose, water, temperature

2 the brain, spinal cord, pancreas

3 Electrical impulses travel faster along nerves than hormones do in the blood.

4 the brain and spinal cord

5 muscles and glands

6 it can cross a synapse and stimulate another neurone or bring about a response in an effector

Show you can

Page 359

1 Homeostasis is maintaining a constant internal environment. Your body regulates the amount of blood glucose. Too much or too little could make you fall into a coma and/or die.

Page 363

2 An electrical signal travels along sensory neurones to your spinal cord. to save time, it does not move in relay neurones to your brain but returns along motor neurones to your muscles. These move to stop your finger burning.

Required practical 6

Page 362–63

1–3 Answers are based on the student's own results.

4 light and sound

5 To close your hand.

Chapter review questions

1 the central nervous system and peripheral nervous system

2 bundles of individual neurones

3 sight, hearing, taste, smell, touch

4 They happen automatically, without you thinking about them.

5 moving your body away from a painful stimulus, your heart rate, controlling light entering your eye

6 Work in pairs. One person holds a ruler above the other person's open hand. The first person drops the ruler and the second person catches it. The distance travelled represents the reaction time; a longer distance is a slower reaction. Repeat before and after drinking caffeine to see the effects of the stimulant.

7 from a receptor to the central nervous system

8 in the brain and spinal cord

9 glands or muscles

10 a gap between the axon of one nerve and the dendrites of another where chemical neurotransmitters transmit the impulse

11 chemical neurotransmitters

12 When an electrical impulse reaches the end of its axon special areas convert the electrical signal into a chemical signal. These chemical neurotransmitters quickly diffuse across the synapse. They meet the dendrites of the next nerve cell and restart the electrical impulse.

13 The impulse is generated by a receptor and travels along sensory neurones and their synapses to the spinal cord. Here relay neurones take over the signal, but it is not sent to the brain. Instead, the spinal cord sends the signal back along motor neurones to the muscles, which quickly contract.

Practice questions

1 **a)** The maintenance of a constant internal environment. [1 mark]

b) If blood glucose levels get too high, homeostatic systems reduce [1 mark] the amount of glucose in the blood, so that they return to their normal [1 mark] level.

2 **a)** 3 [1 mark]

b) 2 [1 mark]

3 **a)** 4 marks: 1 mark for stimulus first, 1 mark for receptor before coordinator, 1 mark for effector after coordinator, 1 mark for response last.

b) **i)** sensory neurone [1 mark]

ii) motor neurone [1 mark]

c) **i)** A synapse [1 mark]

ii) any three from: axons release; chemical signal; diffuses across the gap/synapse; detected by receptors; on dendrites; new electrical impulse/signal generate [3 marks]

d) 1 mark for correct working shown 1.5/120, 1 mark for correct answer 0.0125. [2 marks]

e) alcohol [1 mark]

Working scientifically: Experimental skills

Page 366

1–2

Thermometer	Most accurate (1)	Least accurate (1)	Mean (2)
1	51.0	47.6	49.7
2	48.1	47.9	48.0
3	51.2	51.7	51.5

3 As it is important that a thermometer gives a reading that is true.

4 throat or rectum

5 Thermometer 2 as its results are closest to the mean value.

6 Thermometer 3 as its values are closest to the true values measured by the clinical thermometer.

7 As we cannot say with 100% certainty that it is 100% accurate.

Test yourself on prior knowledge

1 any one from: obesity, diabetes

2 by living a healthy lifestyle, including a balanced diet and regular exercise

3 because it prepares itself for a fertilised ovum to embed in the lining and grow into a baby

Test yourself

1 ADH and TSH

2 to fight or run away ('fight or flight')

3 in the hypothalamus in the brain

4 Insulin lowers blood sugar concentration, and glucagon increases it.

5 type 1

6 the pancreas

7 Glucagon is released from the pancreas. This hormone converts glycogen into glucose in the liver. The glucose is released into the bloodstream, increasing the blood sugar concentration.

8 in the ovaries

9 growth of breasts, widening of hips, growth of underarm and pubic hair, growth spurt

10 Negative feedback occurs when your body detects a change and makes an adjustment to return it back to normal. FSH causes an ovum to mature inside a follicle and the ovaries to produce oestrogen. This thickens the lining of the uterus. High levels of oestrogen stop the production of FSH and increase the secretion of LH, which stimulates ovulation. The corpus luteum releases progesterone, which stops the release of both FSH and LH.

11 a contraceptive medical procedure during which a man's sperm ducts are blocked or cut

12 Some people disagree with it for religious or moral reasons.

13 Women take a specific pill each day for 21 days. For the final 8 days of the cycle they either take a placebo pill or no pill. This is when they have their period.

14 FSH and LH

15 the pill, patch, implant

16 A small operation removes ova from a woman. They are fertilised under a microscope by sperm. They are then inserted back into a woman's uterus to develop.

17 FSH and LH are injected to start the maturation of ova in the ovaries.

18 metabolic rate

19 in the pituitary gland

Show you can

Page 369

1 It releases hormones, which have other glands as their target organs so it makes them function. These help control growth and blood pressure, as well partly control functions of your ovaries or testes, pregnancy, childbirth and your kidneys.

Page 372

2 Type 1 diabetes usually develops when the insulin-producing cells in the pancreas are destroyed by the body's own immune system. People with type 1 diabetes often inject insulin to help reduce their blood glucose concentration. Reduction of sugar in the diet and exercising regularly can also help. People with type 2 diabetes cannot produce enough insulin or, if they can, their liver and muscle cells won't respond to it. This is often linked to obesity. Treatments include eating a balanced, healthy diet and exercising regularly. In type 2 cases liver and muscle cells do not respond to insulin, so injecting insulin is not usually a treatment.

Page 375

3 At the start of the cycle, a woman has her period. This lasts several days. A reduction in progesterone triggers this. After this the lining of the uterus thickens. Oestrogen causes this. Ovulation occurs on about day 14 of the menstrual cycle. If a woman becomes pregnant her progesterone levels remain high and she misses her period. If not, the cycle repeats.

Page 376

4 The pill stops production of FSH hormone. This stops ovulation. The pill can also thicken the mucus in the uterus so it is harder for sperm to travel. It can also thin the lining of the uterus to stop the fertilised ovum implanting.

Page 377

5 FSH and LH are injected. This may be enough for a woman to become pregnant. If not, she can undergo IVF. FSH and LH are injected to help ova mature. Ova are removed and fertilised by sperm. They are then replaced in a woman's uterus.

Page 378

6 It increases the heart rate. This gives more oxygen and glucose to the muscles, which can respire more. This releases more energy, which means they can prepare the body for fight or flight.

Activity

Page 372

1 Task – no answer is required.

2 Patient B as Patient A's concentration of blood glucose returns to normal after 6 hours. Patient B's concentration of blood glucose was still 18 mg/dL higher than before the meal after 6 hours.

3 Because the meal had to be digested and the glucose had to enter the bloodstream.

4 When the meal is eaten blood glucose rises. The pancreas adds insulin to the blood. Glucose is converted to glycogen in the liver, reducing the levels of glucose in the blood to normal.

Chapter review questions

1 glands

2 in the blood

3 testes

4 methods or devices that stop women becoming pregnant

5 Condoms also stop the spread for sexually transmitted diseases.

6 target organ

7 It travels to the liver, where it turns excess glucose into glycogen to be stored.

8 They reduce the sugar in their diet and exercise regularly.

9 It thickens the lining of the uterus.

10 The sperm ducts, which carry sperm from the testes to the penis, are tied or cut in an operation.

11 They sit inside the vagina and stop sperm reaching the uterus.

12 oestrogen and progesterone

13 They contain the same hormones, oestrogen and progesterone, as in the pill but are delivered into a woman's blood by the implant or patch.

14 If women are not producing enough FSH and LH these hormones can be injected into their blood.

15 It controls the release of hormones from the thyroid gland.

16 because we traditionally only eat three times per day but we require glucose all of the time

17 Negative feedback control means your body will detect a change and respond by returning conditions to normal. If your blood sugar is too high it will be lowered. If your blood sugar is too low it will be raised.

18 FSH stimulates the development of an ovum in the ovary and stimulates the production of oestrogen by the ovary. LH stimulates ovulation.

19 FSH and LH are injected to stimulate the maturation of several ova. A small operation removes these ova from the woman's ovaries and they are fertilised by a man's sperm. Sometimes the nucleus of a sperm cell is injected into the ovum. The fertilised ova then develop into embryos, which are placed into the woman's uterus. Nine months later the woman has her 'test tube' baby or babies.

20 More than one of the embryos placed in the uterus develops into a foetus and / or hormone treatment causes two or more ova to be released from an ovary at the same time.

Practice questions

1 **a)** protein / chemical message that travels in the blood to bring about a change / control body functions [1 mark]

b) C Glands [1 mark]

c) in the blood [1 mark]

2 **a)** 185 mg/dL [1 mark]

b) **i)** line to start higher, peak higher and level off at a higher level [3 marks]

ii) B Insulin [1 mark]

iii) manage their diet [1 mark]

c) **i)** for respiration [1 mark]

ii) pancreas [1 mark]

d) pancreas detects the low blood sugar level [1 mark]

glucagon is released into the blood by the pancreas [1 mark]

this converts glycogen to glucose [1 mark]

in the liver and muscles [1 mark]

3 **a)** **i)** idea that between days 1 and 4 it reduces as period/menstruation is occurring; after this the lining build up during days 4 to 14, and then the lining is maintained from day 14 to day 28 [3 marks]

ii) day 14 [1 mark]

b) idea that FSH stimulates oestrogen production; begins egg maturation; oestrogen inhibits FSH; oestrogen stimulates pituitary gland to produce LH; development of the uterine lining; LH stimulates the release of the ovum, or ovulation; LH inhibits oestrogen [4 marks]

4 the ovaries [1 mark]

5 **a)** cell allowed to divide / forms an embryo [1 mark], which is then inserted into the uterus [1 mark]

b) **i)** more likely to succeed / higher success rate [1 mark]

ii) multiple births; more likely to give birth prematurely; people might not want that many children; could harm the mother [1 mark]

Working scientifically: Scientific thinking

Page 382–83

1 Answer is based on the student's own opinions.

2 Any two from: religious objections, wastage of embryos, possibility of multiple births, cost, potential to select and modify embryos.

3 Any sensible answer relating to the cost of IVF.

4 Task – no answer is required.

Test yourself on prior knowledge

1 pollen and ova

2 A fertilised ovum splits into two, which develop into two identical organisms.

3 Cross-pollination is between two different plants, whereas self-pollination is between two flowers of the same plant.

4 chromosomes, genes, DNA

Test yourself

1 23

2 two in meiosis and one in mitosis

3 Mitosis produces identical cells, whereas meiosis produces non-identical ones.

4 gametes / sperm or pollen and ova

5 all the DNA of an organism

6 a short section of DNA that controls a characteristic; a short section of DNA that provides the code to make a protein

7 Some people disagree with it for religious or moral reasons.

8 The development of genetic tests to show that people may be more likely to develop breast cancer and cystic fibrosis, for example.

9 alleles

10 brown eyes, tongue rolling, attached ear lobes

11 BB and Bb give brown eyes, whereas bb gives blue eyes

12 Neither parent has a recessive gene, so it is 100%.

13 A medical condition that is caused by one or more genes passed down from parent(s).

14 Cc

15 mucus in the lungs

16 Babies are born with six fingers or toes.

17 XY

18 XX

19 All offspring of the same parents are not clones and show variation.

Show you can

Page 389

1 If you have siblings, then you would be a clone of your brother or sister if they weren't.

Page 390

2 DNA is made from the base pairs A–T and G–C. A short section of this DNA that codes for a protein is called a gene. A chromosome is made from coding and non-coding regions of DNA that is coiled into an X shape. A genome is the sum of all the DNA in all an organism's chromosomes.

Page 391

3 Some people think that genetic prejudice may exist in the future when people's jobs or insurance might be determined by their genetics (over which they have no control).

Page 394

4 Both parents are heterozygous for tongue rolling (Tt). They have a one in four chance of producing a baby that is homozygous recessive (tt).

Page 395

5 Both parents are heterozygous for cystic fibrosis (Cc). They have a one in four chance of producing a baby who is homozygous recessive (cc) and will have the disorder.

Page 397

6 As women are XX, all their eggs will contain an X chromosome. As men are XY, either the X will fertilise the egg, making it XX and a girl, or the Y will, making it XY and a boy. There is a 50:50 chance of this, as the choice is either X or Y from the sperm.

Chapter review questions

1 One copy of all the DNA found in your diploid body cells.

2 You have inherited one from each of your two parents.

3 A short section of DNA (part of a chromosome) that provides the code to make a protein.

4 A decision that some people disagree with for religious or moral reasons.

5 It is the code that tells your body which proteins to make.

6 identical twins

7 the 23rd pair

8 the identification of the sequence of every one of the three billion base pairs from a random male and female volunteer

9 working together

10 Some people believe that some employers might be prejudiced about the genetics of those that they employ. Others worry that health insurance companies that knew our genetics might charge some people more than others.

11 amino acids

12 ribosomes

13 The future of many medicines and medical treatments is likely to involve the follow-up work to the Human Genome Project.

14 Two heterozygote parents.

15 One parent heterozygous and one homozygous recessive.

Practice questions

1 **a)** sexual; gametes / sex cells; variation; homozygous; heterozygous; XY [6 marks]

b) Punnett square: correct parent gametes [1 mark], correct genotypes for offspring [1 mark], correct genders of offspring deduced [1 mark]

2 **a)** a version of a gene [1 mark]

b) An allele is dominant (e.g. B) if it is expressed in the heterozygous phenotype; a recessive allele (e.g. b) is only expressed if both alleles are recessive. [2 marks]

c) Punnett square: correct parent genotypes (Bb x Bb) [1 mark]; the different offspring produced (BB, 2x Bb, and bb) [1 mark]; bb identified as white [1 mark]; correct probability of 0.25 given [1 mark] [do not accept a ratio/fraction, as not asked for in the question]

3 **a)** the nucleus [1 mark]

b double helix [1 mark]

c) a gene [1 mark]

4 B cc [1 mark]

Working scientifically: Scientific thinking

Page 400

Task – no answer is required.

Test yourself on prior knowledge

1 continuous and discontinuous

2 By genetic factors, which are inherited, or by the environment in which an organism lives.

3 Because discontinuous data come in groups that are best represented by bars rather than points joined up.

Test yourself

1 genetic, environmental, and genetic and environmental

2 continuous and discontinuous

3 on a line graph with a line of best fit

4 a bell-shaped curve that rises in the middle and is low at both sides

5 cats, all farmyard animals

6 a measure of the total genes of a population

7 Disease-resistance has been bred by breeding only those parent plants that are resistant to disease.

8 Any negative characteristics are magnified as well as the desired ones, and the gene pool is reduced, meaning adaptation may be harder.

9 carotene

10 to be drought-resistant

11 Some people disagree with it for religious or moral reasons.

12 a small circle of DNA that is present in bacterial cells

13 Plasmids can move from one bacterium to another. In genetic engineering the plasmids are removed from bacteria and have a gene inserted into them. They then are used to 'infect' other bacteria and take the gene with them.

Show you can

Page 404

1 A mutation is a change in DNA. This can be harmful, have no effect or actually be an advantage. Any change in DNA can be inherited, at which point it becomes a source of genetic variation.

Page 406

2 Our ancestors bred together wolves with certain characteristics such as size or aggression. The offspring of these crosses are likely to inherit the characteristics from their parents. Those that

did were crossed again with other individuals like them. Soon these characteristics were magnified into the dog breeds we have today.

Page 407

3 The gene for glowing in the dark in jellyfish was identified and removed using enzymes. The same enzymes were used to cut open the DNA of a rabbit embryo. The gene was sealed into the rabbit DNA using a different enzyme. The embryo was implanted into a female rabbit.

Page 408

4 Enzymes are used to cut out the gene for insulin; the same enzymes are used to cut a small circle of DNA found in bacteria called a plasmid. The human gene is then inserted into the plasmid.

Activity

Pages 403–404

1 Task – no answer is required.

2 yes

3 Variation is continuous.

4 Allow any sensible suggestion for non-continuous variation such as eye colour, gender, hair colour or blood type.

5 Student B has the most accurate data for the mass of 11 year olds, as their sample size is much larger.

Chapter review questions

1 the differences that exist within a species or between different species

2 genetic, environmental, and genetic and environmental

3 eye colour, blood group

4 scars, tattoos

5 a scientific technique in which a gene is moved from one species to another

6 height, weight

7 environmental

8 continuous, discontinuous

9 data that come in a range and not in groups

10 data that come in groups and not a range

11 bell-shaped with more common values in the middle and less common values at each side

12 If you want to breed a big dog, you choose a big bitch and big dog and let them mate. You then choose the biggest bitch and dog in the next generation and let them breed. You repeat this process over many generations and you will end up with big breeds like the Great Dane.

13 cows for lots of milk, cows for creamy milk, cows and pigs for lots of meat

14 artificial selection

15 It reduces the variation in the gene pool, which magnifies some negative characteristics by mistake alongside the desirable ones.

16 a genetically engineered organism

17 The glow in the dark gene was cut out from the DNA of a jellyfish using enzymes. The same enzyme was then used to cut open the DNA of a rabbit embryo. The jellyfish gene was the inserted into the DNA of the rabbit and sealed into place using a different enzyme. The embryo was then inserted into the uterus of a rabbit, which from this point onwards had a normal pregnancy.

18 to contain carotene to reduce the chance of vitamin A deficiency, which causes blindness

19 to be herbicide-resistant, which means that herbicides can be sprayed all over fields of it to kill all plant life other than the soya

20 A small, circular section of DNA that can moved between bacterial cells.

21 Some say that this is ‘humans playing God’ and that the process is unnatural. Others think that the genes might spread into the wild gene pool.

22 blood clotting proteins (called factors)

23 The plasmid is cut open using the same enzymes that cut open the DNA. The gene is then inserted into the plasmid and sealed in using a second enzyme. The plasmid is then allowed to move into bacterial cells to deliver the gene.

Practice questions

1 a) i) 9 [1 mark]

ii) C 55 [1 mark]

b) i) discontinuous [1 mark]

ii) genetic/inherited [1 mark]

iii) Accept any inherited trait, such as eye colour, gender, attached or unattached ear lobes, tongue rolling. Do not accept height, weight, skin colour or hair colour, as these are affected by the environment too. [1 mark]

2 a) i) selective breeding/artificial selection [1 mark]

ii) idea that it can cause inbreeding, magnify negative characteristics, reduce genetic variation [1 mark]

b) Any four from: male and female individuals chosen, both with large muscles, allowed to breed or artificially inseminated, offspring inspected for larger muscle trait, more muscled offspring mated, repeated over many generations [4 marks]

3 **a)** genetically modified/transgenic [1 mark]

b) to save thousands of lives, prevent blindness [1 mark]

c) **i)** gene to produce carotene cut out from corn; using enzymes; inserted into bacteria; specifically the plasmid; bacteria allowed to multiply; bacteria infect rice embryos; gene transferred into the rice cells; embryos develop into golden rice [5 marks]

ii) idea that concern about effect on wild plants, insect populations, effect of eating the crops on health, accept specific examples, only accept unnatural if explained why [2 mark]

Working scientifically: Dealing with data

Pages 411–12

1 Qualitative: C, D, F. Quantitative: A, B, E.

2 Task – no answer is required.

3 Task – no answer is required.

4 Task – no answer is required.

5 Centimetres provide greater accuracy and allow the data to be continuous.

23 The development of understanding of genetics and evolution

Answers

Test yourself on prior knowledge

1 Charles Darwin

2 They have white fur for camouflage and a thick layer of fat for insulation.

3 because if organisms cannot adapt to these changes they will be outcompeted and all may die out

Test yourself

1 Archaeopteryx

2 antibiotics

3 by the misuse or overuse of antibiotics

4 using antiseptics

5 99%

6 the dodo

7 A mass extinction is when many, many species become extinct at the same time. This happened when the dinosaurs died out and is happening now as a result of the activities of humans.

Show you can

Page 419

1 Antibiotics are used to kill bacteria. Variation exists in bacteria. Some are not killed and are resistant to antibiotics (MRSA). These breed and pass on their resistance to their offspring. This provides evidence for evolution by natural selection.

Page 420

2 A meteor hit the Earth near Mexico and sent a huge cloud of dust into the air. This blocked light and prevented plants from photosynthesising. The plants died, along with many animals that depended upon them, including the dinosaurs.

Activity

Page 419

1 Task – no answer is required.

2 Infection rates increased from 1993 to 2005 for a rate of infection per million of the population from 1 to 26. They then decreased from 2005 to 2011 from 26 to 5.

3 Increased hygiene and control measures in hospitals.

4 A mutation arises that makes the bacteria resistant to antibiotics. These bacteria survive antibiotic treatment. They reproduce, passing the genetic advantage on to the next generation.

Chapter review questions

1 Charles Darwin

2 the smallest group of classifying organisms; individuals of the same species are able to interbreed to produce fertile offspring

3 all of the fossils that have been discovered so far

4 an organism from which others have evolved

5 The natural process by which organisms that are better adapted are more like to survive, which was first described by Charles Darwin.

6 Fossils are the remains of organisms for hundreds of thousands of years ago. We can look at the fossil record and see changes between species as a result of evolution. The Archaeopteryx fossil shows us that reptiles evolved into birds. It has teeth like a reptile but feathers like a bird.

7 because there is no oxygen and the water has a low pH, which stops decaying microorganisms from breaking down the body

8 Not all fossils have been found yet. Many fossils will have been destroyed in hot volcanic lava. In addition, many organisms died and were not preserved.

9 a large number of extinctions occurring at the same time (humans are the latest cause of a mass extinction)

10 Natural selection favours beneficial characteristics in a species or converse. Evolution is the change in a species over time (change usually as a consequence of natural selection).

11 The hooves got smaller as the land became drier. In wet marshy conditions larger hooves were an advantage and natural selection favoured them. As the land got drier (marshes became grassland) smaller hooves were selected for as the horses could run faster with smaller hooves.

12 Antibiotics were discovered around 80 years ago. At that point no bacteria were resistant. Several years after their first use some bacteria, such as MRSA, had evolved resistance.

13 In natural selection the environment (nature) determines which characteristics are favoured. In selective breeding man determines which characteristics are favoured.

23 The development of understanding of genetics and evolution

Answers

Practice questions

1 a) species no longer living [1 mark]

b) any two from: natural catastrophe, e.g. volcano eruption, meteorite; climate change, increased sea temperatures or change to environment; sea dried out; new predator; due to disease or new disease developing; outcompeted; prey died out or food source lost [2 marks]

c) any three from: fish died in the sea and sank to the bottom; covered with layers of sand, volcanic ash, mud or silt from the bottom of rivers and seas; hard parts did not decay or soft parts did decay; the layers above them pushed down, compressing the organisms; minerals entered bones or hard parts; the surrounding water dried, leaving mineral salts, which turned to stone/rock [3 marks]

2 simple [1 mark]

Test yourself

1 kingdom, phylum, class, order, family, genus and species

2 ligers are infertile offspring from lions and tigers

3 Before the work of Carl Woese using DNA and RNA, all organisms were classified into five kingdoms. These are animals, plants, algae, bacteria and single-celled organisms. The three domain system only has eukaryota (with all animals, plants, fungi and protists), bacteria and archaea (primitive bacteria).

Show you can

Page 426

1 They are divided into five groups. (1) Mammals have fur and give birth to live young. (2) Birds are warm blooded and most can fly. (3) Reptiles are cold blooded and lay eggs. (4) Amphibians have moist skin and lay eggs. (5) Fish have gills and lay eggs.

Activity

Page 426

1 Any sensible response, such as long tentacles, colour, shape.

2 **a)** Any sensible response, such as the observations of anatomical features can lead to connections based on superficial links that may be due to convergent evolution, similar body shapes or features for similar roles, and DNA reveals similarities on the genetic level.

b) Because conclusions are based on evidence, scientists must be willing to change their conclusions when new evidence arises.

Chapter review questions

1 putting species into groups based upon their characteristics or genetics

2 the smallest group of classifying organisms, all of which are able to interbreed to produce fertile offspring

3 animals, plants, fungi, protists and prokaryotes

4 *Homo sapiens*

5 family tree

6 Carl Linnaeus

7 genus and species

8 the largest group of classifying organisms, e.g. the animal kingdom

9 in italics with a capital first letter for the genus

10 kingdom, phylum, class, order, family, genus, species

11 class, amphibians, fish, birds

12 genome mapping

13 A species is a group of organisms that can interbreed to produce fertile offspring. A lion can mate with a tiger to produce a liger, but this is infertile. So lions and tigers are different species.

14 *Homo erectus, H. neanderthalensis*

15 Common names like 'daddy longlegs' are not used throughout the world, whereas binomial names are.

16 The three domain system uses DNA and RNA technology to refine classification of organisms

17 primitive bacteria usually found in extreme environments like hot springs

Practice questions

1 a) i) a group of organisms that can interbreed [1 mark]; to produce fertile offspring [1 mark]

ii) genus name or first name first letter should be in capitals and should be underlined or in italics [1 mark]

b) Carl Linnaeus [1 mark]

2 [8 marks]

Level of classification	**Polar bear**	**Brown bear**
Kingdom	**Animalia**	**Animalia**
Phylum	Chordata	Chordata
Class	Mammalia	**Mammalia**
Order	Carnivora	Carnivora
Family	**Ursidae**	Ursidae
Genus	*Ursus*	*Ursus*
Species	***maritimus***	***arctos***

3 a) i) (cellulose) cell wall, chloroplast large/permanent vacuole [2 marks]

ii) any three from: animals, fungi, bacteria or protists [3 mark]

b) i) Bacteria, Archaea, Eukaryota [3 marks]

ii) Classification systems change over time as scientists develop greater knowledge about living organisms [1 mark] e.g. genome mapping [1 mark]

4 a) *Lutra lutra* [1 mark]

b) B Skunk (*Mephitis mephitis*) [1 mark]

c) A Leopard (*Panthera pardus*) [1 mark]

Working scientifically: Scientific thinking

Page 429

1 **a)** Common octopus

b) Great barracuda

c) Nile crocodile

d) Indian elephant

e) Tiger

2 **a)** Common seahorse

b) Red chicken (wild chicken)

c) Grey kangaroo

d) Common fox

e) Bottle-nosed dolphin

3 Task – no answer is required.

25 Adaptations, interdependence and competition

Test yourself on prior knowledge

1 variation (interspecific)

2 Photosynthetic organisms (producers) are the only ones that can convert the Sun's energy into glucose.

Test yourself

1 struggle for existence

2 Interspecific competition is between different species, whereas intraspecific competition is within a species.

3 territory, food, mates

4 the numbers of prey would decrease

5 predator–prey cycling

6 idea that all the species that live in a community depend on each other

7 a greater number of species and more interdependence between them

8 the non-living parts of the environment

9 lime

10 It grows in both acidic soil, with blue flowers, and alkaline soils, with pink flowers.

11 There is not enough light for them to complete enough photosynthesis.

12 to do with living organisms

13 the introduction of a new predator

14 They are being outcompeted by the larger and more reproductively active grey squirrels.

15 The cane toad does not have any natural predators like the caiman in Australia. It is poisonous when eaten. Other predators in Australia are not immune to the poison. The cane toad outcompetes other similar organisms.

16 one in which most organisms would be challenged to live

17 a yellow-and-black pattern mimics that of bees and wasps to stop it being eaten

18 The penguins huddle together in winter to keep warm.

Show you can

Page 433

1 They would compete for light and water. More light and more water would mean more photosynthesis and so more formation of glucose for growth. They would compete to absorb minerals from the soil. They would compete for space to grow.

25 Adaptations, interdependence and competition

Answers

Page 433

2 An increase in predators means fewer prey. After a while this reduced number of prey cannot support the predators, so some predators die. After a while the numbers of prey increase because of the reduced numbers of predators. The number of predators then increases.

Page 435

3 Light, water and pH are all abiotic factors. More light means more photosynthesis, which is often a good thing. Too much light will kill a plant. Too little water or too much water will kill plants. Water is required for photosynthesis. The correct soil pH also helps plants grow most effectively.

Page 436

4 Biotic factors are those that relate to living organisms. So if more zebras moved closer to the original group they would compete for mates. If other herbivores moved closer, they would compete for food. If predators such as a pride of lions moved closer, the zebras would be threatened. All other animals are likely to compete for water.

Page 439

5 They are the only places in the world where life has originated that is not dependent upon light. In all other places, light drives photosynthesis at the bottom of all other food chains. Here bacteria feed directly on the chemicals from the vents.

Practical

Page 432

1 light, minerals, space, water

2 So there is less competition for light as they trees do not have leaves.

3 If bluebells flower too early, some might be killed by poor weather. Also, if it is too cold, pollinators would not be active.

Activity

Page 435

Task – no answer is required.

25 Adaptations, interdependence and competition

Answers

Activity

Page 438

Task – no answer is required.

Chapter review questions

1 the total number of all the organism of the same species or the same group of species that live in a particular geographical area

2 a group of two or more populations of different species that live at the same time in the same geographical area

3 Its flowers actually change colour depending upon the type of soil it grows in. If it grows in acidic soil it has pink flowers. If it grows in alkaline soil its flowers are blue.

4 the contest for resources between organisms within a community

5 the way in which an organism is suited to live where it does

6 an organism that survives in an environment in which it is challenging for most organisms to live

7 the North and South Poles, deserts, volcanoes, deep seabed

8 They can store large amounts of water in their stems and there leaves are reduced to spines with very small surface areas to reduce water loss. The spines also prevent animals from eating the succulent stems.

9 Living organisms and the environment (the biotic and abiotic parts of the environment).

10 the non-living parts of the environment; can be chemical or physical, but not biological

11 sunlight, water, pH, mineral content of soil

12 a living part of the environment

13 any two from: food, new predators, diseases, new species

14 biodiversity or number of species

15 light, water, space, nutrients

16 food, mates, territory

17 idea that all the organisms in a community depend upon each other, and because of this changes to them or their environment can cause unforeseen damage

18 They are disadvantaged against other members of their own species (intraspecific competition) and other species (interspecific competition). They are likely to die without reproducing.

19 structural, behavioural, physiological

20 streamlined body to swim faster, sense of smell to detect prey, sharp teeth to kill prey

21 They can produce venom.

22 The male birds looking after the ova on their feet huddle into a tight circle to keep warm during the cold winter months.

23 They have a small head and ears to reduce heat loss. They have a thick layer of fat (up to 11 cm) under their thick fur to keep warm.

24 high temperatures, high pressures, high concentrations of dissolved minerals

25 Light is not living. The amount of light determines how successful plants are at growing in an ecosystem.

26 Put a small length of pondweed into a boiling tube of water and position a short distance from a lamp. After 2 minutes, record the number of bubbles of oxygen produced. Move the tube progressively further away from the lamp and repeat. (More bubbles of oxygen means more photosynthesis.)

27 *Hydrangea*

28 hair grass, pearlwort

29 As the numbers of prey increase, so do the numbers of predators after a short lag phase. As the numbers of predators increase, the number of prey decrease, as they are being eaten. Eventually, the reduced number of prey means that the numbers of predators fall because there is not enough food.

Practice questions

1 A Light, B Mineral nutrients [2 marks]

2 a) i) accept any appropriate abiotic factor or temperature of water, oxygen availability, river current speed, soil type on river bank, water chemistry [1 mark]

ii) any two from: food availability, predation, competition, disease, parasites, mates, territorial behaviour [2 marks]

b) i) describes an organism that is not native and causes negative effects on an ecosystem [1 mark]

ii) any two from: idea that the American signal crayfish is larger and more aggressive so likely to outcompete the white-clawed crayfish for food; larger so outcompete for the best nesting sites or shelter; larger so likely to predate on the white-clawed crayfish; could carry diseases, which can be passed on to white-clawed crayfish; could carry a parasite that could infect the white-clawed crayfish [2 marks]

3 a) i) the total number of all the organism of the same species or the same group of species that live in a particular geographical area [1 mark]

ii) any two from: competition for food, space, loss of habitat, disease [2 marks]

b) i) idea of winning the competition for resources [1 mark]

ii) any two from: grey squirrels larger/heavier, more of them, have a greater range of food sources, larger numbers of young [2 marks]

iii) interspecific competition [1 mark]

c) 2,500,000 + 160,000 = 2,660,000 (160,000 / 2,660,000) x 100 = 6% [2 marks]

d) any suitable adaptation, e.g. tail for balancing on branches, clawed feet to hold onto bark, strong leg muscles / large back legs to jump from branch to branch [1 mark]

4 a) i) any one from: have horns, to defend themselves, long legs so can run far and fast, adults are large so avoided [1 mark]

ii) idea that live in herd, so more individuals to watch out for predators / strength in numbers [2 marks]

b) idea that can run away from predators / not left behind by the herd [2 marks]

Working scientifically: Experimental skills

Pages 442–43

Answer is based on the student's own data.

Test yourself on prior knowledge

1. idea that all the organisms in an ecosystem require each other
2. Respiration converts carbon in glucose to carbon in carbon dioxide, and releases it into the atmosphere.
3. Deciduous trees have leaves that absorb more carbon dioxide.

Test yourself

1. quadrat
2. transect
3. to save time and money by looking at a part of habitat to draw conclusions about all of it
4. by using random numbers as grid coordinates
5. seaweed, plankton
6. respiration, photosynthesis, combustion
7. 0.04%
8. Carbon, in the form of a fuel-like natural gas, is converted into carbon dioxide.
9. Carbon, in the form of glucose, is converted into carbon dioxide.

Show you can

Page 447

1. You would use random sampling if you were looking at an area without any features or trends, such as a flat school field. You would use a transect if your area had features or trends, such as a school field getting wetter near a stream or shadier near a building.

Page 451

2. As energy is passed along a food chain the amount reduces by 90% at each trophic level. This is because energy is lost in various ways, including heat loss. Only 10% is passed to the organisms above.

Page 452

3. There are three processes in the carbon cycle. During photosynthesis carbon is converted from carbon dioxide to glucose. During respiration carbon is converted from glucose to carbon dioxide. During combustion carbon is converted from a fuel to carbon dioxide.

Page 453

4 There are four main processes in the water cycle. Precipitation occurs after evaporation when water returns to the Earth as rain, snow, hail and sleet. Runoff is when precipitation moves across land like water in streams and rivers. Farmers use this. Infiltration is when water sinks into the ground to become groundwater. Evaporation is when heat turns liquid water into a gas in our atmosphere.

Required practical 7

Pages 448–49

1 Answer is based on the student’s own data.

2 Reason is based on the students’ own data.

3 Your data would be more representative with more transects.

Chapter review questions

1 the process of recording a smaller amount of information to make wider conclusions

2 quadrats

3 Animals can move into or out of the quadrat after we have placed it.

4 photosynthesis, respiration, combustion

5 precipitation, runoff, infiltration, subsurface flow

6 The placement of quadrats must be random.

7 the study of distribution and abundance

8 the regular distribution (not random) of a survey to answer a specific question, usually about a trend

9 Instead of randomly placing a quadrat, you place it in a systematic (or regular) way. You would do this only when you wanted to check whether the distribution of an organism changed in an area.

10 a transect

11 It is converted from carbon dioxide to glucose.

12 It is converted from glucose to carbon dioxide.

13 It is converted from a fuel such as coal to carbon dioxide.

14 When plants die and rot, they release their carbon back into the soil. When animals die and rot, they release carbon dioxide into the atmosphere.

15 if you wanted to look at whether there was more seaweed above or below the waterline, or if you wanted to look at whether the species of seaweed changed with their height on the shore

Practice questions

1 a) i) gas [1 mark]

ii) B and D [2 marks]

b) change: 9.9 – 5.4 = 4.5; (4.5/5.4) × 100 = 83.00% [allow 1 mark for (5.4/9.9] × 100 if answer given is 54.5%, as has the idea of a percentage just not change) [2 marks]

c) global warming [1 mark]

2 C Random sampling using quadrats [1 mark]

3 a) i) the oak woodland [1 mark]

ii) 154 g [1 mark]

iii) month 5 for the pine forest, or 387 [1 mark]

b) idea that water was evaporating from leaves or leaf litter was drying out [1 mark]

c) bacteria and fungi [2 marks]

Working scientifically: Experimental skills

Pages 456–57

1 Accuracy is a measure of how close a measurement is to the true value. Precision relates to the spread of measurements about the mean value. Precision depends only on the extent of random errors – it gives no indication of how close the results are to the true value.

2 Ecologists ensure their results are precise by repeating their samples and taking enough samples to make them representative.

3 Because they have a vested interest in the success of a drug as it is linked to a company's profit.

4 Barnacles

5 Answer is based on the student's own results.

6 Because the community cannot support a population of predators that is more abundant than its prey.

27 Biodiversity and the effect of human interaction on ecosystems

Answers

Test yourself on prior knowledge

1 the range of living organisms in an area

2 The ice caps melt leading to sea level rises.

3 Toxic materials cannot be excreted. Because top predators are at the top of a food chain they absorb all the toxic chemicals that were in all organisms below them.

Test yourself

1 rainforest, ancient woodland

2 desert, polar region

3 Landfill sites attract vermin, produce toxic liquids. They can also be unsightly and use up valuable land.

4 reduce, reuse, recycle

5 Trees and other plants are killed and statues and other stonework can be eroded.

6 120 per square mile

7 many major cities, Bingham Canyon Mine in Utah

8 acidic soils, high rainfall, cool temperatures

9 half

10 80%

11 to sell the wood or make room for crops or animals such as cattle

12 The rainforest is being cut down to grow crops for biodiesel.

13 coal, oil, natural gas

14 China

15 because we are burning fossil fuels

16 Species will move from their current location towards the poles to find areas of land with temperatures that suit them.

17 desert, polar region

18 rainforest, ancient woodland

19 Many animals and plants live in hedgerows and depend upon them for food and shelter.

20 the number of different species of plants, animals and microorganisms that live in an area

Show you can

Page 459

1 because they are made up of many different habitats in which different organisms can live

27 Biodiversity and the effect of human interaction on ecosystems

Answers

Page 462

2 Fertilisers run off fields into stream and rivers. They concentrate in ponds and lakes. Here the excess nutrients cause algae to grow quickly and form a bloom. This blocks off light, which kills aquatic plants. The plants rot and the decomposers use all the oxygen. All animals in the water then die.

Page 463

3 In the Stone Age most of the UK was covered with trees and very little was farmed. The trees have been cut down and were replaced with fields. Villages turned into giant cities, which replaced fields and woodland.

Page 464

4 When trees are cut down the biodiversity reduces massively. Large numbers of animals, plants and microorganisms will live in or near the trees and depend upon them for shelter or food. Soils can dry up and turn into desert.

Page 466

5 We are creating more carbon dioxide by burning fossil fuels and cutting down forests. This creates a layer around the Earth, which traps the Sun's thermal radiation. This 'greenhouse effect' causes global warming, which is the gradual increase in the average temperature.

Page 468

6 by not using pesticides and fertilisers in your garden, leaving areas to become wild (perhaps with a stack of wood in which creatures can hide), using environmentally friendly detergent and washing-up liquid, growing wild flowers, putting waste food into compost not landfill, buying organic foods

Activity

Page 465

Task – no answer needed.

Page 468

Task – no answer needed.

27 Biodiversity and the effect of human interaction on ecosystems

Answers

Chapter review questions

1 food shortages, pollution, deforestation, global warming
2 because they contain heavy metals and other toxic chemicals, which can easily pollute local soil and water
3 reduce, reuse, recycle
4 glass, plastic, paper
5 the clearance of trees from an area that will then be used for other purposes, such as farming or building
6 It reduces photosynthesis, which increases carbon dioxide levels in the atmosphere, causing global warming. Trees are very biodiverse, so cutting them down destroys habitats for many other organisms. Soils can quickly become poor quality and wash away. Cures for diseases may be lost forever.
7 a measure of the different species present in a community
8 Nitrogen dioxide and sulfur dioxide react to form sulfuric acid. This can lower the pH of water and so result in the formation of acid rain.
9 It reduces the need for landfill, and the heat from the incinerator can be used to generate electricity. Some examples of air pollutants have been found in higher concentrations close to incinerators.
10 describes an activity that can continue without damaging the environment
11 Reusing does not require any energy, whereas recycling does.
12 They have high rainfall, low temperatures and high acidity, which means it is difficult for decomposing microorganisms to live there.
13 Ice caps melt, leading to rising sea levels. Tropical diseases occur in temperate regions. Species migrate. Flash floods and other freak weather events become more common.
14 how safe the supply of our food is
15 carbon dioxide, methane, water vapour
16 an activity in zoos to breed captive animals together to increase their gene pool
17 protecting an ecosystem or species of organism from reduced numbers and possible extinction
18 Organisms within them are protected from theft or hunting.
19 Hedgerows are very diverse. Their removal results in the death of many organisms that live in them or find food in them.
20 They are very important areas of biodiversity, often containing species that are not found elsewhere.
21 The increases in carbon dioxide concentration are relatively small.

Practice questions

1 **a)** **i)** at risk of extinction [1 mark]

ii) freshwater fish (do not accept plants, as question stated animals) [1 mark]

iii) $6285 \times 0.3 = 1886$ (accept 1885.5) [2 marks]

b) **i)** any two from: habitat loss, habitat degradation, over-hunting, loss of prey species, chemicals, climate change [2 marks]

ii) Captive breeding: advantage – increases number of individuals; disadvantage – not always successfully reintroduced into the habitat/also not changing the underlying reasons for them being endangered. Education: advantage – long-term change as local communities change what they are doing likely to result in habitat protection and reduced poaching; disadvantage – not directly increasing numbers, individual leopards might be too spread out to breed, takes too long, leopards may leave the area. [4 marks]

2 **a)** **i)** to increase crop yield / make the plants grow better [1 mark]

ii) fungicide, pesticide, herbicide (do not accept water) [1 mark]

b) idea that when it rains, chemicals in the fertiliser dissolve into the water [1 mark]; as the rain percolates through the soil it picks up the chemicals, and washes into the river by groundwater or surface runoff [1 mark]

c) nitrates increase growth of plants and algae; this reduces the light available for photosynthesis; this leads to the death of plant species; as the plants decay, microorganism numbers increase; they use up oxygen from the water in their respiration; leading to oxygen depletion; fish die, as they can't get enough oxygen. [4 marks]

3 **a)** C Carbon dioxide, D Methane [2 marks]

b) D Reduced sea levels [1 mark]

Working scientifically: Dealing with data

Pages 472–73

1 There is a correlation between levels of carbon dioxide and temperature anomalies. As the levels of CO_2 in ppm have increased, the temperature anomalies in °C have also increased.

2 This is a strong positive correlation.

3 Carbon dioxide is a greenhouse gas, so can contribute to the greenhouse effect and increase global warming.

4 Any sensible ideas, such as different people have different conclusions based on the data, some people argue that global temperatures always change.

5 Task – no answer is required.

6 There is a correlation between increasing human populations and number of extinctions.

7 This is a moderate positive correlation overall; at low numbers there is no correlation but as the values increase there is greater correlation.

8 Any valid response, such as deforestation, urbanisation, over-harvesting, hunting, etc.

Test yourself on prior knowledge

1 a) Two examples of very fast reactions, e.g. any explosions, fuels burning

b) Two examples of very slow reaction, e.g. rusting, food going off

c) Two examples of exothermic reactions, e.g. explosions, fuels burning

d) Two examples of endothermic reactions, e.g. decomposition reactions, reaction of hydrogen carbonates with acids

2 a) Exothermic reactions release thermal energy to the surroundings and so the temperature increases

b) Endothermic reactions take in thermal energy from the surroundings and so the temperature decreases

Test yourself

1 2.5 cm^3/s

2 0.00625 g/s

3 0.00020 mol/s

4 a) A, slope is steepest at this point

b) F, slope is zero or line is horizontal

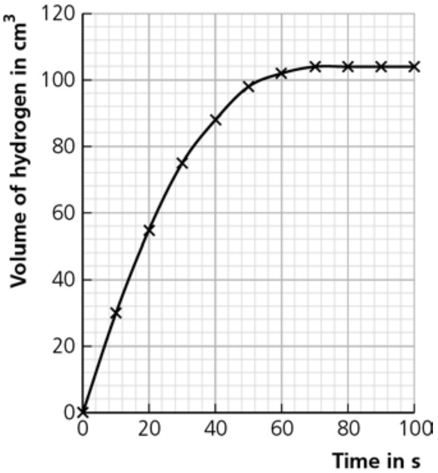
c) B, slope is steeper than at E

5 a) P

b) R

6 a) 3 cm^3/s

b)



c) About 2.3 cm^3/s

d) About 1.1 cm^3/s

e) Magnesium + sulfuric acid → magnesium sulfate + hydrogen

f) $Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$

7 a) A substance that increases the rate of a reaction but is not used up

b) They provide an alternative route with a lower activation energy

c) E

d) The molecules that act as catalysts in biological systems

8 The higher the pressure, the more reactant particles are present and so the more frequent successful collisions

9 a) D

b) The higher the concentration the greater the rate of reaction; experiments A, B, C

c) The higher the concentration, the more reactant particles are present and so the more frequent successful collisions

d) The higher the temperature the greater the rate of reaction; experiments B, D

e) The higher the temperature, the more energy the particles have and the faster they more so the more frequent successful collisions

10 a) Powder

b) Large pieces = 1.3 cm^3/s, small pieces = 2.1 cm^3/s, powder = 20 cm^3/s

c) The higher the surface area the greater the rate of reaction

d) The higher the surface area, the more reactant particles are available for collisions and so the more frequent successful collisions

11 a) 600 cm^2

b) 600 : 1000 = 0.6 : 1

c) 6000 cm^2

d) 6000 : 1000 = 6 : 1

12 a) Exothermic

b) One where no substances can get in or out

c) Both reactions take place simultaneously and at the same rate

d) $2HI \rightleftharpoons H_2 + I_2$

13 a) Exothermic

b) Endothermic

c) +42 kJ

14 a) 2

b) 1, 2

c) 4

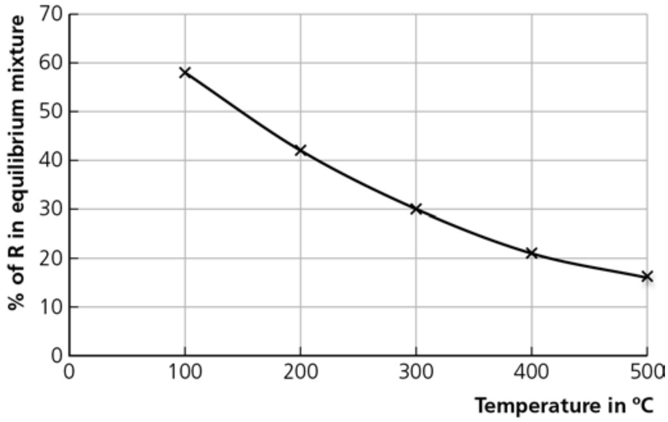
15 Goes darker brown; equilibrium moves right in endothermic direction to oppose increase in temperature, this produces more of the brown NO_2

16 a) If a change is made to the conditions of a system at equilibrium, then the position of the equilibrium moves to oppose the change in conditions

b) Goes blue; equilibrium moves right to remove added Cl^- ions

c) Endothermic; equilibrium moves left in exothermic direction to oppose decrease in temperature

17 a)



b) Exothermic; equilibrium moves left in endothermic direction giving less R as temperature increases

Show you can

Page 475

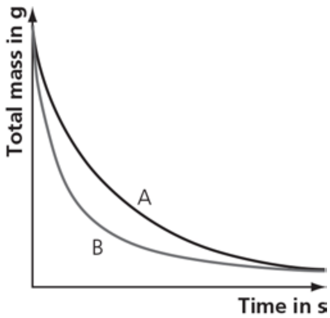
Rate = $\frac{1.2}{40}$ = 0.03 g/s

Page 478

a) Carbon dioxide gas escapes from flask

b) To prevent loss of mass due to acid spray

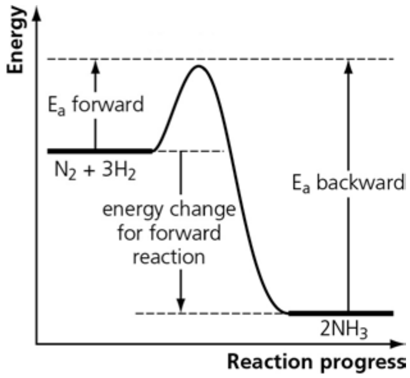
c)



d) See graph in answer c).

Page 487

a)



b) In a closed system when the forward and reverse reactions are taking place at the same rate

Page 491

a) Low pressure gives more tetrafluoroethene as there are more gas molecules on the right hand side so equilibrium moves right at low pressure to increase pressure; however reaction rate would be slower

b) High temperature gives more tetrafluoroethene as reaction is endothermic and so equilibrium position moves right in endothermic direction to lower temperature; rate is also increased

Required practical 11a

Page 483

1 Gas syringe

2 So no gas escapes

3 Stopwatch/measuring cylinder/balance

4 $Mg + 2HCl \rightarrow MgCl_2 + H_2$

5 Bubbles/Mg gets smaller and disappears

6 Use same volume of acid, same temperature, same mass of magnesium, same surface area of magnesium

7 Temperature is not controlled / loss of gas on inserting bung

8 9 minutes, 12 minutes

9 At 6 minutes for 1.0 mol/dm^3 concentration, it does not fit the trend

10 0.5 mol/dm^3

11 Increasing the concentration of acid increases the rate of reaction

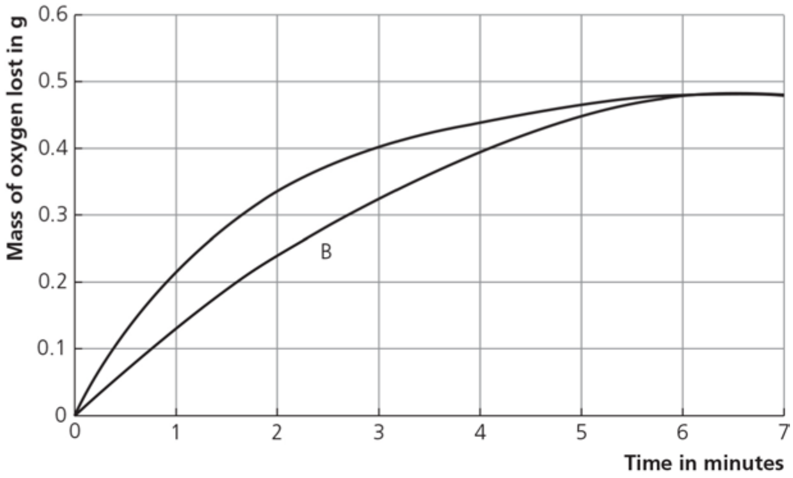
12 At higher concentration, there are more particles present per unit volume/particles are closer together and so there is a greater frequency of successful collisions

Practical

Page 484

1 a) $2H_2O_2 \rightarrow 2H_2O + O_2$

b) Allows gas to escape but prevents solution spraying out

c) 

d) 0.40/0.41 g

e) Gas syringe to collect the oxygen

f) The graph rises to the same height but is less steep e.g. graph B

2 a) Diagram of filtration apparatus, with manganese(IV) oxide labelled in the filter paper (as residue)

b) Dry the manganese(IV) oxide and find its mass at the end of the experiment, it should remain the same

c) catalyst

Required practical 11b

Page 485

1 Sulfur

2 0.0313 s^{-1} (to 3 sf)

3 Any three of: same concentration of HCl; same volume of HCl; same volume of sodium thiosulfate solution; same temperature, same cross

4 Rate increases as concentration increases

5 The rate increases because there are more reactant/sodium thiosulfate particles and so there is a greater frequency of successful collisions

6 Use a thermostatically controlled water bath as it is difficult to control the room temperature and increased temperature increases rate

Chapter review questions

1 a) Reversible reaction where both forward and reverse reactions take place simultaneously and at the same rate

b) Exothermic

c) +42 kJ

d) Substance that speeds up a chemical reaction but is not used up

2 a) Minimum energy that particles need to react

b) Particles do not have enough energy to react

c) $2H_2 + O_2 \rightarrow 2H_2O$

3 a) 1.25 cm^3/s

b) 0.008 g/s

4 2 = R, reaction 2 is slower than reaction 1 as the acid concentration is lower

3 = Q, reaction 3 is faster than reaction 1 as the temperature is higher

4 = P, reaction 4 is faster than reaction 1 as the surface area is greater, reaction 4 is faster than reaction 3 as the effect of producing a powder is greater than increasing the temperature by 10°C

5 a) The higher the temperature, the more energy the particles have and the faster they move, so the more frequent successful collisions

b) The higher the concentration, the more reactant particles are present and so the more frequent successful collisions

c) Increasing temperature

6 a) Equilibrium shifts right to the side with least gas molecules to oppose increase in pressure; this gives more methanol

b) High pressure is very expensive

c) There are more particles/closer together so there are more frequent successful collisions

d) Reaction rate is too slow at low temperatures

7 a) Goes orange; equilibrium position shifts right to remove added H^+

b) Goes yellow; equilibrium position shifts left to replace H^+ ions removed by OH^-

8 a) Experiment 1, volume of rhubarb = 5 cm^3; experiment 2, volume of rhubarb = 5 cm^3

b) Experiment 1, surface area of rhubarb = 22 cm^2; experiment 2, surface area of rhubarb = 30 cm^3

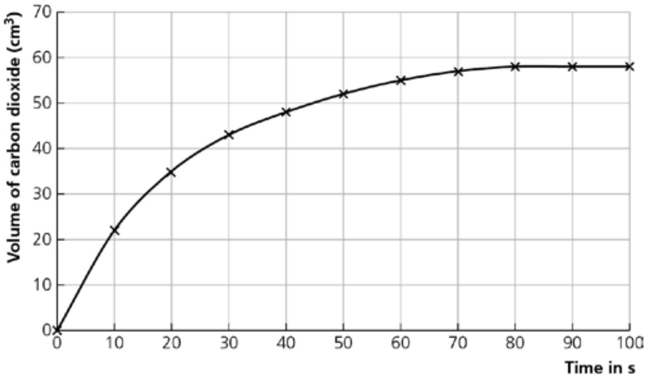
c) Experiment 1, ratio = 22 : 5 = 4.4 : 1; experiment 2, ratio = 30 : 5 = 6 : 1

d) The greater the surface area the greater the rate of reaction

e) The greater the surface area the more particles available for collisions and so the greater the frequency of successful collisions

f) Temperature, mass of rhubarb, volume of solution, concentration of solution

9 **a)**



b) About 1.0 cm^3/s

c) About 0.25 cm^3/s

d) Calcium carbonate + hydrochloric acid → calcium chloride + water + carbon dioxide

e) $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

Practice questions

1 A Catalyst [1 mark]

2 C zinc powder reacting with an excess of 80 g/dm^3 HCl at 30°C [1 mark]

3 C [1 mark]

4 **a)** 70 s [1 mark]

b) $\frac{30}{70}$ = 0.43 cm^3/s [1 mark]

c) B, faster reaction but same amount of gas produced [2 marks]

d) D, slower reaction but same amount of gas produced [2 marks]

e) E, same initial rate but half the mass of magnesium used so half the volume of gas produced [2 marks]

f) Reactant particles closer together, more frequent successful collisions, increases rate of reaction [3 marks]

5 **a)** Forward and reverse reaction take place simultaneously, and have the same rate of reaction [2 marks]

b) More gas molecules on left hand side, equilibrium position moves left to increase pressure, more brown gas is formed [3 marks]

c) Forward reaction is exothermic, equilibrium position moves right to increase temperature, brown colour fades [3 marks]

Working scientifically: Presenting data and information in a scientific way

Pages 495–96

1

Time in s	10	20	30	40	50
Volume 1 in cm^3	30	49	59	63	63
Volume 2 in cm^3	32	51	59	63	65
Mean volume in cm^3	31	50	59	63	64

2 **a)**

Temperature in °C	10	30	50	70	90
Solubility in g/100 g water	9.3	13.0	16.5	19.8	22.9

b) Increasing the temperature increases the solubility

3 **a)** The result at 4.5 minutes.

b) Time

c) 7 minutes

d) 100.3g

Test yourself on prior knowledge

1 Substances that burn in oxygen releasing a lot of thermal energy

2 Crude oil, coal and natural gas

3 Covalent

4 4

5 Long chain molecules

6 Fractional distillation

Test yourself

1 a) Over millions of years, from plankton, died and buried in mud under the sea, heat and pressure converted them to oil

b) Biomass is a resource made from living or recently living creatures; oil was made in this way but a very long time ago

c) It cannot be replaced once it has been used

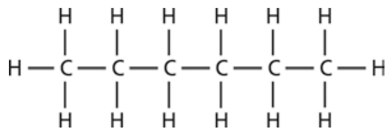
2 a) A compound containing hydrogen and carbon only

b) They have different boiling points

c) Oil is vaporised; put into tower that is hot at the bottom and cool at the top; alkanes rise, cool and condense at different heights; smaller molecules are separated nearer the top.

3 a) A molecule that only contains single covalent bonds.

b) C_6H_{14}

c) 

4 a) Decane

b) Pentane

c) Decane

5 a) $C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$

b) $2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$

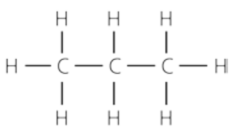
Show you can

Page 503

a) It contains carbon and hydrogen only

b) $x = 3$, $y = 8$

c) Propane



Chapter review questions

1 a) Saturated: molecule containing only single bonds/no double bonds; unsaturated: molecules that contain double bond(s); hydrocarbon: compound containing hydrogen and carbon only

b) i) It stays orange

ii) Goes from orange to colourless

2 a) Oil is vaporised; put into a tower that is hot and bottom and cool at the top; alkanes rise, cool and condense at different heights; due to having different boiling points; smaller molecules are separated nearer the top

b) i) Any two of the following: less flammable, more viscous, burns with smokier flame

ii) Cracking

iii) Heat the alkanes to vaporise them and then pass them over a hot catalyst; or heat the alkanes to vaporise them, mix them with steam and then heat them to very high temperature

iv) Alkenes

v) $C_{18}H_{38} \rightarrow C_{10}H_{22} + 2C_3H_6 + C_2H_4$

Practice questions

1 D C_4H_{10} [1 mark]

2 a) i) Mixture of hydrocarbons/remains of an ancient biomass or plankton that was buried in the mud [1 mark]

ii) Fractional distillation [1 mark]

iii) Any two from: petrol, diesel, kerosene, fuel oil, liquid petroleum gas (LPG) [2 marks]

b) i) Only single bonds [1 mark], only contains carbon and hydrogen [1 mark]

ii) C_nH_{2n+2} [1 mark]

c) i) Cracking [1 mark]

ii) $C_8H_{18} \rightarrow C_3H_6 + C_5H_{12}$ [1 mark for correct formula, 1 mark for balanced equation]

iii) Bromine water, changes from orange to colourless [2 marks]

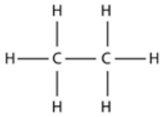
iv) $C_2H_4 + Br_2 \rightarrow CH_2BrCH_2Br$ (or $C_2H_4Br_2$) [1 mark]

3 a) Heptadecane [1 mark]

b) High temperature [1 mark] and steam or a catalyst [1 mark].

4 a) Evaporation vaporises the crude oil, changing it to gas [1 mark]. The hydrocarbons condense (change back to liquid) at different heights in the tower as they have different boiling points [1 mark].

b) The larger the hydrocarbon the higher the boiling point (or converse). The larger the hydrocarbon the more viscous it is (or converse). The larger the hydrocarbon the less flammable it is (easier to ignite) (or converse). [3 marks]

5 a)  [1 mark]

b) C_3H_8 [1 mark]

Working scientifically: Assessing risk in scientific experiments

Pages 507–508

1

Hazard	**Risk**	**Control measure**
Hydrated copper sulfate	Irritating to eyes (Hazcard 27c)	Wear safety glasses
Heating in a test tube	Solid may spit out of test tube and may cause burn or hurt eyes	Wear safety glasses; point test tube away from face and others
Cracked glass	Causes cuts	Check test tube carefully before heating; do not touch broken glass
Long hair	May catch fire	Keep long hair tied back
Bags and stools	Could be a tripping hazard	Tuck stools under benches; leave bags in bag store

2

Hazard	**Risk**	**Control measure**
Concentrated sulfuric acid	Corrosive (Hazcard 22)	Wear safety glasses; wear gloves; use the lowest concentration possible
Ethanol	Flammable (Hazcard 60)	Heat in a water bath; keep ethanol away from naked flames
Ethanoic acid	Corrosive (Hazcard 38a)	Wear safety glasses; wear gloves
Cracked glass	Causes cuts	Check boiling tube carefully before heating; do not touch broken glass
Long hair	May catch fire	Keep long hair tied back
Bags and stools	Could be tripping hazard	Tuck stools under benches; leave bags in bag store

3 Place 20 cm^3/ an excess of ethanol in a beaker and using forceps add a small piece of sodium (about 2 mm each side) to the ethanol; wear safety glasses

4 Keep power pack away from water supply; ensure that there are no bare leads and that the power pack has been checked for electrical safety

Test yourself on prior knowledge

1 Diamond, carbon dioxide

2 a) Ag, S, Co, Br_2

b) H_2O, CH_3COOH, CO, SiO_2

3 aluminium oxide (Al_2O_3), calcium bromide ($CaBr_2$), sodium nitrate ($NaNO_3$)

Test yourself

1 a) A natural substance that has had nothing added to it

b) It is a mixture of several different substances

2 Not pure – it would freeze at 0°C if it was pure

3 C only – it melts at 136°C

4 a) A mixture that has been designed as a useful product

b) Any four of: alloys, fertilisers, fuels, medicines, cleaning agents, foods (or specific examples of these)

5 a) So that the pencil would not run

b) So the samples do not dissolve in the solution in the beaker

c) 1, 3, 4, 6; only one spot

d) 2

e) 3 and 4

f) Green = 0.75, red = 0.33 (to 2 sf)

g) Brown

6 a) Solvent 1 = 0.40, solvent 2 = 0.73 (to 2 sf)

b) Substance had stronger attraction to solvent 2 so moved faster

7 a) Hydrogen

b) Magnesium + hydrochloric acid → magnesium chloride + hydrogen

c) $Mg + 2HCl \rightarrow MgCl_2 + H_2$

8 a) Carbon dioxide

b) Calcium hydroxide solution

c) Copper carbonate + nitric acid → copper nitrate + carbon dioxide + water

d) $CuCO_3 + 2HNO_3 \rightarrow Cu(NO_3)_2 + CO_2 + H_2O$

9 a) Chlorine

b) Hydrogen

c) $2Cl^- - 2e^- \rightarrow Cl_2$ or $2Cl^- \rightarrow Cl_2 + 2e^-$, oxidation

d) $2H^+ + 2e^- \rightarrow H_2$, reduction

10 a) Oxygen

b) Hydrogen

c) $4\,OH^- - 4\,e^- \rightarrow O_2 + 2\,H_2O$ or $4\,OH^- \rightarrow O_2 + 2\,H_2O + 4\,e^-$, oxidation

d) $2\,H^+ + 2\,e^- \rightarrow H_2$, reduction

Show you can

Page 513

a) Liquid

b) Solid

c) Solid

d) Mixture of metals with other elements

e) A: element; B: element; C: alloy. Elements are pure substances with exact boiling and melting points, alloys are mixtures and change state over a range

Page 517

a) It is not alkaline, not chlorine

b) Not carbon dioxide

c) Hydrogen

Required practical 12

Page 515

1 The pencil line is insoluble and will not move with the solvent or interfere with the results; it does not dissolve in the solvent in the tank

2 If the solvent is too deep, the spots on the paper will be in it and will dissolve

3 Using a capillary tube, add a spot of the solution to the base line, allow it to dry and re-apply the solution to make a concentrated spot

4 Copper(II), iron(III)

5 $Fe(OH)_2$

6 R_f = distance moved by spot/distance moved by solvent = 0.24–0.26

7 R_f values vary depending on the solvent used

Chapter review questions

1 a) No it is a mixture, it contains several different substances

b) N_2, O_2, Ar

c) CO_2, H_2O

2 A: oxygen; B: chlorine; C: hydrogen; D: carbon dioxide

3 a) 2

b) X and Z

c) i) W, X, Z

ii) Y

d) So it would not run/dissolve in the solvent

e) 0.40, 0.80

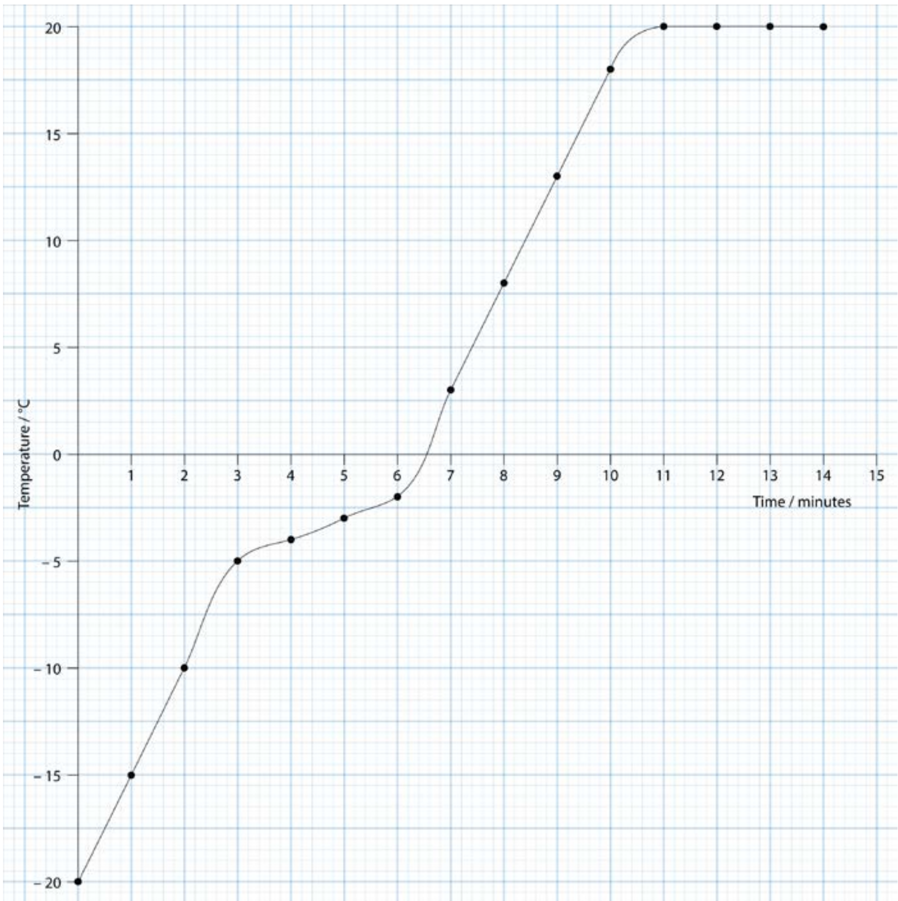
f) It would have a different value

4 A mixture that has been designed as a useful product

Practice questions

1 C determine the melting point [1 mark]

2 a)



Axis [1 mark] scaling [1 mark] points and curve [1 mark]

b) No the change of state takes place over a range of temperatures (starts at -5oC rather than 0oC). [1 mark]

c) The temperature of the water is the same as its surroundings (the temperature of the air). [1 mark]

3 a) The solvent front is the distance the solvent travelled up the chromatography paper. [1 mark]

b) The Rf value is the distance the substance (spot) travels divided by the solvent front – a substance can never travel further than the solvent front. [1 mark]

c) You could run a chromatogram of the mixture and the three dyes separately [1 mark]. The three dyes in the mixture will separate on the chromatography paper and each will have an Rf value [1 mark] the same as one of the separate dyes [1 mark].

Working scientifically: Recording observations

Pages 520–21

1 a) Copper sulfate + magnesium → copper + magnesium sulfate

b) The observations should be that the grey magnesium turned red brown and the blue colour of the solution faded. The student simply recorded names of products, not observations

2 a) $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

b) Bubbles (calcium carbonate disappears)

3

Reaction	**Observations**
ethanoic acid + sodium carbonate	Bubbles
potassium iodide solution and silver nitrate solution	Colourless solution to yellow precipitate
bromine water + alkene	Orange solution to colourless solution
hydrochloric acid + magnesium	Bubbles
acidified barium chloride and sulfuric acid	Colourless solution to white precipitate

Test yourself on prior knowledge

1 Nitrogen, oxygen

2 Carbon dioxide + water → glucose + oxygen

3 The temperature of the Earth is rising

4 Coal, oil, natural gas

5 a) hydrogen + oxygen → water

b) carbon + oxygen → carbon dioxide

c) sulfur + oxygen → sulfur dioxide

d) methane + oxygen → carbon dioxide + water

e) hydrogen sulfide + oxygen → water + sulfur dioxide

Test yourself

1 a) Bar chart showing 78% nitrogen and 21% oxygen

b) Argon, other noble gases, carbon dioxide, water vapour

2 a) Inside the Earth/volcanoes

b) Water vapour released from volcanoes cooled and condensed

3 a) Photosynthesis

b) carbon dioxide + water → glucose + oxygen

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

4 a) The remains of plants were buried in swamps and compressed to form coal, which is a sedimentary rock, over millions of years

b) Algae and other plankton died in oceans and their remains were buried in the mud on the sea floor and compressed over millions of years, forming crude oil and natural gas that was trapped under rocks

5 Carbon dioxide dissolved in oceans to form insoluble compounds that became sediment; carbon dioxide dissolved in oceans to form soluble compounds that became part of shells and skeletons of animals that died and those shells and skeletons fell into sediment

6 The radiation given off by the Earth has a longer wavelength

7 a) It is a gas that absorbs long wavelength infrared radiation given off by the Earth but does not absorb the Sun's radiation

b) Water vapour, carbon dioxide, methane

8 a) Increasing

b) More fossil fuels being burned, deforestation

9 a) Increasing

b) Increased farming; increased production from landfill sites

10 It is examined by other scientists who are experts in the same area of science to check that it is scientifically valid

11 a) An increase in the temperature at the Earth's surface

b) An increase in the amount of greenhouse gases in the atmosphere

12 a) Melting of ice; thermal expansion of water in the oceans

b) Rising sea levels cause flooding

c) The sea wears away the rock along the coast

13 a) A shortage of fresh water

b) May cause more droughts

14 a) More frequent and severe storms, changes in rainfall patterns

b) Could affect the capacity of some regions to produce food due to changes in rainfall patterns, drought, flooding, higher temperatures and the type and number of pests in the region

15 Plants may flower earlier, birds may lay eggs earlier, animals may come out of hibernation earlier, some species may migrate further north as temperatures rise

16 The amount of carbon dioxide and other greenhouse gases given out over the full life cycle of a product, service or event

17 a) Wind turbines, solar cells, nuclear power, etc.

b) Using more energy efficient engines in cars and other vehicles; increasing insulation in homes; using more energy efficient boilers in heating systems; using low energy light bulbs instead of filament light bulbs; using better detergents so clothes can be washed at lower temperatures; switching off electrical devices instead of leaving them on standby

c) Capture carbon dioxide in waste gases at power station, pump and compress, store deep underground in rocks

d) Setting up renewable energy projects, setting up plants to prevent the emission of methane from landfill sites, planting more trees

e) High cost of fuel causes consumer demand for cars that use less fuel

f) Their use results in zero net release of greenhouse gases to the atmosphere. It releases the same amount of carbon dioxide when it burns as the crops it was made from took in for photosynthesis as they grew

18 It is costly to reduce greenhouse gas emissions and any doubt about whether it needs to be done could stop it happening

19 We are using more electrical devices, we expect to be warmer in our homes than in the past, we are travelling more

20 a) i) Carbon in isooctane reacts with oxygen with complete combustion

ii) Carbon in isooctane reacts with oxygen with incomplete combustion

iii) Carbon in isooctane reacts with oxygen with incomplete combustion

iv) Hydrogen in isooctane reacts with oxygen

b) There may be some sulfur in petrol which reacts with oxygen

c) Nitrogen in the air reacts with oxygen in the air at high temperature

d) Acid rain, respiratory problems

e) Wastes fuel, greenhouse gas

21 a) i) When a substance burns with a poor supply of oxygen

ii) Combines with haemoglobin in blood reducing the ability of the blood to carry oxygen

iii) Colourless and has no smell

b) i) Carbon

ii) Blacken buildings, cause respiratory problems, global dimming

Show you can

Page 526

a) Decrease in carbon dioxide. This is because plants developed, photosynthesised and removed carbon dioxide; carbon dioxide also dissolved in oceans and formed sedimentary rocks and fossil fuels formed

b) Increase in nitrogen; volcanoes produced nitrogen; nitrogen is not very reactive and, once formed, it is not easily removed from the atmosphere again

c) Increase in oxygen; this is because plants developed and photosynthesised producing oxygen

Page 529

A) The concentration of carbon dioxide has risen steadily since 1960; **B)** There has been no decrease in carbon dioxide concentration over the past 50 years

Page 538

a) NO

b) NO_2

c) Air

d) Water

e) SO_2

f) Remove sulfur from fuels, remove SO_2/NO_2 from waste gases

Practical

Page 538

1 The hot gas is cooled in the U tube and condenses to form a liquid

2 Water

3 Limewater/calcium hydroxide; the carbon dioxide produced reacts with the limewater to form a solid

4 Water and carbon dioxide

5 Carbon/soot; incomplete combustion of fuel

6 a) Sulfur dioxide

b) Reacts with liquid A (calcium hydroxide) and is neutralised

c) The sulfur dioxide produced causes acid rain/respiratory problems

Chapter review questions

1 billion; little; volcanic

2 a) Bar chart showing 78% nitrogen, 21% oxygen and 1% other gases

b) Evolution of life/algae/plants

3 a) Gas that does not absorb the Sun's radiation but does absorb the Earth's radiation

b) Carbon dioxide: combustion of fossil fuels; methane: animal farming and landfill sites; water vapour: combustion of fossil fuels

c) Temperature increasing

d) Sea levels rising, more frequent/severe storms, changes in rainfall patterns, water stress for humans and wildlife

4 a) Pie chart showing 38% water vapour, 50% carbon dioxide, 10% sulfur dioxide, 2% other gases

b) Water vapour cooled and condensed

5 a) Mars, Venus

b) Carbon dioxide + water → glucose + oxygen, $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

6 sedimentary; calcium carbonate; shells

7 a) Sulfur in fuel reacts with oxygen; causes acid rain/respiratory problems.

b) Nitrogen in air reacts with oxygen at high temperatures; causes acid rain/respiratory problems

c) Carbon in fuel reacts with oxygen with complete combustion; greenhouse gas

d) Carbon in fuel reacts with oxygen with incomplete combustion; toxic

e) Carbon in fuel reacts with oxygen with incomplete combustion; global dimming/respiratory problems/blackens buildings

8 a) Animal farming, landfill sites

b) Burning large amounts of fossil fuels, deforestation

9 a) The amount of carbon dioxide and other greenhouse gases given out over the full life cycle of a product, service or event

b) Any three of: energy conservation/efficiency, use of alternative energy sources, carbon capture and storage, carbon off-setting, carbon taxes and licences, using carbon neutral fuels

c) Any three of: scientists disagree about global warming, expense, incomplete international co-operation, lack of public information and education, lifestyle changes

10 a) $2H_2 + O_2 \rightarrow 2H_2O$

b) $C_7H_{16} + 11O_2 \rightarrow 7CO_2 + 8H_2O$

c) $2CH_3OH + 3O_2 \rightarrow 2CO_2 + 4H_2O$

11 $2C_4H_{10}S + 15O_2 \rightarrow 8CO_2 + 10H_2O + 2SO_2$

12 a) Earth's radiation is longer wavelength

b) Absorb the Earth's radiation but not the Sun's

Practice questions

1 D oxygen [1 mark]

2 B calcium hydroxide [1 mark]

3 a) i) Break up a substance, using heat [2 marks]

ii) $2Fe(OH)_3 \rightarrow Fe_2O_3 + 3H_2O$ [1 mark for correct formulae, 1 for balanced equation]

b) In Earth's atmosphere there is: (much) less carbon dioxide, (much) more nitrogen, (much) more oxygen, also trace amounts of methane, also has small amounts of noble gases [4 marks]

c) i) $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$ [1 mark]

ii) Energy is needed to break bonds and energy is released when making bonds. There is less energy released making bonds than is needed breaking bonds [3 marks]

iii) Carbon dioxide dissolved in the water [1 mark]

4 a) i) Increasing the % carbon increases the heat energy released when burned [1 mark]

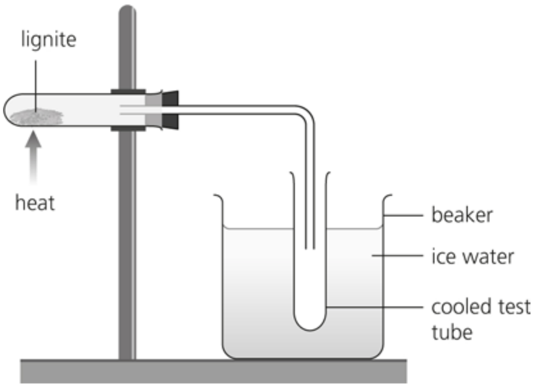
ii) Increasing the % moisture decreases the heat energy released when burned [1 mark]

b) Lignite: is softer, lower % C, higher % moisture, lower heat energy released when burned [any 3 for 3 marks]

c) Carbon/soot/particulates, carbon monoxide [2 marks]

d) Sulfur dioxide, acid rain, respiratory problems [3 marks]

e) i) Suitable way of holding and heating lignite, suitable way of condensing and collecting water, well drawn and labelled [3 marks]



ii) Carbon dioxide, water [1 mark]

5 a) i) CO_2, CH_4 [2 marks]

ii) Infrared [1 mark]

iii) An increase in temperature at the Earth's surface [1 mark]

iv) More carbon dioxide is being produced [1 mark]

b) There is evidence that shows if there is a high concentration of carbon dioxide there is an increase in temperature; however this could be due to other factors [2 marks]

c) Carbon capture and storage, carbon off-setting, using carbon neutral fuels, carbon taxes, energy conservation, renewable energy sources [any 2 for2 marks]

d) Companies can only produce as much CO_2 as they have a permit licence for [1 mark]

Working scientifically: Communicating scientific conclusions

Pages 543–44

1 Presented at press conference rather than to a scientific journal

2 Presented to a scientific journal; peer review by other scientists

3 a) That as the number of particulates in the air increases, the number of people seeking medical attention for asthma increases

b) Data has not been repeated so this set of results may be a 'one off'; only one town has been investigated, data from other towns may disagree with this data, more evidence is needed

c) i) Confidence is low because: correlation does not mean cause, there could be other causes; opinions of other scientists have not been given and there is no peer review; the journalist may not be a scientist and could be biased so may have his/her own interpretation of data; claim may be correct because: there is a clear correlation so asthma could be affected by particulates and also the points are all close to straight line and there are no anomalies/outliers so conclusions from data will have some validity

ii) During incomplete combustion of hydrocarbon fuels carbon particulates are formed

Test yourself on prior knowledge

1 a) Rocks/ores

b) Rain water/fresh water/sea water

c) Air

d) (Cotton) plants

2 a) Examples include copper, zinc, iron, lead

b) Examples include aluminium, sodium, magnesium, calcium, potassium

3 a) Mixtures of metals with small amounts of other metals or carbon

b) Alloy is harder

4 a) Long chain molecule made from joining lots of short molecules together

b) Examples include poly(ethene), poly(propene), PVC, Perspex, polystyrene, Teflon

5 The products can turn back into the reactants

Test yourself

1 a) Ores in rocks

b) Crude oil

c) Crude oil and some plants

2 a) One that we cannot replace once it has been used

b) Examples include coal, oil, natural gas, metal ores

c) One that we can replace once it has been used

d) Examples include biodiesel, ethanol made from plants

3 a) Using resources to meet the needs of people today without compromising the ability of future generations to meet their needs

b) Use renewable energy sources, e.g. wind, solar, tidal

4 a) Reuse: use product again for the same use; recycle: melt down product and make into new product

b) Separate types of glass, melt down, remould into new product

5 Add scrap steel to some iron from a blast furnace, to reduce the amount of new iron needed

6 The better the separation the higher the quality of recycled plastic produced

7 An examination of the impact of a product on the environment throughout its life

8 Raw materials: copper ore; sustainability: running out of copper ores; obtaining raw materials: mining for copper ores damages the environment and uses much energy; transporting raw materials: uses up fuels and causes some pollution; extraction of copper: uses much energy; manufacture of pipes: uses energy; use of pipes: uses fuels to transport pipes and causes some pollution; recycled: uses fuels to transport pipes and causes some pollution, energy to melt down copper

9 Life cycle assessment could be incomplete and misleading to promote product

10 Water that is safe to drink

11 a) Water found in places such as lakes, rivers, the ice caps, glaciers and underground rocks and streams

b) Removes solids in the water; the water is passed through filter beds made of sand

c) Kills microbes; use small amounts of chlorine/ozone/pass ultraviolet light through the water

12 a) Removal of dissolved substances from sea water

b) There is very little fresh water but lots of sea water

c) Sea water is heated so that it boils; the water molecules are turned to steam leaving behind the dissolved substances; the water vapour is then cooled and condensed

d) Sea water is passed through a semipermeable membrane using pressure; the water molecules pass through the membrane but many of the dissolved substances cannot

13 a) Domestic, industrial, agricultural

b) i) Water passed through grid to remove large solids

ii) Water left to settle in tanks, this separates the human waste from the rest of the water which is called effluent

iii) Air is passed through the effluent in aeration tanks which leads to good bacteria killing harmful bacteria

iv) In the absence of air, bacteria produce methane from sludge

14 a) An ore containing a low percentage of metal compounds

b) As we have run out of high-grade ores of copper

15 The use of bacteria to produce soluble metal compounds from insoluble metal compounds

16 Plants (e.g. brassica/cabbages) are grown in soil rich in copper compounds. The plants absorb these copper compounds, and when the plants are burned the leachate is produced by bioleaching the plant ash

17 a) i) Negative

ii) Copper ions are positive and opposites attract

iii) $Cu^{2+}(aq) + 2e^{-} \rightarrow Cu(s)$

iv) Copper ions gain electrons

b) i) Iron is more reactive than copper

ii) $Cu^{2+}(aq) + Fe(s) \rightarrow Cu(s) + Fe^{2+}(aq)$

iii) $Cu^{2+}(aq) + 2e^{-} \rightarrow Cu(s)$

iv) Copper ions gain electrons

Show you can

Page 548

a) Coal, peat, rock salt, crude oil, natural gas, iron ore, limestone

b) Wind, bioethanol, cotton, wood, sugarbeet

Page 550

a) To use the plastic milk bottle once the energy used is 6.9 MJ; to use the glass milk bottle once the energy used is 9.7 MJ; if it is re-used the energy used is 12.2 MJ; however to use the equivalent plastic bottles the energy is 13.8 MJ; a saving is made if the glass bottle is re-used once

b)

	Plastic	**Glass**
Raw materials	Usually crude oil	Sand Calcium carbonate Sodium carbonate
Sustainability	Crude oil is finite	Calcium carbonate and sodium carbonate are finite
Obtaining raw materials	Uses energy and damages environment	Uses energy and damages environment, e.g. quarrying
Transporting	Raw materials and finished products Uses energy and causes pollution. Oil spillage at sea or elsewhere may cause environmental damage	Raw materials and finished products. Uses energy and causes pollution. Extra energy needed for reuse, but is compensated for in energy saved in manufacture
Manufacture	Energy needed for fractional distillation of crude oil, cracking and for polymerisation	Energy needed to provide high temperatures
Disposal	Energy used in incineration or in transport to landfill. Incineration gives off greenhouse gases	Energy used in transport to landfill or to recycle

Page 555

a)

	Waste water	**Ground water**	**Salt water**
Method of producing potable water	Screening and grit removal Sedimentation (Anaerobic digestion of sludge) Aerobic biological treatment of effluent	Filtration Chlorination	Desalination by distillation or reverse osmosis

b) From fresh water by filtration and chlorination; there is lots of ground water in the UK

c) The UK has a good supply of fresh water, and it is cheaper to obtain potable water in this way. Israel has a shortage of water, has a long coastline with lots of seawater available, the energy for desalination and reverse osmosis can be supplied by solar power

d) They do not have enough water of their own and do not want to be reliant on Malaysia; investing in waste treatment plants is more beneficial than paying to pipe water long distances; Singapore has a heavy water demand due to electronics and other industries

Page 557

Electrolysis: $Cu^{2+}(aq) + 2e^{-} \rightarrow Cu(s)$

Displacement: $Cu^{2+}(aq) + Fe(s) \rightarrow Cu(s) + Fe^{2+}(aq)$

In both processes the copper ions gain two electrons and form copper; gain of electrons is reduction

Required practical 13

Page 560–61

1 Sodium chloride/salt

2 Water

3 Antibumping granules that aid smoother boiling

4 B water out, C water in

5 D condenser – cools the gas and condenses it

6 100°C; it is pure water that is distilling over

7 It remains in the flask because it has a much higher boiling point and will not evaporate with the steam

8 a) Evaporation is a change from liquid to gas on heating, it occurs in the flask

b) Condensation is a change from gas to liquid on cooling; it occurs in D

9 The temperature of the distillate can be recorded; condensation is more efficient; larger quantities can be distilled; in the basic apparatus there is the disadvantage that some salt solution may splash into the delivery tube and some steam may escape before condensation

10 To cool and condense the steam

11 X conical flask, Y delivery tube, Z test/boiling tube

12 Check if the boiling point is 100°C

13 It uses a lot of energy; this could increase the use of fossil fuels which are non-renewable resources; it could increase carbon dioxide emissions from burning fossil fuels that contribute to global warming

14 Use a pH probe/use universal indicator paper and compare to colour chart

15 Evaporate the water, if dissolved salts are present a solid residue should be left on the container

Chapter review questions

1 a) air

b) crude oil

c) ores

d) plants

2 a) finite

- b) finite
- c) renewable
- d) renewable
- e) finite

3 a) Can be maintained in the future
 b) i) Use recycled aluminium
  ii) Use biofuels or electric car
  iii) Reuse old bottle or use recycled glass
  iv) Use renewable energy source, e.g. wind, solar
 c) Reuse: use product again for the same use; recycle: melt down product and make into new product

4 a) Filtration: removes solids; sterilisation: kills microbes
 b) i) Sea water is heated so that it boils; the water vapour is then cooled and condensed
  ii) Sea water is passed through a semipermeable membrane using pressure
 c) High energy costs: heat for distillation; pressure for reverse osmosis

5 a) Bacteria
 b) i) $Cu^{2+} + 2e^{-} \rightarrow Cu$
  ii) $CuSO_4 + Fe \rightarrow Cu + FeSO_4$
 c) Plants grown in copper rich soil, plants absorb copper compounds, plants are burned, copper extracted from ash

6 a) Removes large solids from the waste water
 b) Separates the human waste from the rest of the water which is called effluent
 c) Air is passed through the effluent in aeration tanks which leads to good bacteria killing harmful bacteria
 d) In the absence of air, bacteria produce methane from sludge

Practice questions

1 C distillation [1 mark]

2 Resources are running out [1 mark]

3 a) waste water [1 mark]
 b) ground water [1 mark]
 c) fresh water [1 mark]
 d) potable water [1 mark]

4 a) Sedimentation is the process where semi-solid organic matter sinks to the bottom of sedimentation tanks [1 mark] allowing the water to be removed to the next stage [1 mark]

b) anaerobic digestion of sludge (sedimented waste) by bacteria [1 mark] converts the sludge into methane [1 mark] harmful bacteria in the effluent [1 mark] are killed by beneficial bacteria in aerobic conditions [1 mark]

5 **a)** **i)** Large amount of energy would be needed/labour intensive as copper had to be extracted from a large amount of rock/land [1 mark]

ii) More traffic/noise pollution/more solid waste/dust pollution [any 2 for 2 marks]

b) **i)** Plants absorb copper compounds through their roots; the plants are then burned so that the copper ions react with oxygen; this produces ash that contains the copper compound/oxide; copper extracted from the ash [4 marks]

ii) Less energy/expense to extract the small amounts of copper; can extract copper from lower grade ores [2 marks]

c) **i)** Scrap iron is cheap [1 mark]

ii) $CuSO_4 + Fe \rightarrow Cu + FeSO_4$; iron is more reactive than copper and displaces it [3 marks]

Working scientifically: Evaluating results and procedures

Pages 204–05

1 **a)** Student A = 21.3 ± 0.2%, student B = 22.5 ± 0.1%

b) Student A was accurate, Student B was not accurate

c) Both students had repeatable results

d) Due to random errors

e) Student B had a systematic error; results were consistently about 1.3% too high

2 Using a measuring cylinder is not accurate enough – use a 25.0 cm^3 pipette

Place the conical flask on a white tile to aid detection of the colour change

Carry out a rough titration and then accurate titrations, by adding the acid drop-wise near the end point

Mean volume = 25.0 ± 2.8 cm^3

Results are not very precise – there is quite a lot of spread around the mean

3 The temperature of the room may not be controlled. To improve the method, carry out the experiment in a thermostatically controlled water bath

The experimenter must look down through the solution at the cross to observe it disappearing. Using a different pencil cross means that the experiment is not a fair test and the results may not be accurate. The same cross must be used throughout

4 Some gas escapes before the stopper is inserted

Two people carrying out this experiment may be an improvement so that one can start the stopwatch as the other adds the chemicals

A gas syringe will measure the volume of gas produced more accurately

Some carbon dioxide may react with/dissolve in the water

The temperature in the room may change. The experiment could be placed in a thermostatically controlled water bath

Test yourself on prior knowledge

1 There are many, e.g. gravity, friction, a push or a pull to move a chair.

2 A single force that has the same effect of the combined effect of all the other forces acting on an object.

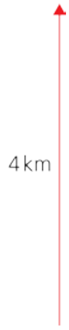
Test yourself

1 **a)** energy

b) force

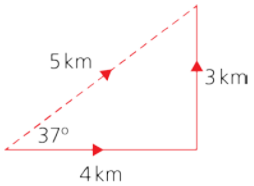
2 Velocity also needs to specify a direction.

3 **a)** You need to draw an arrow pointing northwards and mark it 4 km.



b) Displacement is 0; distance travelled is 8 km.

c)



i) Displacement is 5 km, in a direction 37° north of east.

ii) 7 km

d) When you go for a walk you cover a distance over the ground: e.g. we walked 7 km today. Displacement states the distance and direction away from your starting point.

4 **a)** A contact force is exerted by one body on another, when the two bodies are in contact (touching each other).

b) Friction.

5 **a)** A non-contact force is exerted over a distance, when two bodies are not in contact.

b) Electrostatic.

6 One magnet can support another one which is in contact with it. Since the lower one does not fall, the magnetic force must be bigger than the pull of gravity.

7 570 N

8 **a)** 3 N to the right

b) 4 N upwards

c) 1 N to the left

d) 10 N to the right

e) 0

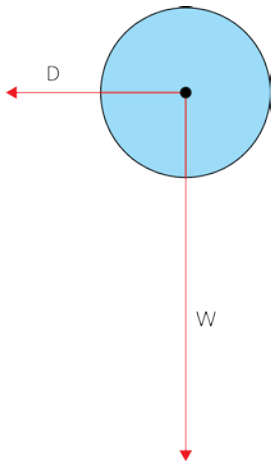
f) 0

9 $W = mg$

$= 120 \times 3.7$

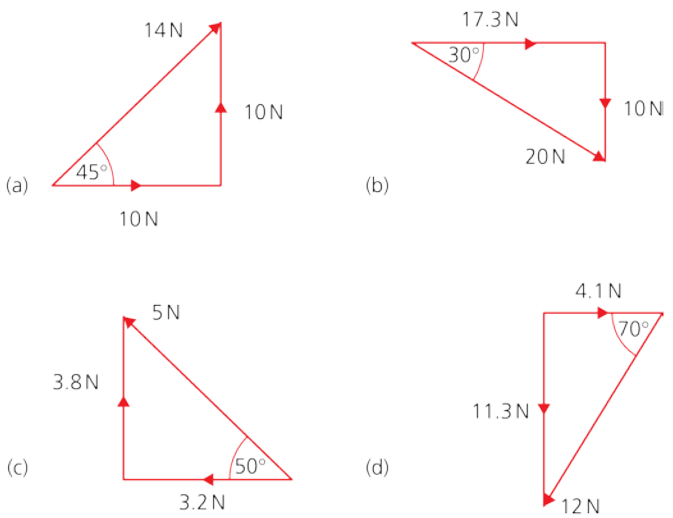
$= 444\,\text{N}$

10



The ball is moving horizontally to the right.

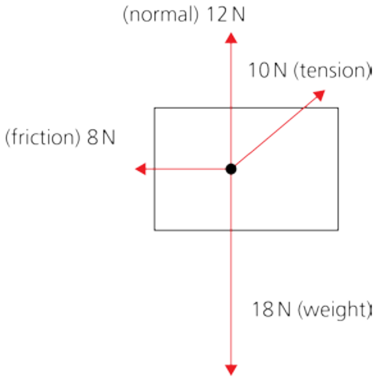
11



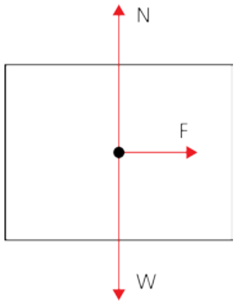
12 **a)** 8 N to the left

b) 18 N − 6 N = 12 N

c)



13 a)



b) There is an unbalanced force to the right that slows the box down.

14 b), c). In both b) and c) energy is being transferred, and something is being moved. In a) and d) there is no movement, so no work is being done.

15 a) 50 J

b) 600 J

16 Opening door	7.2 J
Wheeling suitcase	20 N
Lifting box	1.5 m
Pushing toy	0.35 J
Driving	15 MJ

17 a) $W = mg$

$= 150 \times 1.6$

$= 240\,\text{N}$

b) Work $= F \times d$

$= 240 \times 8$

$= 1920\,\text{J}$

18 B, C

B and C will 'spring' back to their unstretched position as soon as the compressive forces are removed, so elastic potential energy is stored.

A, D have no energy stored in them, as there is no force applied to stretch them elastically.

19 When something is stretched elastically, it can return to its original shape once the stretching force is removed.

20 a) 4.6 N

b) $F = kx$

$4.6 = k \times 0.136$

$$k = \frac{4.6}{0.136}$$

$= 33.8\,\text{N/m}$

or 34 N/m (to 2 sf)

21 $k = \dfrac{F}{x}$

$$= \frac{600}{0.03}$$

$= 2 \times 10^4\,\text{N/m}$

22 See the Required practical 18, Page 573.

Show you can

Page 564

A scalar quantity only has size (magnitude). A vector quantity has magnitude and direction. So speed is a scalar – something travels at 15 m/s; velocity is a vector – something travels at 15 m/s due east.

You can find other examples on Pages 563 and 564.

Page 568

If you cannot answer this, look at Figure 33.8 page 568. Figure b) shows 2 N and 2 N adding up to 4 N; Figure c) shows how 2 N and 3 N in opposite directions adding up to a resultant force of 1 N to the left.

Page 569

Your mass remains the same everywhere in the universe, because it is determined by the amount of matter in your body. Your weight is a force – it is the pull of gravity on you. A larger planet exerts a larger pull.

$W = mg$ (Page 566)

Page 571

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

Work is only done if an object moves in the direction of an applied force.

In Figure 5.15, Samantha does no work as she is not moving the weight. In the diagram of a car (Figure 33.14) on top of page 571, Martin does no work because he is pushing in the wrong direction.

Page 575

This idea can be demonstrated well using an empty drinks can. If you give the can a gentle squeeze, it bends in slightly; when you take your fingers away, the can returns to its original shape. This is elastic deformation. If you squeeze the can hard, the can deforms inelastically; when you remove your fingers, the deformation of the can is permanent.

Required practical 18

Page 573

1 Clamp the retort stand to the bench and wear eye protection.

2 Yes as the investigation produces a set of result that answers the question being asked. The method is **valid** if the data recorded shows a clear relationship.

3 By removing the masses one at a time and measuring the extension as the force decreases.

4 Fix a light pointer (a pin) at the bottom of the spring so that the pointer is across the ruler and moves with the spring.

or

Use a set square to line up the bottom of the spring with the scale on the ruler.

Chapter review questions

1 Scalar: speed, mass, temperature.

Vector: force, weight.

2 **a)** **i)** The force of gravity acts over a distance.

ii) Magnetic force; electrostatic force.

b) $W = mg$

$= 85 \times 10$

$= 850\,\text{N}$

3 work done $= F \times d$

$= 600 \times 300$

$= 180\,000\,\text{J}$ or $180\,\text{kJ}$

4 **a)** When something is deformed elastically, it returns to its original shape.

b) The stretched spring can be released and the stored energy can be used to accelerate a mass, so giving the mass kinetic energy.

5 $F = kx$

$10 = k \times 0.025$

$k = \frac{10}{0.025}$

$= 400\,N/m$

6 a) 50 N to the left

b) They have both a size and a direction.

Practice questions

1 velocity [1 mark]

2 a) $W = mg$

$= 18 \times 9.8$ [1 mark]

$= 176\,N$ [1 mark]

b) Work $= F \times d$

$= 176 \times 2.1$ [1 mark]

$= 370\,J$ [1 mark for answer, 1 for unit]

3 a) Newton [1 mark]

b) Limit of proportionality [1 mark]

c) A and B [1 mark]

d) A force of 200 N must be applied [1 mark]

i.e. to stretch the spring 1 metre [1 mark]

4 a) i) $W = mg$

$= 24 \times 9.8$ [1 mark]

$= 235\,N$ [1 mark]

ii) The balance reads the resultant force:

balance reading $= 235\,N - 100\,N$ [1 mark]

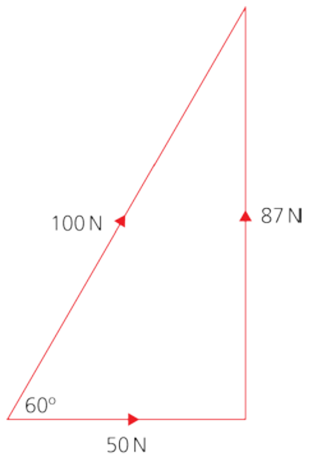
$= 135\,N$ [1 mark]

b) i) Only a component of the force now acts upwards. [1 mark]

ii) The vertical component of the force is:

$235\,N - 148\,N = 87\,N$ [2 marks]

iii)



horizontal component = 50 N [3 marks]

iv) The mass remains stationary because there is no resultant force on it. [1 mark]

There must be a 50 N frictional force to the left. [1 mark]

Working scientifically: Hypotheses and predictions

Pages 578–79

1 People were able to see that the two objects did not hit the ground at exactly the same time.

2 Other factors not taken into account (in this case air resistance) would affect the results.

3 To check for any anomalies and to calculate a mean.

4 0.325 s.

5 Yes they were repeatable as all of the values for time were similar.

6 The time taken by each of the sheets to fall 50 cm is almost the same so, although the sheets have different masses, each one must have accelerated at the same rate. This supports Galileo’s idea.

Test yourself on prior knowledge

1 The forces balance; when an unbalanced force acts the parachute accelerates or decelerates.

2 **a)** Along the road in the direction of the acceleration.

b) Zero.

c) There is a resultant (or unbalanced) force acting backwards.

3 **a)** $\text{speed} = \frac{10}{3.33}$

$= 3\,\text{km/h}$

b) $\text{speed} = \frac{\text{d}}{\text{t}}$

$80 = \frac{560}{t}$

$t = \frac{560}{80}$

$= 7\,\text{h}$

so the total time taken is 8 hours, when two 30 minute breaks are included.

Test yourself

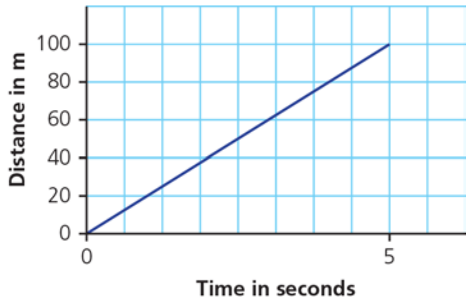
1 **a)** $\text{speed} = \frac{d}{t}$

$= \frac{300}{2}$

$= 150\,\text{km/h}$

b) The velocity is 15 km/h on a bearing of 150°

2



3 **a)** 40 s

b) The last part – the gradient is steeper after his stop at the traffic lights.

4 Row 1: Average speed = 10.4 m/s

Row 2: Time = 19.4 s

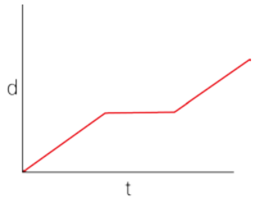
Row 3: Time = 44.9 s

Row 4: Distance = 1491 m (1500 m)

Row 5: Average speed = 5.7 m/s

Row 6: Distance = 42.196 km (Marathon)

5



6 10 m/s

7 Your speed could be constant, but you are changing direction.

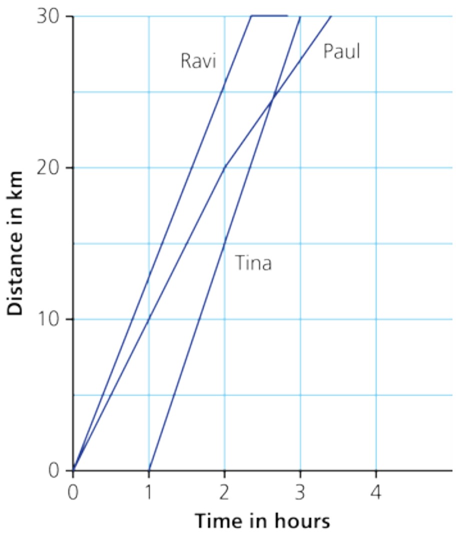
8 a) Ravi – the gradient is constant, and the gradient is equal to the speed.

b) average speed $= \dfrac{30}{3.4}$

$= 8.8\,\text{km/h}$

c) He slowed down.

d)



e) Tina has run about 24 km.

9 m/s^2

10 a) acceleration $= \dfrac{\text{change of velocity}}{\text{time}}$

b) i) $a = \dfrac{v-u}{t}$

$= \dfrac{30}{2}$

$= 15\,\text{m/s}^2$

ii) $a = \dfrac{v-u}{t}$

$= \dfrac{1}{0.001}$

$= 1000\,\text{m/s}^2$

11 a) $a = \dfrac{v-u}{t}$

$$= \frac{-12}{4}$$

$$= -3\,m/s^2$$

b) $\text{area} = \left(\frac{1}{2} \times 12 \times 8\right) + (12 \times 8) + \left(\frac{1}{2} \times 12 \times 4\right)$

$$= 48 + 96 + 24$$

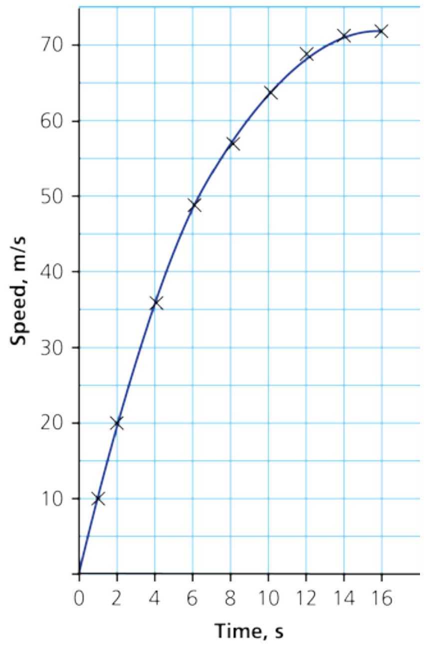
$$= 168\ m$$

c) $\text{average speed} = \frac{d}{t}$

$$= \frac{168}{20}$$

$$= 8.4\,m/s$$

12 a)



b) i) 0

ii) $10\,m/s^2$

c) About 800 m

13 Cheetah 30 m/s

Train $0.1\,m/s^2$

Aircraft 60 m/s

Car crash 0.2 s

14 a) $\text{speed} = \frac{400}{6}$

$$= 67\,m/s$$

b) $a = \frac{150}{6}$

$= 25\,\text{m/s}^2$

15 $v^2 - u^2 = 2as$

$60^2 - 0 = 2 \times 2.5 \times s$

$s = \frac{3600}{5}$

$= 720\,\text{m}$

16 Her weight is the same size as the air resistance.

17 An object falls at its terminal velocity when the drag acting on it upwards is the same size as the weight acting downwards.

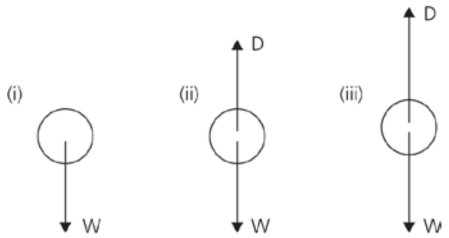
18 Air resistance on the sheet of paper is large so the paper falls slowly. When screwed into a ball, the air resistance is much less, so the paper ball accelerates.

19 a) 5 m/s

b) As she falls faster, the air resistance (or drag) on her increases. So the resultant force on her decreases and therefore so does the acceleration ($F = ma$).

c) 1000 m

d)



20 $F = ma$ and $a = \frac{F}{m}$, so the lower the mass the greater the acceleration for the force provided.

21 The shot is massive, so the force we can apply only accelerates it slowly. Since the mass of the tennis ball is low, we can accelerate it faster.

22 a) $F = ma$

$= 8 \times 2.5$

$= 20\text{ N}$

b) $a = \frac{F}{m}$

$= \frac{15}{3}$

$= 5\,\text{m/s}^2$

c) $m = \frac{F}{a}$

$= \frac{10}{4}$

$= 2.5\text{ kg}$

23 $a = \frac{F}{m}$

Because the mass is so large, the deceleration is very slow.

24 a) $a = \frac{v - u}{t}$

$= \frac{32 - 84}{1.3}$

$= -40\ \text{m/s}^2$

b) $F = ma$

$= 730 \times 40$

$= 29\,200$ N

25 a) $g = \frac{W}{m}$

$= \frac{48\,000}{30\,000}$

$= 1.6$ N/kg

b) i) 63 000 N − 48 000 N = 15 000 N

ii) $a = \frac{F}{m}$

$= \frac{15\,000}{30\,000}$

$= 0.5\ \text{m/s}^2$

26 The passenger needs a force for him to accelerate with the train. A force can be exerted if he is holding on to a seat or a rail. Without a force, he stays where he is (inertia); then he loses his balance.

27 The car has brakes whereas the parcel does not have brakes. So the parcel keeps moving forwards until it is slowed by contact with the floor in front of it.

28 a) You exert a force on the wall; it exerts an equal and opposite force back again.

b) You push the water backwards; the water pushes you forwards.

c) There is very little friction between you and the ice so the ice does not provide a forwards force to enable you to move forwards.

29 850 N

30 a) i) Thinking distance is the distance a car travels while the driver moves his foot from the accelerator to the brake, as the reacts to a hazard ahead.

ii) Braking distance is the distance a car travels while braking.

iii) Stopping distance is the distance a car travels from when the drivers starts to react until it comes to a complete stop when braking

b) stopping distance = thinking distance + braking distance

31 An icy road.

32 a) Missing words: force; speed.

b) mobile phone.

33 The surface can be made rougher.

34 a) When the tread is less, the braking distance is increased.

b) The data shows that the braking distance is always greater on the concrete surface.

35 a) The braking distance increases from 23 m to 36 m when you travel at 40 mph instead of 30 mph.

b) At 20 mph the stopping distance is only 12 m – half the stopping distance at 30 mph. This means a pedestrian is much safer in a crowded town centre.

c) Speed 48 km/h $= \dfrac{48\,000\text{ m}}{3600\text{ s}}$

$= 13.3$ m/s

distance = speed × time

$9 = 13.3 \times t$

$t = \dfrac{9}{13.3}$

$= 0.68$ s

36 $v^2 - u^2 = 2as$

a) 20 mph = 32 km/h

$= \dfrac{32\,000\text{ m}}{3600\text{ s}}$

$= 8.9$ m/s

$v^2 = 2as$

$8.9^2 = 2a \times 6$

$= \dfrac{8.9^2}{12}$

$= 6.6\text{ m/s}^2$

b) 60 mph = 96 km/h

$= \dfrac{96\,000}{3600}$

$= 26.7$ m/s

$v^2 = 2as$

$26.7^2 = 2a \times 55$

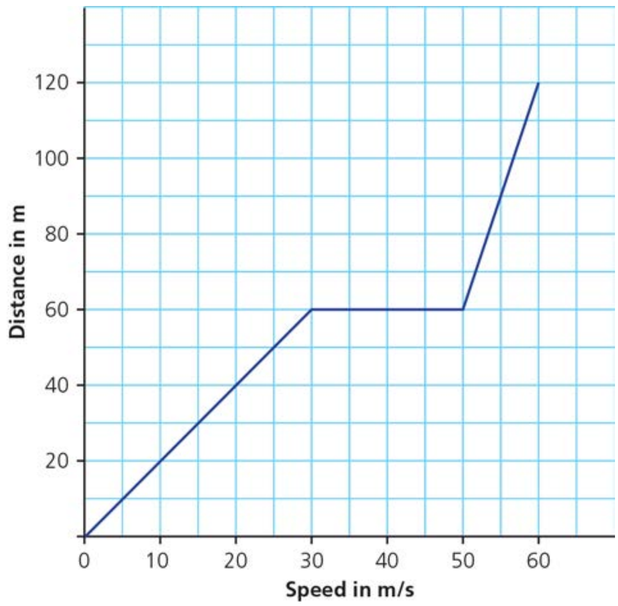
$= \dfrac{26.7^2}{110}$

$= 6.5\text{ m/s}^2$

Note that in each case, you must work in m/s and use the braking distance, because the deceleration takes place over the braking distance.

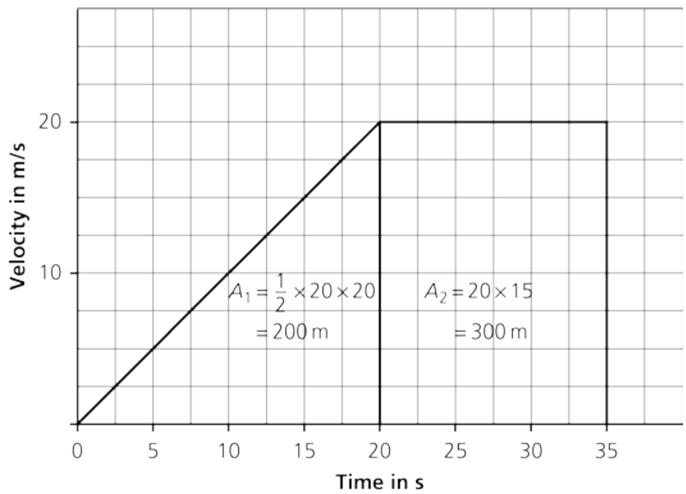
Show you can

Page 585



The gradient of the graph is the man's speed.

Page 588



The acceleration over the first 20 seconds is calculated as follows:

$$a = \frac{v - u}{t}$$

$$= \frac{20}{20}$$

$$= 1\,\text{m/s}^2$$

The distance travelled is the 'area' under the graph, which is the area of the triangle, A_1, and the rectangle, A_2.

$$A_1 = \frac{1}{2} \times 20 \times 20 = 200\ \text{m}$$

$$A_2 = 20 \times 15 = 300\,\text{m}$$

So the total distance travelled = 500 m

Page 595

You can answer this question by summarising Required practical 19 Pages 594–95, or by explaining how you did this practical yourself.

Page 596

Newton's First Law of Motion states that an object remains at rest or continues to move in a straight line at a constant speed, unless acted on by an unbalanced force (Page 592). There are many demonstrations to choose. For example:

You can hang a 1 N weight (about 100 g mass) on a spring balance. Then explain that the weight stays at rest because the weight down (1 N) is balanced by the (1 N) pull of the spring upwards.
Drop a cup cake holder, which falls at a constant speed. Weight is balanced by air resistance.
Set up an air track. Show that a slider, when pushed, moves at a constant speed – there is no force pushing the slider and air resistance is very small.

Page 597

Newton's Third Law states that to every force there is an equal and opposite force.

If you lean against a wall, you exert a force on it. You do not fall over because the wall pushes you back. Or you can lean against another person – you each feel the force.
Set up two small polystyrene balls or two balloons. Then charge them with the same sign of charge. They exert a force on each other, as shown in Figure 33.55.

Connect two dynamic trolleys, of the same mass, with springs. Mark the centre between them. Pull the trolleys apart, then release them. They return to the central place, showing that each exerts the same force on the other. [Newton's Law also works, of course, for trolleys with different masses, but they move different distances.]

Page 600

Information to answer this question is included under thinking distance on Page 597 and braking distance on Pages 598–99.

Practical

Page 589 – Light gates

1 The light gates need to be adjusted to measure the time taken for the diameter of the ball to pass through. So the light gates need to be at the height of the centre of the ball.

2 **a)** 0.52 m/s

b 0.69 m/s

3
$$a = \frac{v_B - v_A}{t}$$
$$= \frac{0.69 - 0.52}{0.23}$$
$$= 0.74 \text{ m/s}^2$$

Page 589 – Ticker timer

1 50 cm/s or 0.5 m/s

2 0.1 m/s

Page 591 – Terminal velocity and surface area

1 Consider a safe place to drop the parachute – do not stand on a stool balanced high on a bench. Drop a small mass.

2 You need to measure the distance the parachute falls and the time taken to fall. Repeat the measurements.

3 You can gauge the speed as it falls. Better than that, you can repeat the experiment dropping from a different height and check that the speed is the same.

4 Area of the parachute.

5 Distance the parachute falls; weight of the figure.

Required Practical 19

Page 594

1 The time used to calculate the velocity is taken while the trolley is still accelerating.

2 The values for acceleration would have been slightly greater as the effect of friction would have been reduced.

3 Both mass and accelerating force are variables that affect the acceleration of an object. If both are changed at the same time it is not possible to tell what effect each has on the acceleration.

Chapter review questions

1 **a)** A to B – the gradient is steeper.

b) i) 100 s

ii) 1500 m

iii) 1000 m

c) $\text{speed} = \frac{d}{t}$

$= \frac{1500}{100}$

$= 15\text{ m/s}$

2 **a)** $\text{speed} = \frac{d}{t}$

$45 = \frac{d}{30}$

$d = 30 \times 45$

$= 1350\text{ m}$

b) $\text{speed} = \frac{d}{t}$

$45 = \frac{9000}{t}$

$t = \frac{9000}{45}$

$= 200\text{ s}$

3 **a) i)** 23 m/s – 5 m/s = 18 m/s

ii) $a = \frac{v-u}{t}$

$= \frac{18}{6}$

$= 3\text{ m/s}^2$

b) i) $a = \frac{v-u}{t}$

$= \dfrac{15 - 23}{20}$

$= -0.4\,\text{m/s}^2$

ii) $F = ma$

$= 1500 \times 0.4$

$= 600\,\text{N}$

4 When the arms are spread out and loose clothing worn, the skydiver provides a larger surface area. Then the drag is bigger for a particular speed. The skydiver reaches terminal velocity when drag balances the weight. This balance occurs at a lower speed when the area is larger.

5 **a)** $a = \dfrac{v - u}{t}$

$= \dfrac{80}{40}$ [choose any point on the graph]

$= 2\,\text{m/s}^2$

b) Distance covered equals the area under the graph.

$d = \dfrac{1}{2} \times 90 \times 45$

$= 2025\,\text{m}$

6 **a)** work $= F \times d$

$= 400 \times 80$

$= 32\,000\,\text{J}$

b) work $= F \times d$

$= 470 \times 3.6$

$= 1692\,\text{J}$

$= 1700\,\text{J}$ (to 2 sf)

c) No work is done because the object has not been moved.

d) work $= F \times d$

$= 60\,000 \times 3000$

$= 1.8 \times 10^8\,\text{J}$ or $180\,\text{MJ}$

7 **a)** 700 N – drag and weight balance.

b) There is now a resultant force of 800 N upwards, so she slows down until the drag again balances the weight.

8 momentum $= m \times v$

$195\,000 = m \times 6.5$

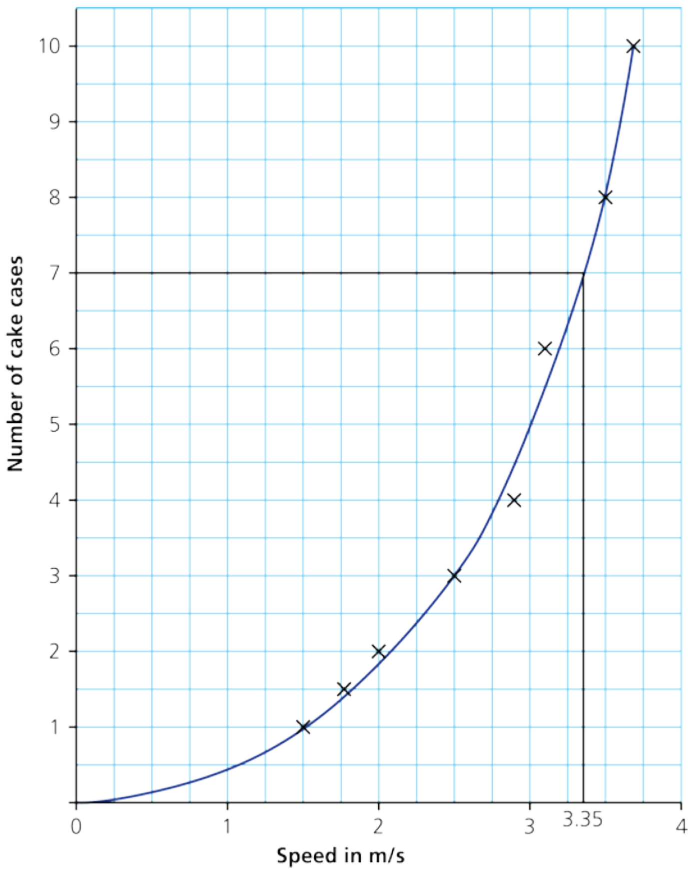
$m = 30\,000$ kg

9 **a)** To reduce the effect of random timing errors.

b)

Number of cake cases	Time of fall in s	Average time in s	Average speed in m/s
1	2.7, 2.6, 2.6	2.63	1.5
1.5	2.2, 2.3, 2.2	2.23	1.8
2	2.0, 2.0, 1.9	1.97	2.0
3	1.5, 1.6, 1.7	1.60	2.5
4	1.4, 1.4, 1.4	1.40	2.9
6	1.3, 1.3, 1.2	1.27	3.1
8	1.1, 1.1, 1.2	1.13	3.5
10	1.1, 1.1, 1.0	1.07	3.7

c)



d) This is difficult to do as the exact line of the curve is hard to predict.

But the answer lies in the range 3.3 s to 3.4 s.

e) The graph suggests that the terminal velocity of the cake cases increases with their weight.

f) Since they fall at a constant speed, the drag is the same size as the weight. So we can conclude that drag increases with speed.

10 There are many factors; here are some you might have found.

Cars have many safety features: seat belts, crumple zones, air bags, side impact bars.

We have an MOT test to ensure: safe tyres, safe brakes and many other safety features.

There are speed limits.

We have hazard warning signs.

There are crash barriers at corners.

We have hazard lights and fog lights on our cars.

There are barriers in towns to protect pedestrians.

There are pedestrian crossings.

We have traffic lights.

There are well-designed junctions and roundabouts.

There are laws about driving with drink and drugs in our bodies.

There are laws about dangerous and careless driving, with penalties.

We have driving tests – first introduced in 1935.

We educate people to drive carefully and raise awareness of how dangerous driving can be.

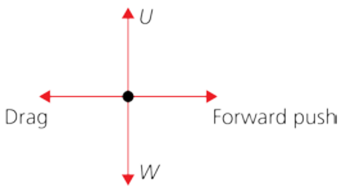
Lorry drivers and bus drivers have to take a more advanced test.

Motor cyclists have to wear crash helmets.

We have cycle and bus lanes.

Practice questions

1 a)



The four forces are:

Forwards push from the water (shown)

Drag backwards [1 mark]

Weight (W) [1 mark]

Upthrust (U) [1 mark]

b) i) $\text{speed} = \frac{\text{distance}}{\text{time}}$

$= \frac{1500}{1200}$

$= 1.25\,\text{m/s}$ [1 mark]

ii) $\text{speed} = \frac{\text{distance}}{\text{time}}$

$= \frac{51500}{6800}$ [1 mark]

= 7.6 m/s [1 mark]

Add all the distances, then divide by the sum of the times.

c) The gradient of the graph is the speed.

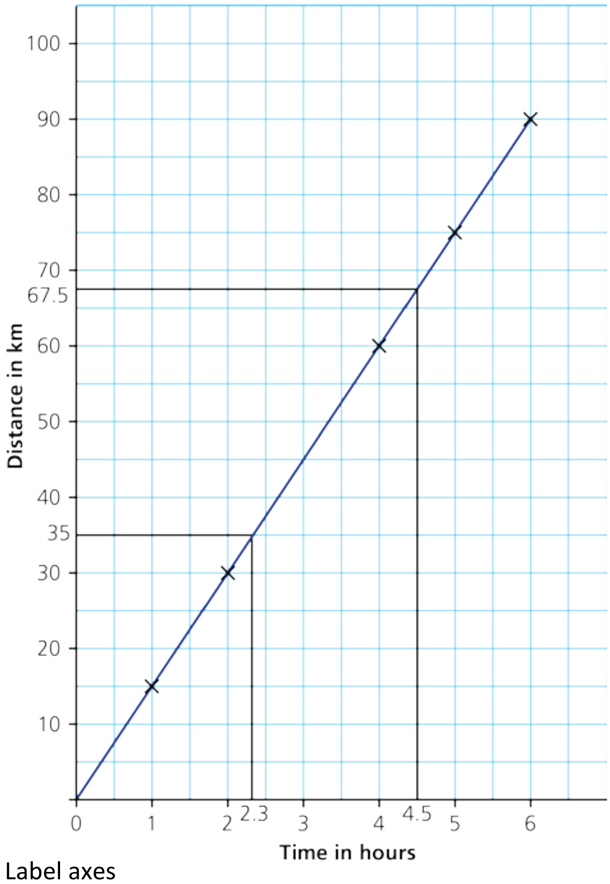
For 700 s he went at a constant speed.

Then he slowed down, then went quickly

again, before slowing down towards the end.

[1 mark for each point (up to 3)].

2 a)



Label axes

Accurate points

Straight line

b) i) 67.5 km

ii) 2.3 hours

c) speed = $\frac{\text{distance}}{\text{time}}$

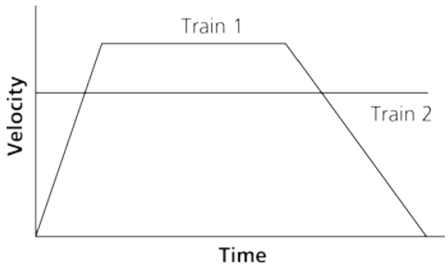
3 a) The train is slowing down.

OR The gradient of the graph is negative.

b) The distance travelled is the area under the graph.

[Areas A + B + C]

c)



[1 mark for a constant velocity. 1 mark for a velocity between 0.5 and 0.9 of the original velocity.]

4 a) i) *F* is bigger because the lorry accelerates in the direction of the resultant force. (*F*–*B*). [1 mark]

ii) resultant force = mass × acceleration [1 mark]

iii) $F = ma$

15 000 = 12 500 × a [1 mark]

$$a = \frac{15000}{12500}$$

$= 1.2\,\text{m/s}^2$ [1 mark for answer, 1 for unit]

You must include the correct unit.

b) i) The driver is distracted. [1 mark]

Or The driver is under the influence of alcohol or drugs.

Or Some drivers are just slower than others.

ii) An icy road. [1 mark]

Or Worn tyres.

Or The road surface – water or mud.

Or Worn brakes.

Or The speed of the car.

Or Having a heavy load in the car.

c) The driver's reaction time does not depend on the speed. [1 mark]

The councillor should have said the braking distance is less at 20 mph. [1 mark]

5 a) stopping distance = thinking distance + braking distance [1 mark]

b) The graph shows:

the thinking distance is proportional to the speed [1 mark]

the braking distance increases rapidly at high speeds. [1 mark]

c) About 30 m. [1 mark]

d) For the minimum stopping distance, you need to take the smallest distance found in the test. [1 mark]

e) i) There is no change to the thinking distance. This just depends on the reaction [1 mark] time of the driver. [1 mark]

ii) The braking distance increases, because there is a smaller braking force on the car, so its deceleration is less. [2 marks]

6 a) $\text{acceleration} = \dfrac{\text{change of speed}}{\text{time}}$

$= \dfrac{78}{60}$ [1 mark]

$= 1.3\,\text{m/s}^2$ [1 mark for answer, 1 for unit]

b) As the speed increases, the drag (air resistance) on the plane increases. [1 mark]

So the resultant force on the plane decreases. [1 mark]

Acceleration decreases, because:

resultant force = mass × acceleration. [1 mark]

c) Distance = area under the graph [1 mark]

The area is about 30 squares. [1 mark]

1 square = 10 m/s × 10 s = 100 m

So distance = 30 × 100

= 3000 m [1 mark]

7 a) $\text{acceleration} = \dfrac{\text{change of speed}}{\text{time}}$

$= \dfrac{4}{8}$ [1 mark]

$= 0.5\,\text{m/s}^2$ [1 mark for answer, 1 for unit]

b) resultant force = mass × acceleration

$60 - R = 80 \times 0.5$ [1 mark]

$60 - R = 40$ [1 mark]

$R = 20\,\text{N}$ [1 mark]

8 a) i) The length of the card. [1 mark]

ii) If the track is tilted, gravity will slow down or speed up the glider. Friction would slow the glider down. [1 mark]

b) i) A vector has direction as well as size (or magnitude). [1 mark]

ii) momentum = $m \times v$

$= 2.4 \times 0.6$ [1 mark]

$= 1.44\,\text{kg m/s}$ [1 mark]

You must have the correct unit.

iii) Zero.

Working scientifically: Understanding variables

Page 609

1 The 500g mass has inertia; it is also an example of Newton's third law of motion.

2 **a)** Type of material used for the crumple zone.

b) How far the 500g mass moved forwards before stopping.

3 The area and thickness of the materials used to model the crumple zone.

Test yourself on prior knowledge

1 Seismic waves.

Mechanical waves travelling on a rope.

Examples of electromagnetic waves other than light, X-ray, radio waves, etc.

2 Seismic waves cause the ground to move – this energy can knock down buildings. We can work out where the centre of the earthquake was (information).

Energy is transmitted in the vibrations of the rope. Information could be carried in a code of pulses.

Radio waves carry energy in oscillating electric and magnetic fields. Radio waves carry information – TV and radio signals.

3 There is a time lag between hearing the thunder and seeing the lightning.

Test yourself

1 **a)** Draw a diagram like Figure 34.2 page 611.

b) Draw a diagram like Figure 34.4 page 612.

2 In a longitudinal wave, areas of compression are the parts where the spring coils are close together (or an area of greater pressure in a sound wave).

A rarefaction occurs where coils of the slinky are further apart or, in sound, where the air pressure is less.

3 **a)** Up and down.

b) The balls also move up and down.

4 A slinky transfers energy – we can feel a pulse being transmitted from one end to another.

We could use a code (Morse code for example) to transmit a message down a slinky.

5 The pulses on rope A have a higher amplitude and a higher frequency than the pulses on rope B.

6 **a)** These are all one wavelength.

b) This is the amplitude of the wave.

c) **i)** 2 m

ii) 30 cm

iii) 3.5 m

7 $f = \frac{1}{T}$

a) 4 Hz

b) 100 Hz

8 $v = f\lambda$

$0.4 = f \times 0.08$

$f = 5\ \text{Hz}$

9 Copy Figure 34.10 page 614. Distance b–f or d–g represent one wavelength. One wavelength is the distance between two neighbouring compressions or neighbouring rarefactions.

10 You can time how long it takes for a pulse to be reflected out and down the slinky. If it takes 2 s to travel up and down twice:

$$v = \frac{d}{t}$$

$$= \frac{4 \times 5}{2}$$

$$= 10\,\text{m/s}$$

11 $d = v \times t$

$t = 4.2 \times 1\,\text{ms}$

$= 4.2\,\text{ms}$

$\text{d} = 330 \times 0.0042$

$= 1.39\,\text{m}$

12 All travel at 3×10^8 m/s (speed of light) in a vacuum.

They carry energy (in oscillating electric and magnetic fields).

They carry information.

They can be characterised by a frequency.

They can be characterised by a wavelength.

They refract when entering a different medium.

They can be reflected off surfaces.

They all have uses.

They can call be dangerous at high intensity – (less so with radio waves).

13 Refraction. When waves are transmitted from one medium to another, the waves change speed and can also change the direction of travel.

Reflection. When waves are incident on the surface of a different medium, some (or all) of the energy is reflected back into the original medium. (The angle of reflection equals the angle of incidence.)

Absorption. When energy is absorbed from a wave, the amplitude of the wave (and therefore the energy carried by the wave) reduces. For example, infrared radiation is absorbed by meat in an oven. The wave energy is transferred into the meat which cooks.

Transmission. When an electromagnetic wave is transmitted through a medium, there is little absorption. For example, glass transmits light – we can see through glass.

14 a) $v = f\lambda$

$3 \times 10^8 = 10^8\ \lambda$

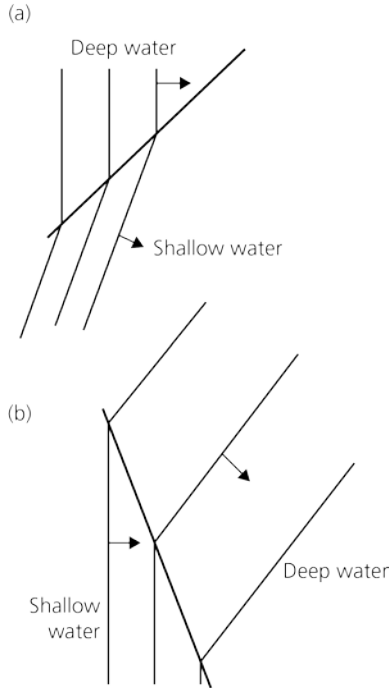
$$\lambda = \frac{3 \times 10^8}{10^8}$$

$$= 3\,\text{m}$$

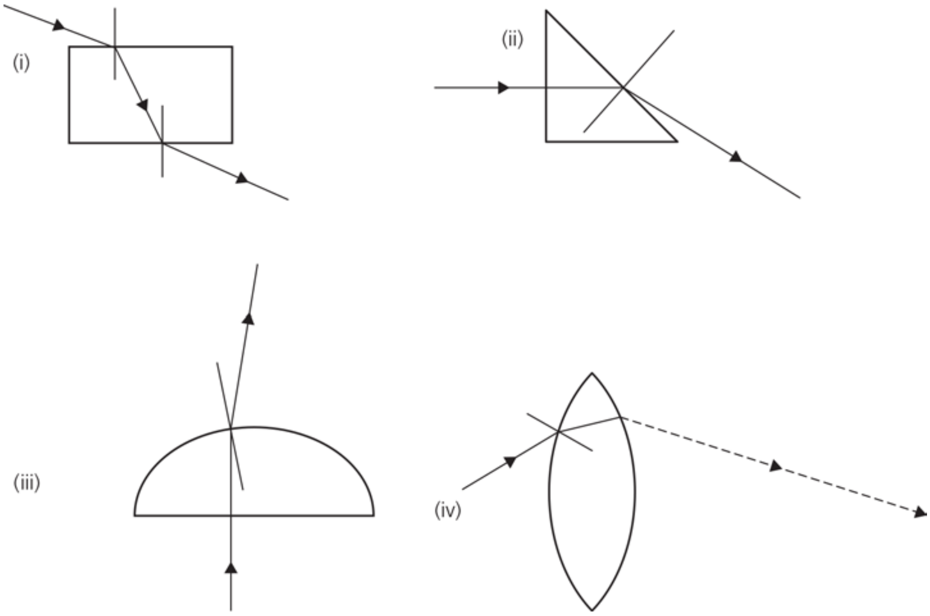
b) $f = \dfrac{3 \times 10^8}{1500}$

$= 200\,\text{kHz}$

15



16



17 X-rays and gamma rays.

18 a) Radio waves.

b) Ultraviolet. Ultraviolet radiation is most likely to cause skin cancer as we are exposed to it from the Sun. But large doses of X-rays or gamma rays could also cause skin cancer.

c) X-rays.

19 Choose from Pages 622–23.

Show you can

Page 612

You can demonstrate the transmission of energy on a slinky. You can feel the energy of the pulse arriving, but the slinky does not pile up at the end.

Page 614

These terms are shown in Figure 34.8 page 613.

Page 624

A high frequency alternating current makes electrons oscillate up and down inside the transmitting aerial. This sends an electromagnetic wave which transfers energy in its oscillating electric and magnetic fields. These fields then make electrons oscillate up and down in the receiving aerial, so that a current is produced and detected.

Practical

Page 625

1 Amount of infrared detected will depend on distance. So distance is a variable that must be controlled.

2 The type of surface is a categoric variable.

Chapter review questions

1 a) In a longitudinal wave, the vibrations in the medium are parallel to the direction of energy transfer.

In a transverse wave, the vibrations in the medium are perpendicular to the direction of energy transfer.

b) Longitudinal: longitudinal waves on a slinky spring, sound waves, P-waves in an earthquake.

Transverse: transverse waves on a slinky spring, water ripples, electromagnetic waves, S-waves in an earthquake.

2 a) Infrared radiation (also visible light and ultraviolet).

b) Microwaves.

c) Ultraviolet (this is also dangerous and can cause cancer).

3 a) $T = \frac{1}{f}$

$= \frac{1}{512}$

$= 0.002\,s$ or $2\,ms$

b) $v = f\lambda$

$330 = 512 \times \lambda$

$\lambda = \frac{330}{512}$

$= 0.64\,m$

4 a) An echo occurs when sound is reflected off a large solid object – a cliff, for example.

b) d = speed × time

$= 330 \times 4$

$= 1320\,m$

so the cliff is ½ × 1320 = 660 m away as the sound has to travel there and back.

5 a) 20 cm

b) 60 cm

c) $T = \frac{2}{5}$

$= 0.4\,s$

d) $f = \frac{1}{t}$

$= \frac{1}{0.4}$

$= 2.5\,Hz$

e) One wavelength = 60 cm

f) $v = f\lambda$

$= 2.5 \times 0.6$

$= 1.5\,m/s$

or $v = \frac{\lambda}{t}$

$= \frac{0.6}{0.4}$

$= 1.5\,m/s$

Practice questions

1 **a)** Missing words: transmits; absorbs. [2 marks]

b) Killing cancer cells. [1 mark]

c) 40[2 marks]

2 **a)** Sound waves are longitudinal waves. [1 mark]

A vibrating source of sound causes compressions and expansions in the air. [1 mark]

The vibrations in the air move backwards and forwards along the direction in which the sound travels. [1 mark]

b) **i)** 0.01 s [1 mark]

ii) $\text{speed} = \frac{\text{distance}}{\text{time}}$ [1 mark]

c) **i)** Student 1: 0.44 + 0.46 + 0.44 + 0.48 + 0.43 = 2.25

$\text{average} = \frac{2.25}{5}$

$= 0.45\,\text{s}$ [1 mark]

Student 2: 0.5 + 0.6 + 0.4 + 0.4 + 0.6 = 2.5

$\text{average} = \frac{2.5}{5}$

$= 0.5\,\text{s}$ [1 mark]

ii) $\text{speed} = \frac{\text{distance}}{\text{time}}$

$\text{speed} = \frac{150}{0.45}$

$= 333\,\text{m/s}$

or 330 m/s (to 2 sf) [Student 1] [1 mark]

$\text{speed} = \frac{150}{0.5}$

$= 300\,\text{m/s}$ (to 1 sf) [Student 2] [1 mark]

3 **a)** A: Visible light. [1 mark]

B: X-rays. [1 mark]

b) Infrared. [1 mark]

c) Microwaves. [1 mark]

d) Gamma rays. [1 mark]

e) Choose any two, for example:

i) Gamma rays, X-rays, ultraviolet.

Each of these radiations can cause cancer. [1 mark]

Infrared radiation can burn you. [1 mark]

Too much light can damage your eye, and even cause blindness. [1 mark]

ii) Ultraviolet. You can reduce your exposure to UV radiation by keeping out of the Sun, or by putting on sunblock cream. [1 mark]

X-rays. Radiographers wear lead aprons and keep away from X-ray machines. [1 mark]

4 White light is made up of all the colours. The red flower reflects the red light but absorbs all the other colours. [2 marks]

5 a) i) D [1 mark]

ii) C [1 mark]

b) Transverse. [1 mark]

Although the wave oscillates up and down, the energy is transferred along the surface of the water at right angles to the surface. [1 mark]

c) $f = \frac{1}{4}$ [1 mark]

$= 0.25\,\text{Hz}$ [1 mark]

Working scientifically: Communication in science

Pages 628–29

1 $2.44\,\text{ms} = 2.44 \times 10^{6}\,\text{ns}$

2 Systematic error.

3 So they could go through the process of peer review.

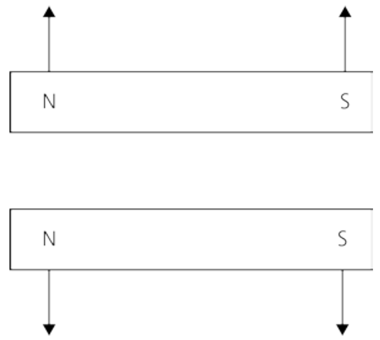
4 Opinions.

5 When there is no doubt about the evidence, it is not contradicted by other evidence.

6 Probably not – it is only a small sample from the very large numbers of mobile phone users throughout the world.

Test yourself on prior knowledge

1



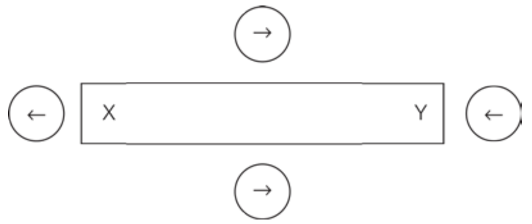
2 Missing words: magnetises; south; north; weight.

3 The head of each nail is magnetised south. Since like poles repel each other, the pins repel and stick out sideways.

Test yourself

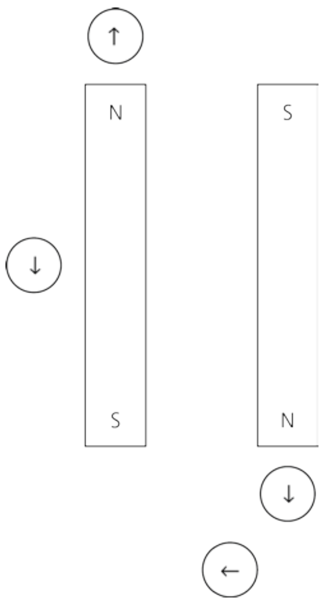
1 steel pin, iron nail.

2 a)



b) X is north; Y is south. The compass needle points away from X and towards Y.

3



4 a) A permanent magnet always produces a magnetic field. It has two poles, north and south.

b) Some materials become magnetic, when placed in a magnetic field. These are induced magnets.

5 Increase the current.

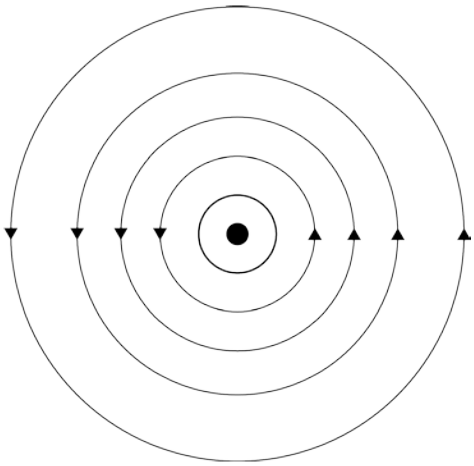
Increase the number of turns.

Put the turns closer together.

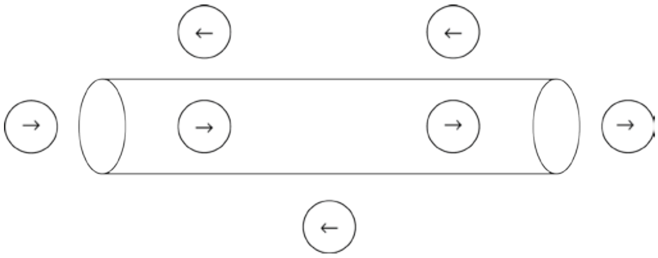
Insert iron into the turns.

6 To ensure that the current flows through each turn, without the current crossing from coil to coil or flowing through the iron.

7



8 **a)**



b) The left end.

c) The compasses all change direction by 180°.

d) The field will be the same shape as Figure 35.16 on page 635; but the direction of the field depends on the direction of the current.

9 Increasing the magnetic field strength; increasing the current in the wire.

10 Placing the wire so that the current is parallel to the magnetic field.

11 **a)** $\downarrow$

b) $\downarrow$

c) $\rightarrow$

d) $\rightarrow$

12 $F = BIL$

$= 2 \times 4.5 \times 0.2$

$= 1.8\,\text{N}$

13 BC is parallel to the magnetic field so there is no force on the wire.

14 Increase the current.

Increase the number of turns.

Increase the strength of the magnets.

15 a) i) Down.

ii) Up.

b) Anticlockwise as we look at it (from the end AD).

c) When it is vertical.

16 a) i) This is reversed.

ii) This is reversed.

iii) The direction of the force stays the same.

b) Both a.c. and d.c. supplies cause the coil to rotate. The a.c. supply works because both the current direction and magnet polarity reverse, but the rotation force is not changed.

[See Question 12 on Page 638.]

c) The parallel supply allows different currents to be supplied to the magnet and coil.

Show you can

Page 633

First you need one permanent magnet which is then used to test unknown magnetic materials. If a material is a permanent magnet, it has a north and a south pole; one pole will be attracted to your test magnet and one pole will be repelled. Induced magnets will always be attracted to your test magnet.

Page 636

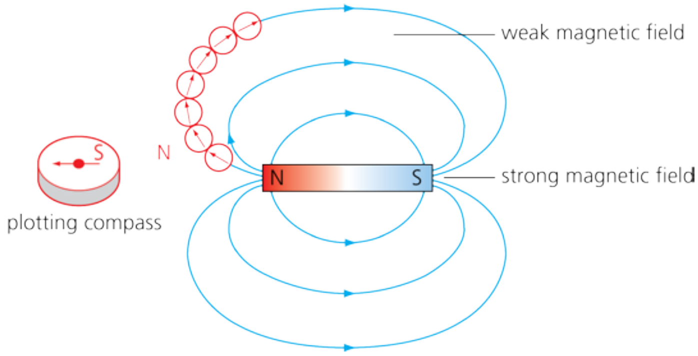
You wrap many turns of the insulated wire around the nail. When the wire is connected to a battery or power pack (d.c. supply), the nail becomes an electromagnet. Then the induced magnet (the nail) can pick up paper clips.

Page 640

You need to refer to Figure 35.26 page 639. When the coil passes the vertical position, the two halves of the commutator change contact from one brush to the other. This changes the direction of the current in the coil, so that the forces on the coil continue to make it turn. You will need to draw your own diagram to illustrate this.

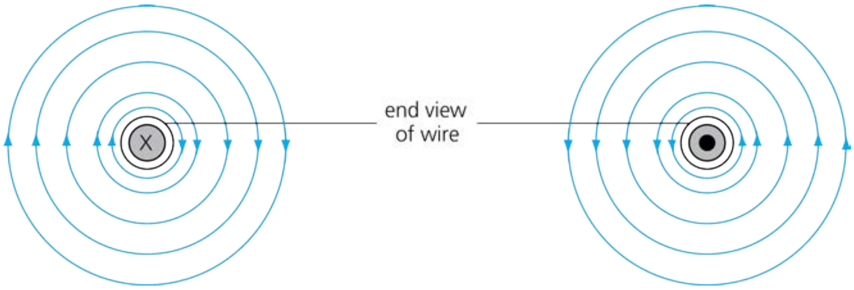
Chapter review questions

1 a)

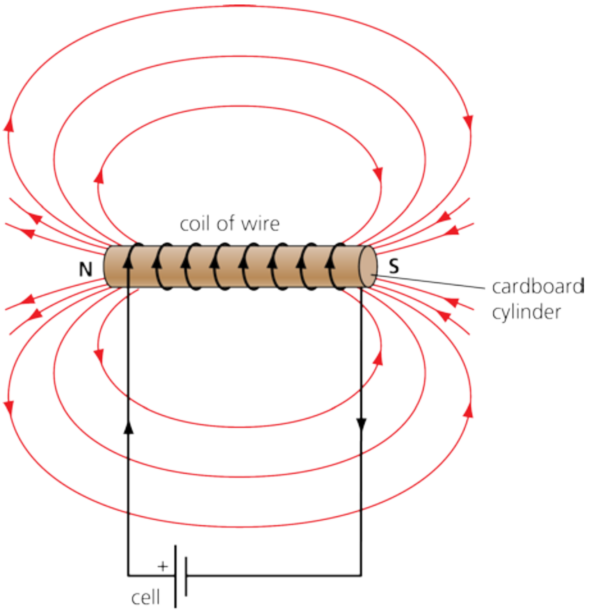


b) You can use the compass as shown above to trace out the pattern of field lines.

2 a)

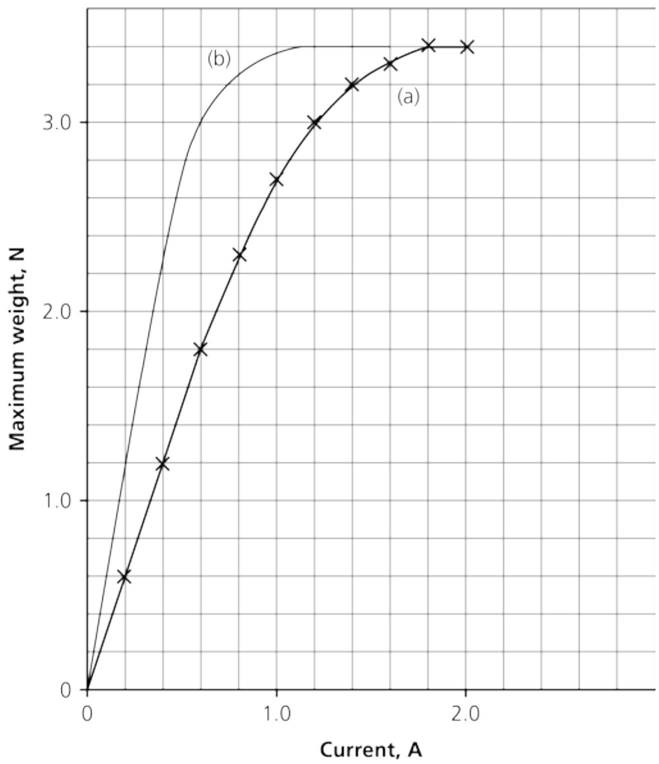


b)



3 a)

b)



Practice questions

1 a) steel [1 mark]

b) gravity [1 mark]

c) A permanent magnet will attract one end of another permanent magnet and then repel the other end. [1 mark] An unmagnetised iron bar will become magnetised by a magnet, [1 mark] but there will always be an attraction between the bar and the magnet. [1 mark]

2 An induced magnet only becomes magnetic when placed in a magnetic field. (it is a temporary magnet) [1 mark]

3 a) The area around a magnet which is affected by the magnet's magnetic force. [1 mark]

b) The magnetic field is strongest near the poles of the magnet / the magnetic field decreases with distance away from the poles of the magnet [1 mark]

c) Field lines run from north to south [1 mark]

The magnetic field will be circular (and perpendicular to the wire) [1 mark]

The magnetic field gets weaker further away from the wire [1 mark]

4 Any three from

- Using a larger current
- Using more turns of wire
- Putting the turns closer together
- Adding an iron core into the middle of the solenoid [3 marks]

5 **a)** There is a force down on one side of the coil (left), and there is a force up on the other side of the coil (right). This turns the coil. [2 marks]

The split ring commutator keeps the current flowing in the same sense, so that the coil always had forces to turn it in the same direction. [1 mark]

b) Stronger magnets. [1 mark]

Larger current from batteries with a higher p.d. [1 mark]

c) Reverse the magnets. [1 mark]

Reverse the battery. [1 mark]

6 **a)** The wire moves to the right. [1 mark]

[Use the left hand rule.]

b) The direction of the movement is reversed so the wire moves to the left. [2 marks]

[You will get carry through marks here; if you said in part a) the wire moves to the left, you get 2 marks for saying it moves to the right in part ii).]