Igcse Physics 3ed tr coursebook answers

eco hl (Podar International School)

Exam-style questions and sample answers have been written by the authors. In examinations, the way marks are awarded may be different.

Coursebook answers

Chapter 1

Questions

1 a Fill a measuring cylinder with enough water that it will cover the steel block and the block of wood but not overspill.
Gently immerse the steel block and record the reading on the measuring cylinder.
Raise the steel block and allow any drips of water to fall into the measuring cylinder.
Gently place the wooden block into the measuring cylinder.
Lower the steel block to immerse both the wooden and metal blocks.
Record the new reading on the measuring cylinder.
Subtract the smaller reading from the bigger reading to get the volume of the wooden block.

b 18 cm^3

2 a 0.1 mm

b 3.12×10^3 cm^3

3 a 0.215 m, 0.1025 m, 0.065 m

b 1.43×10^{-3} m^3

c 1955 kg/m^3

4 a 9.71×10^{-2} g

b 0.222 cm^3

c 0.44 g/cm^3

d Density is less than that of water (1.0 g/cm^3) so it will float.

5 5.5×10^3 kg/m^3

6 0.05 cm^3

7 a 840 cm

b 0.29 cm

c 215.4 cm^3

d 1.88 kg

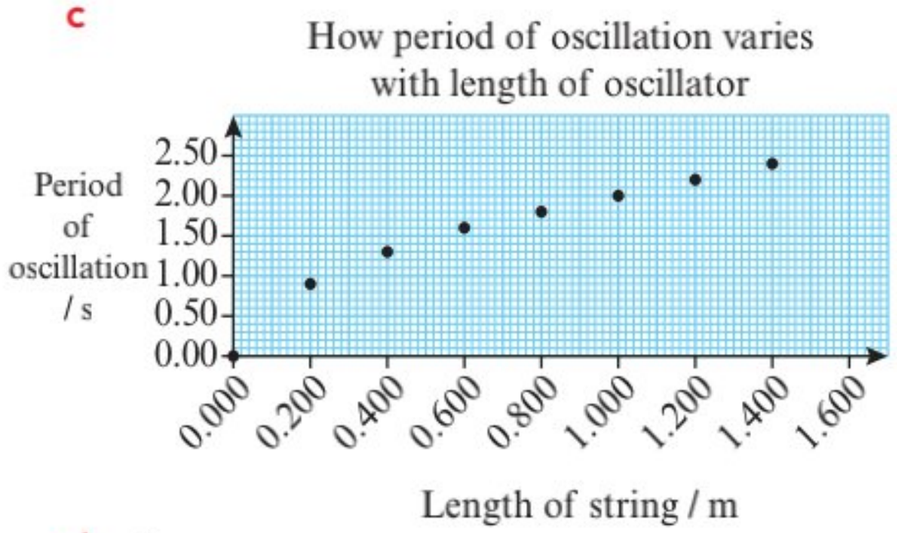
8 a 16.7 ms

b 2.5

9 a Any random error with starting or stopping the stopwatch would be divided by 20.

b Values are, reading down the column: 0.000, 0.905, 1.255, 1.615, 1.770, 2.025, 2.220, 2.395

c



d 1 m

Exam-style questions

1 D; **[1]**

2 B; **[1]**

3 D; **[1]**

4 A; **[1]**

5 **a** **i** 262 mm − 173 mm = 89 mm; **[1]**

ii 88.5 mm; **[1]**

6 Measure the thickness of a ream of paper (500 sheets) and then divide by 500; **[1]**

7 $m = pV = 2.24 \times 7.5 \times 2.6 \times 0.1$
[1] = 4.37 g; **[1]**

8 **a** **i** 15.82 g; **[1]**

ii 15.90 cm^3; **[1]**

iii 0.90 g/cm^3; **[1]**

iv 0.85 g/cm^3; **[1]**

b **[2]**

colour of layer	Thickness of layer / cm
clear	2.0
blue	3.5
green	2.9
red	1.6

9 Provided that the ship does not leak, the overall density of the ship is less than the density of water so will float; **[1]**

10 Measure and record the mass of lots of drawing pins (no need to count them but at least 50).

Pour enough water into a measuring cylinder to immerse the drawing pins. Measure and record the volume of water; **[1]**

Immerse the *same* drawing pins in the water and measure and record the new volume; **[1]**

Subtract the smaller volume from the bigger volume to find the volume displaced by the drawing pins.

Calculate the density by dividing the mass of the drawing pins by the displaced volume; **[1]**

Chapter 2

Questions

1 **a** 10.44 m/s

b He started from rest and had to accelerate so he ran slower than his average speed so he must also have run faster.

2 32.2 m/s

3 **a** C

b B

4 300 m/s

5 114.3 km/h; 31.7 m/s

6 5.36×10^{11} m = 5.36×10^{8} km = 536 million km

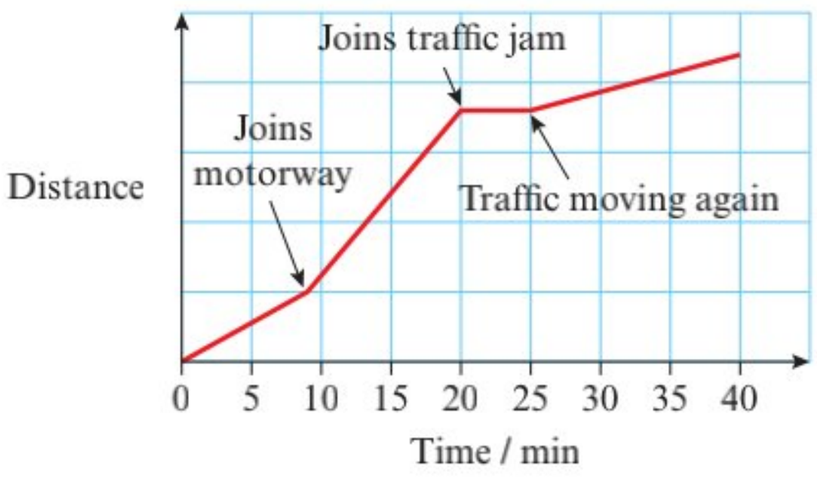
7 8 minutes

8 **a** 3.23 s

b 6 m/s

c 19.35 m

9



10 **a** 40 km

b 5.0 km/h

c 2

d Between C and D (between 5 pm and 5.30 pm)

e At E (6 pm)

f 6.15 km/h

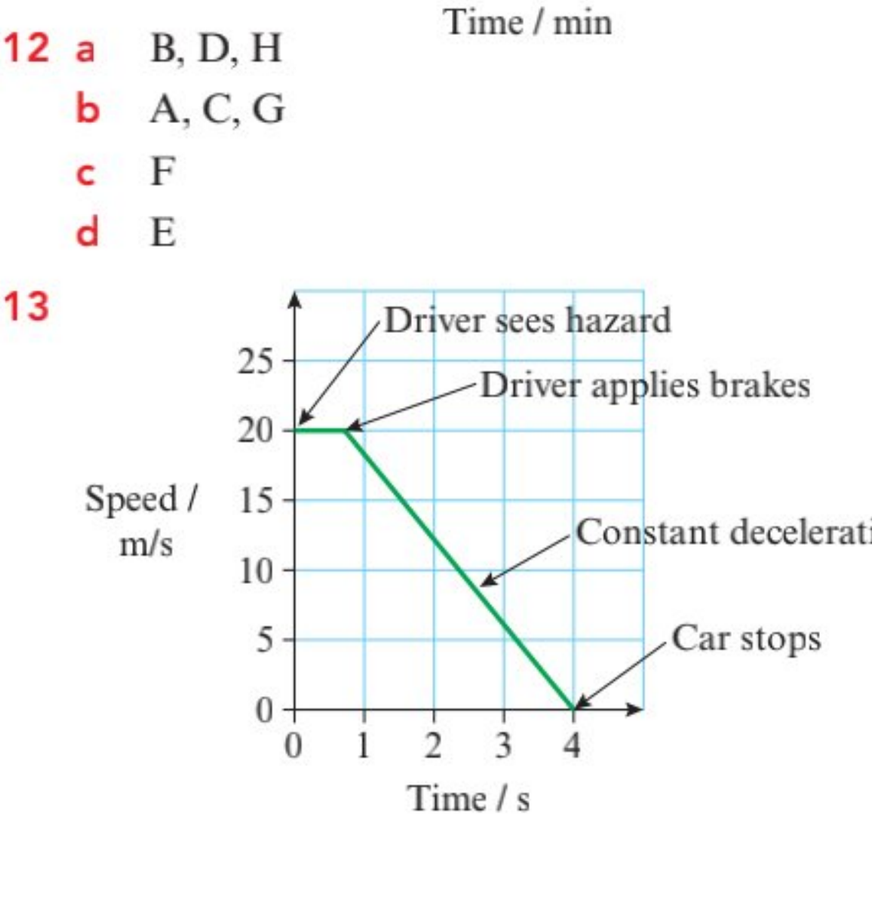
g 20 km/h between D and E

11 **a** 37.5 min

b 30 min

c 7.5 min

d



12 **a** B, D, H

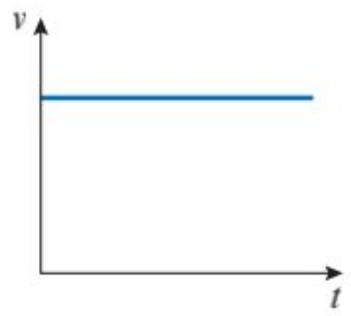
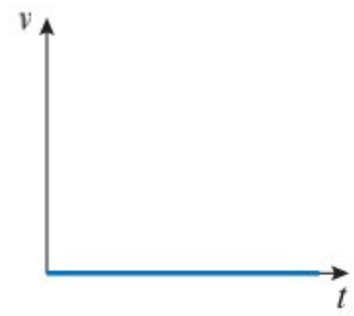
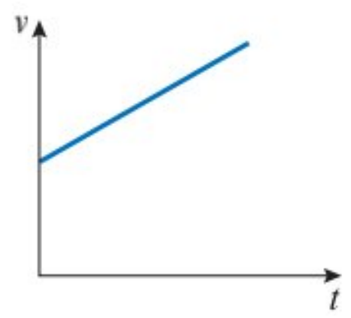
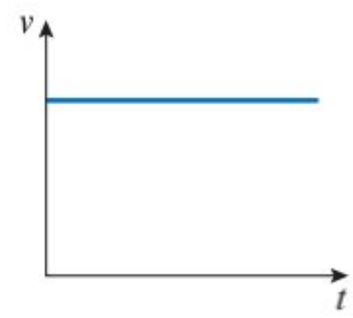
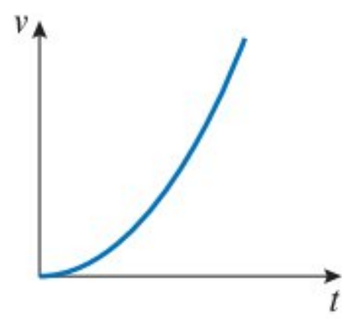
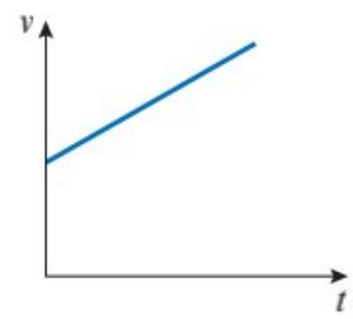
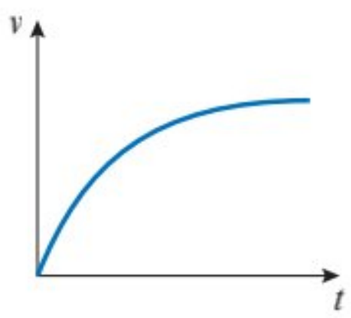
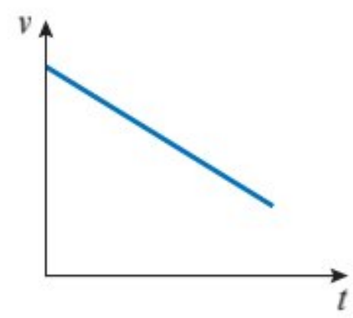
b A, C, G

c F

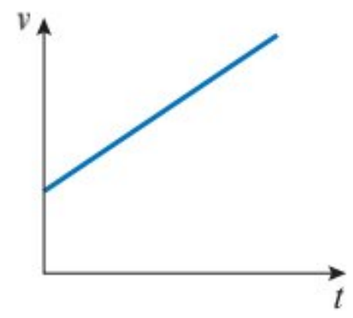
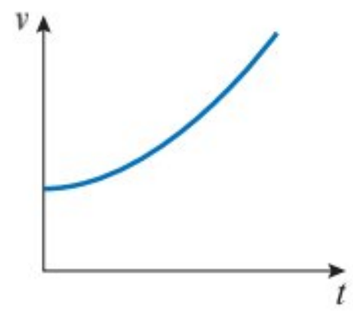
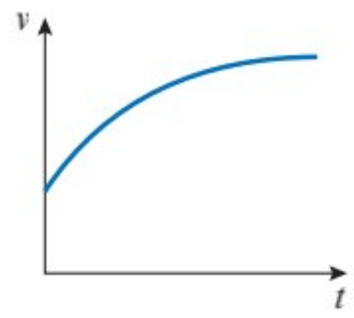
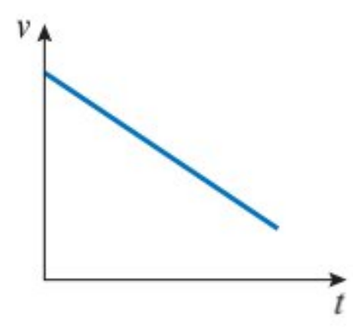
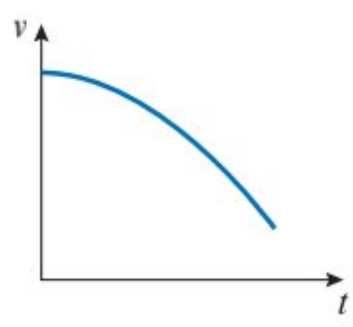
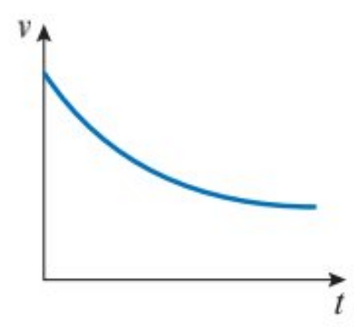
d E

13

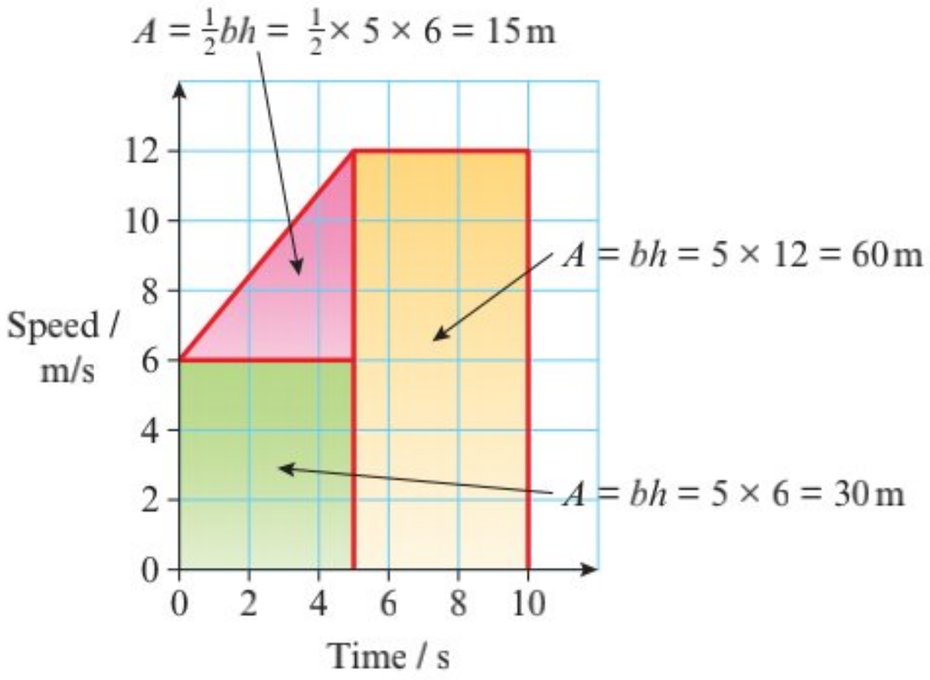
14 a

Motion of body	Distance–time graph	Speed–time graph
at rest		
moving at constant speed		
constant acceleration (speeding up)		
constant deceleration (slowing down)		

b It may help to correctly plot increasing and decreasing deceleration by thinking of negative acceleration in place of deceleration.

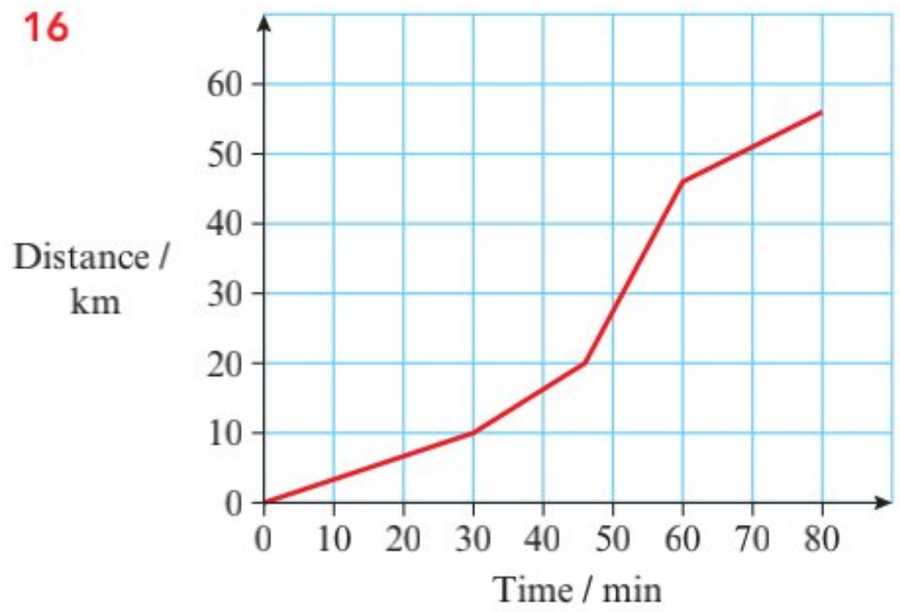
Motion of body	constant acceleration	increasing acceleration	decreasing accleration
accelerating			
decelerating			

15 a, b



c Total distance = 105 m

16



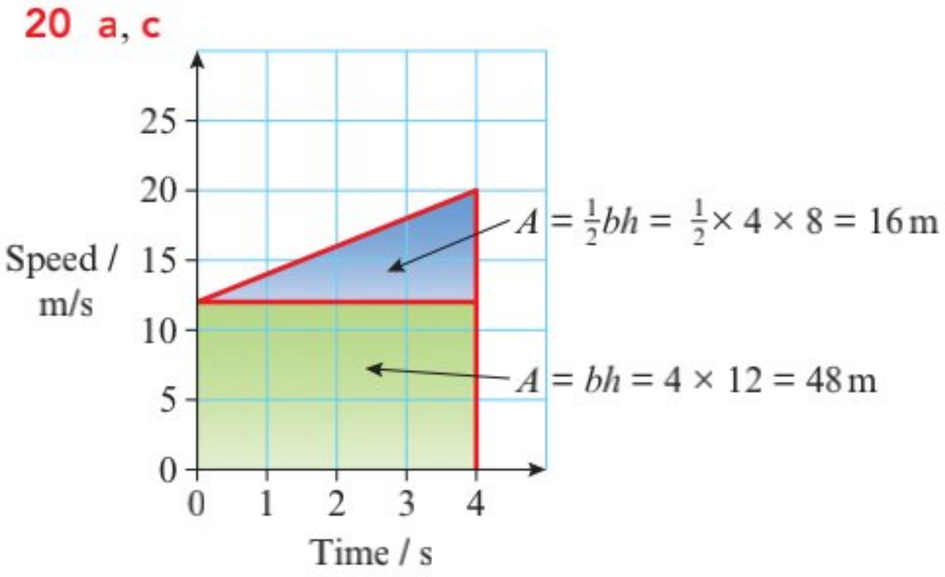
Average speed = 42 km/h

17 km/s

18 2.1 m/s²

19 0.2 m/s²

20 a, c

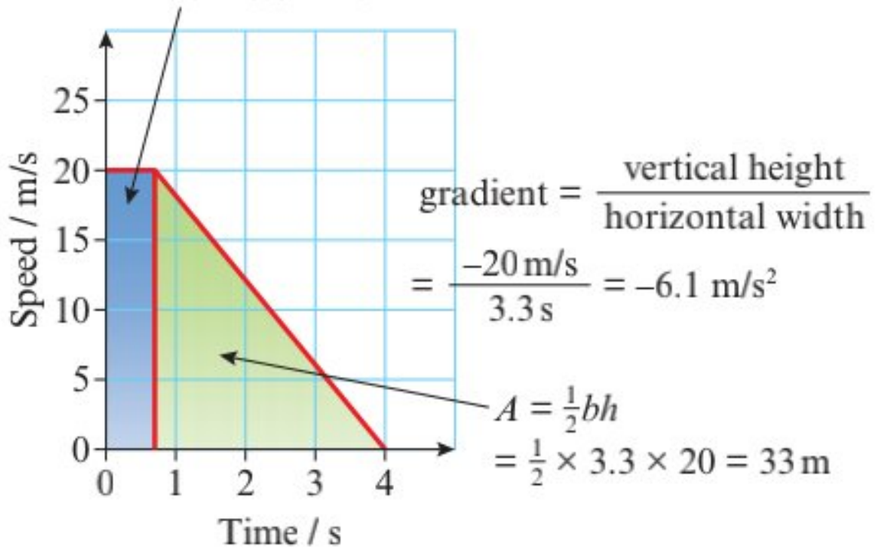


b $a = (v - u)/t = (20 - 12)/4 = 2\,\text{m/s}^2$

c $16 + 48 = 64\,\text{m}$

d $s = \frac{1}{2}(u + v)t = \frac{1}{2}(12 + 20)^4 = 64\,\text{m}$

21 a $A = bh = 0.7 \times 20 = 14\,\text{m}$



$$\text{gradient} = \frac{\text{vertical height}}{\text{horizontal width}}$$

$$= \frac{-20\,\text{m/s}}{3.3\,\text{s}} = -6.1\,\text{m/s}^2$$

$A = \frac{1}{2}bh$

$= \frac{1}{2} \times 3.3 \times 20 = 33\,\text{m}$

b 6.1 m/s²

c thinking distance = 14 m; braking distance = 33 m; stopping distance = 47 m

Exam-style questions

1 B; **[1]**

2 C; **[1]**

3 D; **[1]**

4 C; **[1]**

5 a 1.744 s; **[1]**

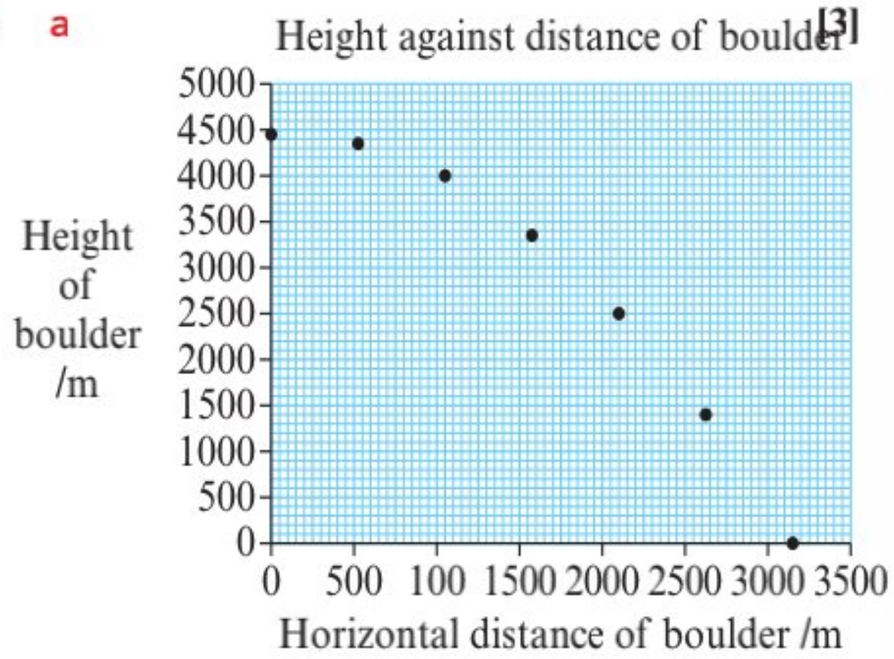
b 5.73 m/s; **[1]**

c 10.58 m/s; **[1]**

d 5.60 m/s²; **[1]**

e 12.35 m/s; **[1]**

6 a



[3]

b boulder moving at a constant speed in the horizontal direction and accelerating vertically; **[1]**

c 2.85×10^3 m; **[2]**

d 27 s; **[1]**

e 105 m/s; **[2]**

f rock and dust will have been moving at different speeds and angles. Fine dust will have been affected more by air resistance than solid rock; **[1]**

Chapter 3

Questions

1 a accelerate to right
b slow down / accelerate to left
c change direction

2 a unbalanced; 20 N to left; accelerate to left
b balanced; no acceleration
c unbalanced; 50 N downwards; accelerate downwards

3

mass	weight
scalar	vector
unit = kg	unit = newton
measure of the amount of matter in a body; does not change with positon	value depends on local value of acceleration due to gravity
measured with a (top-pan) balance	(measured with a newton meter)

4 a mass = 1 kg; weight is less than 10 N
b mass = 1 kg; weight is greater than 10 N

5 a i 686 N
ii 70 kg
iii 12.12 N
iv 5000 kg
v 7.69×10^{-3} m/s^2
b always the same
c The force of gravity is much (15 033 times) greater on Jupiter.

6 a accelerating
b weight greater than air resistance
c The parachutist will slow down until weight equals air resistance; and then fall at constant speed.

7 Diagram should show a force acting towards the centre of a circle that the bend is part of.

8 force of gravity

9 a increases
b increases
c increases

10 a 500 N
b 1.6 m/s^2
c 22 000 kg
d 0.15

11 a 23.53 N
b 23.52 N
c same; weight is a force

12 66.7 m/s^2

13 5.81 kgm/s

14 a 3×10^5 Ns
b 3×10^5 Ns

15 They both experience the same impulse (change in momentum) but for the driver this takes place over a longer interval of time, which means that he experiences a smaller force.

16 a $F = \frac{\Delta p}{\Delta t}$
b 2.4×10^4 N
c 980 N
d 24.5
e 240 N/kg

17 a 1.3 m/s
b 5 m/s; 36.9° east of south

Exam-style questions

1 C; **[1]**

2 C; **[1]**

3 A; **[1]**

4 C; **[1]**

5 **a** $F = ma$; **[1]**

b 2.5 m/s^2; **[1]**

c 14 s; **[2]**

d Graph with time on the x-axis and speed on the y-axis. **[1]** Straight line drawn from (0, 0) through (14, 35); **[1]**

e 245 m; **[1]**

f change direction; **[1]**

6 **a** $p = mv$; **[1]**

b 1079 kg m/s; **[1]**

c 7.35×10^3 N; **[2]**

d For a given change in momentum, seat belts and the crumple zones increase the time it takes for the car passengers to come to a stop, **[1]** which reduces the force on them. **[1]** In turn, this reduces the potential injuries; **[1]**

Chapter 4

Questions

1 a bigger
b further
c 90°

2 F_3 biggest turning force; equal biggest distance but force at 90° to the object which makes turning force bigger than F_2.

3 Bigger distance from the pivot so can apply a smaller force to achieve same turning force.

4 a the turning force is increased because a stronger wind applies a bigger force.
b the wind applies bigger turning force because the perpendicular distance from the pivot is increased.

5 moment of a force (Nm) = force (N) × perpendicular distance from pivot to force (m)

6 a 50 cm
b 15 Nm

7 231.4 N

8 3.3 m

9 a 0.115 m
b 257 N

10 a 9.4×10^{-2} Nm
b 9.4×10^{-2} Nm
c 0.12 m

11 a lines drawn connecting opposite vertices, cross in centre
b cross in centre of circle
c lines drawn connecting each vertex with the centre of the opposite site, cross in centre
d cross in centre of inner circle

12 a Both buses would topple if tilted any further because their centres of mass would be to the right of the 'pivot' (the right-hand wheel) which would exert a clockwise moment.
b Stability reduces as the centre of mass moves upwards. As can be seen, this means that the bus is tilted through a smaller angle before it topples over.
c This is to reproduce the worst-case scenario (most extreme situation).

13 a The centre of mass is above the point where the wheel makes contact with the ground (pivot). The line of force associated with the cyclist's weight does not pass either side of where the bike makes contact with the road.
b No, because there is an unbalanced force to the right.
c The cyclist is unstable, because the forces are not balanced.

Exam-style questions

1 C; [1]
2 D; [1]
3 C; [1]
4 B; [1]
5 a Increase (perpendicular) distance from the pivot; [1]
b Increase the applied force; [1]
6 a resultant; [1]
b zero; [1]
7 a moment of a force (Nm) = force (N) × perpendicular distance from pivot to force (m); [1]
b moment = 0.94 Nm; [2]
c i The moment has decreased as the perpendicular distance to the pivot has decreased; [1]
ii The clockwise moment also decreases because the angle-poise lamp is in equilibrium and principle of moments says that the clockwise and anti-clockwise moments must be equal; [1]
8 a The force decreases **[1]** because the perpendicular distance from the pivot increases; [1]
b For a body to be in equilibrium the forces (including turning forces) acting on it must be balanced otherwise the body will change velocity or will start to spin; [1]
c 0.5 m; [2]
d Move his centre of mass closer to the pivot (by leaning out less). **[1]** This would ensure that his clockwise moment would reduce to match the reduced anti-clockwise moment of the wind. This would ensure that the system stayed in equilibrium; [1]

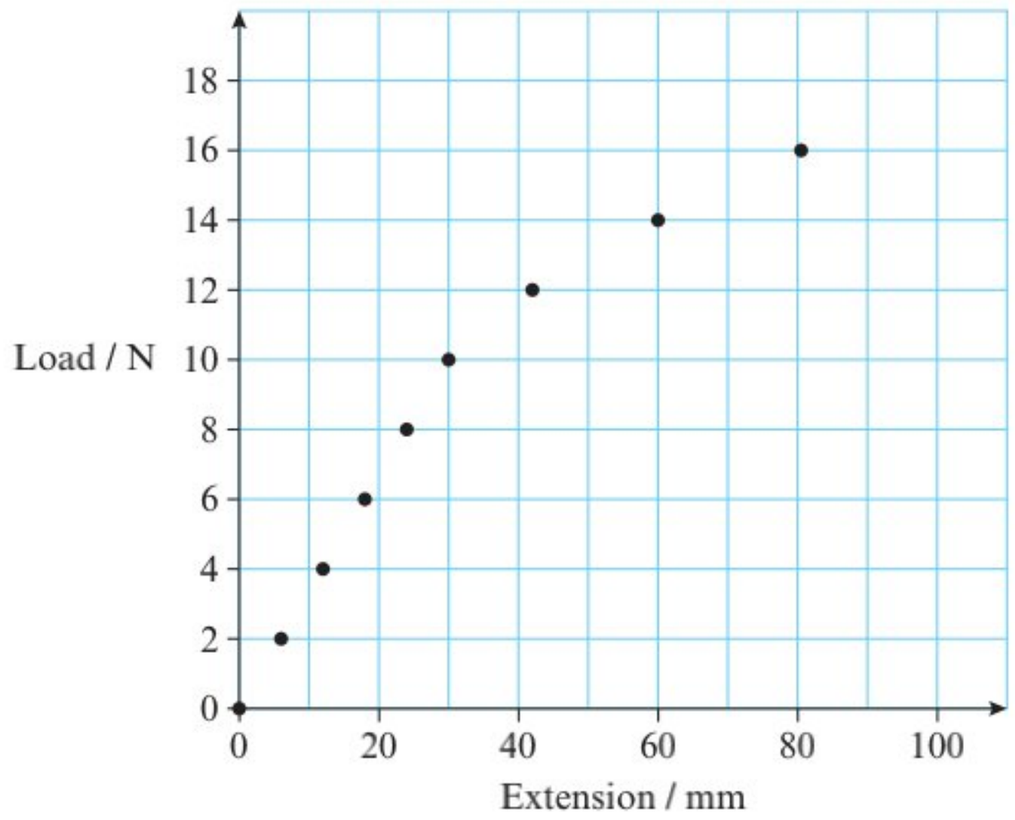
Chapter 5

Questions

1 22 cm

2

Load / N	Extension / mm
0	0
2	6
4	12
6	18
8	24
10	30
12	43
14	60
16	81

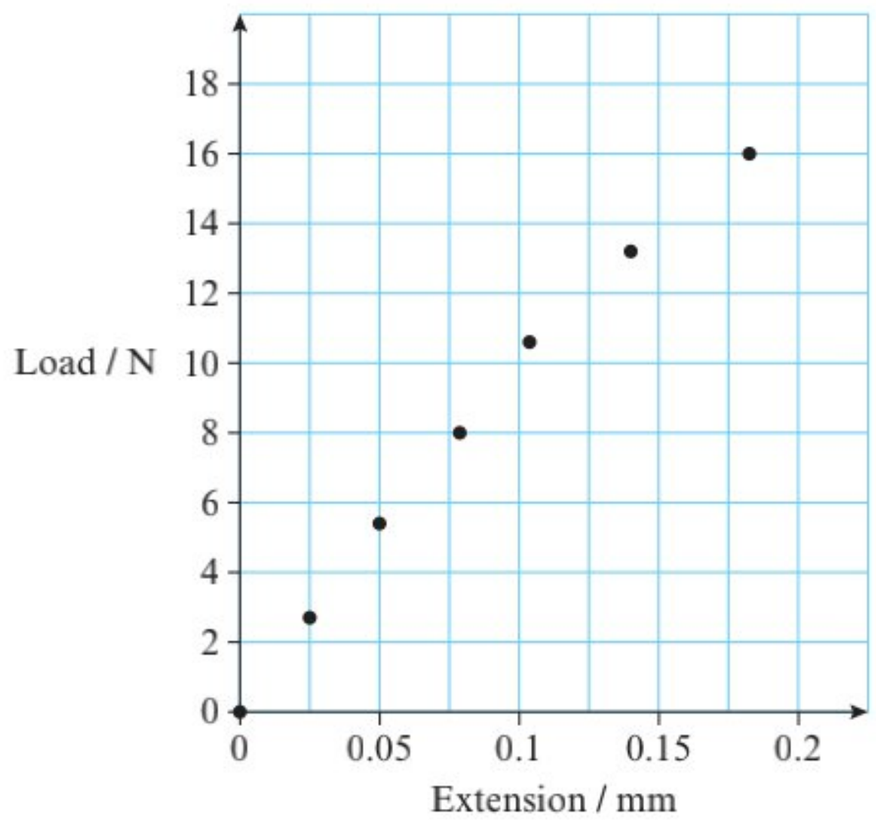


3 18 N

4 35 N

5

Load / N	Extension / m
0	0
2.6	0.026
5.3	0.052
7.9	0.079
10.6	0.105
13.2	0.140
15.9	0.183



6 $p = \frac{F}{A}$

7 pascal, Pa

8 200 N acting on 1.0 m^2

9 2×10^4 Pa

10 1.88×10^6 N

11 **a** $W = mg$

b $p = \frac{F}{A}$

c elephant: 50 000 N, 3.85×10^5 Pa; woman: 600 N, 2.4×10^7 Pa

d If the woman puts all of her weight on one stiletto heel, she would exert a bigger pressure than an elephant.

12 2.5×10^5 Pa

13 **a** $3\,m^3$

b 2.76×10^4 N

c 9.2×10^3 Pa

d 9.2×10^3 Pa

14 **a** 5×10^6 N

b The roof does not collapse because there is an equal balanced force acting upwards on the roof. The pressure in a fluid acts in all directions (including upwards) and, because the roof is at the same 'depth' of atmosphere, the pressure will be virtually the same above and below the roof.

c The roof would probably collapse because it would not be designed to carry as much weight as calculated in part **a**.

15 1.5 m

Exam-style questions

1 A; **[1]**

2 A; **[1]**

3 B; **[1]**

4 A; **[1]**

5 **a** The weight of the air above us; **[1]**

b $\triangle p = \rho g \triangle h$; **[1]**

c 7.69×10^3 m (7.69 km); **[1]**

d Air density decreases with height; **[1]**

6 **a** The weight of water is great in butt A; **[1]**

b $6.37 \times 10^{-2}\,m^3$; **[1]**

c **i** $m = \rho V$; **[1]**

ii 63.7 kg; **[1]**

d **i** $W = mg$; **[1]**

ii 637 N; **[1]**

e **i** $P = \frac{F}{A}$; **[1]**

ii 9100 Pa; **[1]**

f **i** $\triangle P = \rho g \triangle h$; **[1]**

ii 9100 Pa; **[1]**

g **i** Final depth = 62.5 cm so students should draw a line showing the *same* depth of water in both butts, half-way between the original depth in A and the original depth in B;

ii When the water level is higher, the pressure at the bottom of the butt is higher. Because the tubing has a constant cross-sectional area A, the force F pushing water along tubing will be proportional to p (from $F = pA$). As long as the water in butt A is at a higher level, the force of water from butt A will exceed the force of water from butt B and water will flow from A to B until the levels are equal. When the levels are equal, the forces of water being pushed into the tubing from both butts will be equal and the water stops flowing; **[3]**

7 **a** $P = F/A = 50\text{ N} / 2 \times 10^{-4}\,m^2 = 2.5 \times 10^5$ Pa; **[2]**

b $F = pA = 2.5 \times 10^5\text{ Pa} \times 40 \times 10^{-4}\,m^2 = 1000$ N; **[2]**

Chapter 6

Questions

1 kinetic energy

2 gravitational potential energy; an object can gain g.p.e. by being raised.

3 strain energy or elastic potential energy

4 Both are at the same temperature but steam has more internal energy (because the molecules are further apart)

5

Energy stores	Example
kinetic energy (k.e.)	A moving object (e.g. car)
gravitational potential energy (g.p.e.)	a raised object (for example, lifting an object into overhead locker)
chemical energy	cell, battery, food, fossil fuel
elastic (strain) energy	catapult ready to fire
nuclear energy	nuclear fuel
internal energy	technically, anything warmer than absolute zero

6

Physical clue	Which energy store is changing?
material changing shape	elastic
object changes speed	kinetic
chemical reaction	chemical
change of temperature	internal
nuclear fission or fusion	nuclear
distance between objects changes	gravity

7 a chemical (store) → thermal energy (transfer) → internal energy of surroundings (store)

b electrical (transfer) → increases internal energy (store) of light bulb → light radiation (transfer) + thermal radiation (transfer)

c electrical energy (transfer) → kinetic energy (store) + thermal energy (transfer) + sound (transfer)

8 a 60 J

b 56 J

9 a thermal

b sound

10 Energy is expensive, supplies are often limited, and our use of energy can damage the environment.

11 Electrical energy transferred to the mobile phone cell/ battery. This also raises the internal energy store of the cell/ battery and the phone and this is transferred to the surroundings as thermal energy.

12 60%

13 32%

14 150 J

15 a increasing

b constant

c decreasing

16 2×10^5 J

17 800 m

18 velocity (speed)

19 1605 J

20 6.2×10^3 J

21 wasp

Exam-style questions

1 **a** P; [1]

b Q; [1]

c B; [1]

2 [2]

Description	Energy	
energy of a moving object	kinetic energy	store
energy stored in a hot object	internal energy	store
energy stored in a fuel	chemical	store
energy that we can see	light	transfer
energy stored in a squashed spring	strain	store
energy carried by an electric current	electrical	transfer
energy stored in the nucleus of an atom	nuclear	store
energy escaping from a hot object	thermal	transfer

3 **a** thermal energy; [1]

b efficiency; [1]

c conservation; [1]

4 **a** waste energy = energy input – useful energy output; [1]

b efficiency = $\frac{\text{useful energy output}}{\text{energy input}} \times 100\%$; [1]

5 **a** $E_k \times \frac{1}{2}mv^2$; [1]

b 3.61 J; [2]

c 3.61 J; [1]

d 7.69×10^{-2} m (7.69 cm); [2]

e how far it swings horizontally; [1]

f it was transferred into the internal energy of the block and then radiated as thermal energy; [1]

6 **a** 312 J; [1]

b 67%; [1]

c 4.1%; [1]

d thermal energy; [1]

Chapter 7

Questions

1 The Sun heats some parts of the Earth's surface more than others. The surface warns the air above it so that some parts of the atmosphere are warmer than others. Heated air expands and moves – this is a convection current (see Chapter 11). This is the origin of winds.

2 **Solar panels** are used to collect energy from the Sun to heat water. Solar cells use solar energy to generate electricity.

3 Advantages: solar power is becoming cheaper; it can be used in remote locations (away from the electricity grid).

Disadvantages: unreliable (does not produce power when you want it); diffuse (needs a large area of land or roof space to generate power).

4 Chemical (potential).

5 When we burn biomass, we are releasing energy that came from the Sun in the recent past. In the case of trees, the energy might have been captured ten or a hundred years ago. Manure might be from food that captured energy a few days or months before. When we burn coal, the energy released is from sunlight trapped by trees hundreds of millions of years ago.

6 Fossil fuels are the remains of organisms (plants and animals) that lived in the past. Many of the Earth's coal reserves, for example, formed from trees that lived in the Carboniferous era, between 286 and 360 million years ago. These trees captured sunlight by photosynthesis, they grew and eventually they died. Their trunks fell into the swampy ground, but they did not rot completely, because there was insufficient oxygen.

7 Advantages: relatively cheap; concentrated energy resource.
Disadvantages: Expensive because of the initial cost of building the power stations and the costs of disposing of the radioactive spent fuel and decommissioning the stations at the end of their working lives. It also gets a bad press because of accidents (Chernobyl, 1986; Fukushima Daiichi, 2011).

8 Kinetic energy

9 A hydroelectric power station stores gravitational potential energy in the same way that a cell (or battery) stores chemical (potential) energy. Electrical energy cannot be stored unless it is transformed into another form of energy. By having turbines that can be reversed, water can be pumped up to the reservoir so that off-peak (and cheap) electrical energy can be transformed into gpe that can be changed back to electrical energy when demand is higher.

10 C

11 D

12 A plasma is a gas of positive nuclei and electrons.

13 Gravity confines the plasma in a star. In a tokamak the plasma will be confined by magnetic fields.

14 Nuclear fusion will have an almost limitless supply of fuel and will not produce nuclear or other waste or greenhouse gases that lead to global warming.

15 Nuclear fusion is when the nuclei of atoms fuse (join together) and fission is when a heavy nucleus splits into two or three smaller nuclei.

Exam-style questions

1 B; [1]

2 D; [1]

3 A; [1]

4 C; [1]

5

Energy resource	Non-renewable	Renewable
wave power		✓
hydroelectricity		✓
geothermal		✓
coal	✓	
nuclear energy	✓	
oil	✓	
solar energy		✓
natural gas	✓	
tidal energy		✓
wind energy		✓

[2 for 3 non-renewable correct, 1 for 2 correct; 2 or 3 renewable correct, 1 for 2 correct]

6 a gravitational potential energy → kinetic energy → energy transferred by electricity; [1]

b Sunlight drives the water cycle. In more detail, solar energy warms up the surface of a body of water (e.g. the sea). This causes some water to evaporate. The air above the water warms up so expands, which makes it less dense. This makes the warm, moist, air rise. As the air rises, it cools and the water vapour condenses (into clouds). These clouds are blown by the wind and they release rain. Some of this rain ends up in reservoirs.

c When demand is low (and electricity is cheap), water can be pumped up a mountain to a reservoir. **[1]** When demand is higher, water is allowed to flow to turn the turbines and generate electricity; **[1]**

7 a Wind power is renewable; [1]

b Wind is an unreliable source of energy because the wind is not always blowing when there is demand for electricity; [1]

There would need to be 1250 turbines to generate the same power output as the coal-fired power station. This would lead to a large area being covered with turbines; [1]

8

Factor	Solar	Geothermal
location	Is proposed location close to population (otherwise energy is wasted in transit)? Latitude – intensity of sunlight higher near the equator as Sun is higher in the sky Big enough area for a panels?	Is proposed location close to population (otherwise energy is wasted in transit)? Geology – tectonically active area (like Iceland) with hot rocks?
climate	Seasonal variation – better closer to the equator as less variation in the hours of sunlight. Is location on a storm track or is there a rainy season (e.g. monsoon) that can reduce the intensity of sunlight?	Unaffected by weather/ climate.

[4, 1 point from each cell of the table]

9 a Tidal; geothermal; nuclear; [1]

b Tidal might stop working as water freezes; [1]

Chapter 8

Questions

1 The force is acting at right angles to the motion of the Earth. For work to be done, the motion needs to be in the direction of the force.

2 12.5 kJ

3 a gravity 1 N
b 6 J
c g.p.e. to k.e.

4 a 704 J
b 520 J
c When sliding the washing machine up the ramp, work has to be done against friction so some energy is dissipated (wasted) as thermal energy.
d 74%

5 He could lift each brick more quickly or he could lift more than one brick at a time. In other words, he could do more work or he could work more quickly.

6 a 1000 or 10^3
b 106

7 a 1.497×10^4 kg
b 1.497×10^5 N
c 4.56×10^4 J
d 760 W

8 a 10 450 000 or 10.45 MJ
b 121 W

9 144 kJ but the brain has done no mechanical work because it has not moved anything.

10 100 W

11 increased

Exam-style questions

1 D; [1]

2 B; [1]

3 B; [2]

4 a more; [1]
b more; [1]
c energy; [1]
d work; [1]

5 a 625 N; [1]
b work done = force × distance (in the direction of the force); [1]
c 2×10^5 J; [2]
d power = energy transferred ÷ time taken; [1]
e 349 W; [1]

6 a The fact that the platform is higher than the tracks in the tunnels means that less braking is required and less energy is required by the motor. As the train climbs the slope to the platform, less kinetic energy is dissipated as thermal energy when using the brakes. Instead, some of the energy is transformed into gravitational potential energy, which will be available when the train leaves the platform. As the train leaves the platform less electrical energy is required by the motor because the gravitational potential energy is transformed into kinetic energy as the train descends to the level of the tunnels; [2]

b i $E = \frac{1}{2}mv^2$; [1]
ii 24.6 m/s; [2]

Chapter 9

Questions

1 solid, liquid, gas; volume; volume; space; melts, liquid; melting point; liquid, gas.

2 **a** boiling point (or condensing point)
b solidification or freezing
c freezing point or melting point

3 A liquid takes up the shape of a container without its volume changing.

4 Diagrams similar to Figure 9.9

5 **a** solid
b gas
c gas

6 **a** Brownian motion is the motion of small particles suspended in a liquid or gas, caused by molecular bombardment.
b Kinetic theory says that the molecules in a liquid or gas are constantly moving. This movement causes them to hit small particles such as smoke, causing them to constantly change direction.
c The particles would move more slowly and change direction less frequently in the colder experiment, because the air molecules would be slower so would hit them less often and with less force.

7 Molecules in liquids and gases are free to move so we can push them aside as we pass through. In a solid, the particles are held together and so do not move apart.

8 gas, pressure, faster, increases, increases

9 The air particles will move more slowly. They will hit the walls of the balloon with less force and less often. The pressure on the balloon will decrease and so it will partially deflate.

10 **a** Speed increases.
b They hit the walls more often.
c They hit the walls with more force.
d The pressure increases.

11 temperature, degrees Celsius, molecules

12 Place the thermometer in melting ice, mark the position of the liquid as 0 °C then place it in boiling water and mark this position as 100 °C. Divide the space in between the two marks into 100 equal parts. Each part is one degree.

13 **a** 293 K
b 1073 K
c 40 K

14 p_1 = pressure at the start, V_1= volume at the start, p_2 = pressure after the change, V_2 = volume after the change

15 3 dm^3

16 2 litres

Exam-style questions

1 A; **[1]**

2 C; **[1]**

3 Solid: particles are in fixed positions **[1]** and only vibrate around these positions. **[1]** Liquids: particles are free to move **[1]** but remain close together. **[1]** Gas: particles are very spread out **[1]** and move completely freely; **[1]**

4 **a** The particles move in a random manner / frequently change direction; **[1]**
b Air molecules; **[1]**
c The kinetic model says are molecules are moving. **[1]** The movement of the smoke particles can be explained by them being bombarded by air molecules; **[1]**

5 **a** 5 cm^3; **[1]**
b The pressure increases **[1]** because the particles are now hitting the walls of the syringe more frequently; **[1]**
c The air molecules have heated up and so move faster **[1]** causing the gas to expand; **[1]**

6 **a** The air particles are moving faster because they are hotter. **[1]** This means they hit the walls more frequently and with more force; **[1]**
b $p_1V_1 = p_2V_2$ **[1]**
2.5 atmospheres × 1200 cm^3 = 1 atmosphere × V_2; **[1]**
V_2 = 3000 cm^3; **[1]**
1200 cm^3 of air will remain in the tyre, 1800 cm^3 will escape from the tyre. **[1]**
Allow 3000 cm^3 for 2 marks (this is the volume of air at 1 atmosphere, but not all will leave the tyre).

Chapter 10

Questions

1 expands, contracts, solids, gases, metals, bend

2 When it is hot the bridge expands and rolls to the right. In the cold it contracts and rolls left.

3 The water would freeze so the thermometer would not work.

4 a ethanol

b Ethanol expands most so will make the thermometer easiest to read. It is also safe if the thermometer is broken.

5 a gold

b J/kg °C

c 840 J

d 8400 J

6 a 1155 J

b 34 650 J

7 a 21 420 J

b 167 450 J

c 188 870 J

8 a 4500 J/kg °C

b It is higher than the given value. Some of the energy is needed to heat the kettle and the surroundings.

9 A Ice is warming up. B ice is melting.
C Water is warming up. D Water is boiling.
E Temperature of water vapour is rising.

10 69 °C

11 Air is a mixture. Each gas has different melting and boiling points so the changes do not happen at one temperature.

12 a evaporation

b fastest, cooler

13 Initially the particles are in fixed positions and the vibrate around these positions. As the ice is heated, they vibrate more until they reach the melting point. At this point they have enough energy to break free and move freely, although attractive forces still hold them together.

14 Forces between tungsten atoms are stronger than forces between iron atoms.

15 a It is melting.

b Energy is required to break bonds between particles (it increases their potential energy).

16 Unfolding the towel increases the surface area, sun increases the temperature and wind provides a draught. These three factors all increase the rate of evaporation.

17 The water from the damp cloth will evaporate and will take the latent heat energy it needs from the milk.

Exam-style questions

1 C; **[1]**

2 A; **[1]**

3 C; **[1]**

4 a The molecules are initially close together and vibrating about fixed positions; **[1]** as it is heated they move faster **[1]** and move from their fixed positions; **[1]**

b 960 °C; **[1]**

c 3 minutes; **[1]**

5 a brass; **[1]**

b The bar will bend **[1]** downwards **[1]** so completing the circuit so that the bell rings; **[1]**

6 a evaporation; **[1]**

b Energy is needed to break the bonds between the particles; **[1]**

c A draught increases the rate of evaporation; **[1]**

7 a 156 000 J; **[1]**

b 156 000 J ÷ (0.42 × 70) **[1]** = 5310 J/kg °C; **[2]**
Allow 1 mark if not rounded i.e. 5306 J/kg °C;

c Too high **[1]** because some of the energy is going to the bowl, not the beans; **[1]**

d The spaghetti will cool quicker **[1]** as it does not store as much heat energy as the beans; **[1]**

Chapter 11

Questions

1 solids, hotter, cooler, insulator, polystyrene

2 A metal spoon would conduct thermal energy from the soup to your hand. The wooden spoon does not conduct thermal energy so stays cools and easy to hold.

3 Marble is a better conductor than wood so more thermal energy would flow from your feet to the marble, cooling your feet down.

4 Air is a very poor conductor. The layer of air trapped between the clothes will reduce the loss of thermal energy from the body.

5 a Copper is a metal and so contains free electrons which carry thermal energy through the metal.

b Wood is solid so the particles are close and in fixed positions which allows vibrations to be passed on. Air is a gas, so its particles are far apart and do not pass on thermal energy easily.

6 Arrow drawn going upwards and labelled 'hot, less dense water' above the heat; arrow going down on the opposite side of the pan, labelled 'cold dense water'

7 Arrows showing cold water sinking below the ice and warm water rising at the sides.

8 The water at the top will heat up and become less dense so it will stay at the top and the water at the bottom will stay cold.

9 a Diagram for hot gas shows fewer particles than for the cold gas. The particles in the hot gas also have longer arrows to indicate faster movement.

b As the gas is heated its particle gain energy and move faster and further apart so the gas expands. This decreases the density of the gas and it rises.

10 Convection cannot happen in a solid because the particles are not free to move.

11 C

12 Space is a vacuum which means there are no particles. Both conduction and convection require particles for thermal energy to be transferred.

13 The engine and the wheels are glowing yellow which means they are still hot.

14 The shiny suit will reflect heat radiation away, keeping the worker cool.

15 A shiny teapot reflects the heat back into the tea/emits less radiation so the tea stays hot. The dark teapot emits a lot of heat radiation so the tea cools.

16 a The rollers are metal and are in contact with the hot metal so are heated by conduction.

b The glowing metal is very hot so emits a lot of heat radiation which heats the worker.

c The hot metal heats the air around it causing convection currents which heat the building.

17 The coat is padded so traps air which is a good insulator. The air in the padding cannot move so this prevents loss of thermal energy by convection. The silver lining will reflect heat radiation back to the person's body.

18 a It is painted black to absorb the maximum amount of infrared radiation from the sun.

b The back is insulated to reduce heat loss by conduction.

c Cold water enters at the bottom so that as it is heated, it will rise due to convection. It leaves from the top because this is where the water is hottest.

Exam-style questions

1 D; **[1]**

2 B; **[1]**

3 C; **[1]**

4 a conduction; **[1]**

b Water at the bottom is heated and so it expands **[1]**. The hot water rises [1] and is replaced by cold water which is then heated; **[1]**

c Add insulation; **[1]**

5 a Which metal is the best conductor? **[1]**

b Copper **[1]** because it is the best conductor; **[1]**

c Any two from: use rods of the same length. Use rods of the same thickness. Attach the drawing pins at the same distance from the Bunsen. Ensure all rods are heated equally; **[2]**

6 a So that there is only one independent variable – the surface; **[1]**

b Matt black: 71.2 °C; **[1]** matt white: 64.5 °C; **[1]** shiny silver: 60.4 °C; **[1]**

c Zain's results will be less precise. **[1]** He will not be able to tell which of shiny black or matt white would emit most as both would be recorded as 65 °C; **[1]**

7 a Plastic is a good insulator; **[1]**

b conduction, **[1]** convection **[1]**

Two of:

Type of insulation		Reduces heat loss by:	
loft insulation	**[1]**	convection	**[1]**
cavity wall	**[1]**	conduction	**[1]**
cavity wall insulation	**[1]**	conduction and convection	**[1]**
draught excluders	**[1]**	convection	**[1]**

8 a A would cool down **[1]** B would warm up; **[1]**

b A is warmer than its surroundings so radiates more energy than it absorbs. **[1]** B is cooler than its surroundings so absorbs more energy than it radiates; **[1]**

c It has stayed at a constant temperature so must be absorbing and radiating equal amounts of energy. **[1]** This means it is at the same temperature as its surroundings; **[1]**

Chapter 12

Questions

1 vibrations

2 drum: drumskin; flute: column of air; violin: strings

3 The drummer hits the skin causing it to vibrate. This makes the surrounding air vibrate. The vibrations pass through the air causing the eardrum to vibrate.

4 There are no particles to vibrate so sound cannot travel.

5 The bell is initially loud but as the air is pumped out the sound becomes quieter until it cannot be heard as there are no particles to carry the sound wave.

6 3 km

7 396 m

8 Salt water is more dense.

9 The microphones record the sound immediately whereas a human with a stopclock has a reaction time

10 20–20 000 Hz

11 The range gets smaller. Exposure to very loud sounds can also have this effect.

12 a 1 as it has the smallest amplitude

b 1 and 2. They have the same frequency (the same number of waves can be seen on the screen).

13 a 375 m

b 150 m

c The fish are at different depths so there are lots of small echoes rather than one distinct one.

Exam-style questions

1 A; **[1]**

2 B; **[1]**

3 D; **[1]**

4 a The number of vibrations or waves per second; **[1]**

b hertz; **[1]**

c ultrasound; **[1]**

d B is louder **[1]** and higher pitched than A; **[1]**

5 a vibrations pass through the air; **[1]**

b longitudinal; **[1]**

c Have an electric bell ringing in a jar; **[1]** Remove the air and you can no longer hear the sound; **[1]**

6 a 2250 m

b 1.2 s

c 5800 m/s

Chapter 13

Questions

1 **a** So that it can easily be read in the rear-view mirror of a car.

b ƎƆILOd

2 **a** 30° (the angle of reflection for 60°).

b She may have measured the angle to the surface rather than to the normal or misread her protractor.

3 Diagram similar to Figure 13.5 but with the angles of incidence and reflection both drawn and marked as 40°.

4 45°. Diagram should show a ray hitting a mirror at 45° and therefore being turned through 90°.

5 **a**, **b** Diagram should be similar to Figure 13.9d

c 6 cm

6 **a** The first mirror reflects the light straight down to the second mirror which reflects it towards the eye. The light turns through 90° at each mirror.

b The light is reflected twice. The first mirror inverts left to right and the second inverts it back.

7 **a** Ray bends towards the normal

b Ray bends away from the normal.

8 The normal is always straight. The boundary could be curved, and this would make measuring the angle difficult.

9 Diagram showing ray passing from glass to air and bending away from the normal. Incident and refracted rays and angles, and the normal all labelled.

10 The light is refracted when it leaves the water. It bends away from the normal. The observer assumes that the light travelled in a straight line, and therefore sees the lamp higher – shown by the dashed ray and lamp.

11 1.52

12 **a** refractive index, $n = \sin i / \sin r$

b A measure of how much light is bent or slowed down by a material. It is a ratio of the two speeds so the units cancel out.

13 **a** it decreases

b One side of the ray enters the glass and is slowed down before the other side. This causes the ray to bend.

c All of the ray enters the glass, and is slowed down, at the same time.

14 **a** $i = 50°$, $r = 31°$

b 1.5

15 Glass has a lower refractive index than diamond so the ray will bend away from the normal.

16 **a** 34.7°

b 197 000 000 m/s

17 Total because all the light is reflected; reflection because the light is reflected back into the material.

18 No, because TIR only happens when the angle of incidence is greater than the critical angle.

19 **a** x = angle of incidence, y = angle of reflection, z = angle of refraction

b $x = y$, $c > a$, $\sin x / \sin r$ = refractive index, $x <$ critical angle

c As x increases, y will increase too and these will have the same value. z will also increase. Eventually when x = the critical angle for the material the ray will be totally internally reflected.

20 Endoscopy, communications, therapeutic play.

21 **a** 1.62

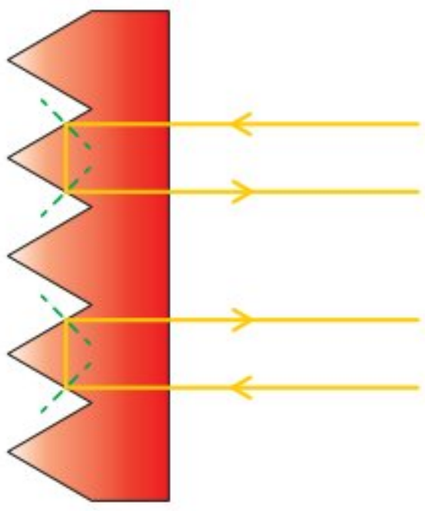
b 24.6°

22 A diagram similar to Figure 13.29b.

23 **a** It enters along the normal.

b 45°

c



d It is less than 45°

24 principal focus, focal length, shorter

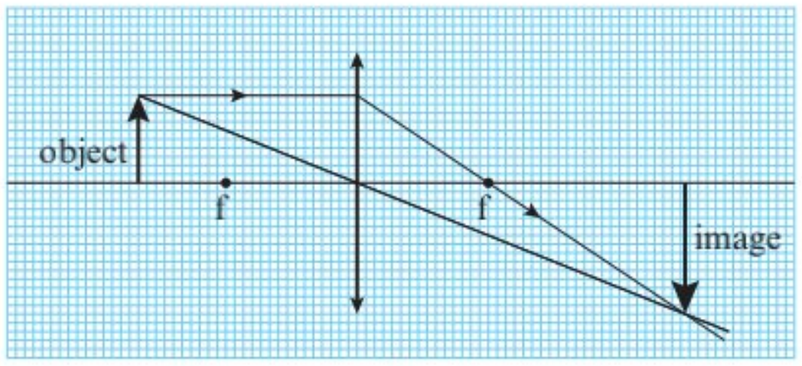
25 **a** Diagram shows rays converging at the principal focus on the right of the lens.

b Diagram shows converging at the principal focus on the right of the lens, but closer to the lens than for part a.

c Diagram shows ray carrying on in a straight line through the lens.

26 No real rays of light come from behind the object.

27 **a**



b distance 7.5 cm, height 3 cm

28 **a** long sight

b The eyeball is too short or the lens cannot become strong enough so the rays meet behind the retina.

c Converging lens added in front of the eye, similar to Figure 13.44b.

29 refraction, less, dispersion

30 Diagram showing light refracting towards the normal as it enters the prism and away from the normal as it leaves. Emerging light is dispersed and the colours red and violet should be labelled.

31 red, orange, yellow, green, blue, indigo, violet

Exam-style questions

1 D; **[1]**

2 C; **[1]**

3 A; **[1]**

4 **a** focal length; **[1]**

b Ray drawn from the top of the object parallel to axis. **[1]** This ray bends to pass through the principal focus on the right. **[1]** Inverted arrow drawn at the point where rays cross; **[1]**

c diminished, **[1]** inverted; **[1]**

5 **a** It is travelling along the normal; **[1]**

b The ray is reflected so it travels vertically down; **[1]**

c total internal reflection; **[1]**

d a plane mirror; **[1]**

6 **a** Ray reflected into block at the same angle. **[1]** Ray refracted away from normal as it leaves the glass; **[1]**

b It is less than 300 000 000 m/s; **[1]**

c $n = 1/\sin c$; **[1]**

d 1.49; **[1]**

e 74°; **[2]**

7 **a** Lens drawn with axis and principal foci marked. **[1]** Ray striking centre of lens and passing straight through. **[1]**] Ray parallel to axis refracted through *f*. **[1]** Both rays continued back until they meet.**[1]** Upright image drawn where rays meet; **[1]**

b It is not formed by real rays; **[1]**

Chapter 14

Questions

1 a energy, matter
b transverse, longitudinal

2 a the same.
b different
c dimmer

3 Wavelength drawn from one crest to the next or one trough to the next. Amplitude drawn from rest position to a crest or trough.

4 Longitudinal – sound. Transverse – light, water or any electromagnetic wave.

5 4 cm

6 a 5 Hz
b 0.2 seconds

7 a Light travels faster than sound.
b i transverse, at right angles to, can
ii longitudinal, parallel to, cannot
c 990 m

8 v is wave speed (or velocity) in m/s; f is frequency in Hz; λ is wavelength in metres

9 1.5 m/s

10 a 330 m/s
b sound
c 0.0009 seconds

11 The longer pipes fit waves with a longer wavelength. Long wavelength means low frequency, so a low pitched note.

12 90 000 kHz

13 a speed increases
b wavelength increases
c frequency stays the same
d period stays the same

14 a The waves diffract as they pass through the doorway creating semicircular waves which reach person B.
b longitudinal

15 a waves reflect upwards; reflection
b waves get closer together; refraction
c waves get closer together and bend towards the normal; refraction
d waves spread to make semicircles; diffraction

16 Sound waves have a similar wavelength to the width of a door, so they are diffracted. Light waves have a much smaller wavelength, so the diffraction is negligible.

17 The longer wavelength waves are diffracted as their length is similar to the size of the mountain. The short waves are not diffracted significantly.

18 The waves form circular wave fronts as they pass through the gap.

Exam-style questions

1 B; **[1]**

2 C; **[1]**

3 B; **[1]**

4 a decreases; **[1]**
b decreases; **[1]**
c stays the same; **[1]**
d stays the same; **[1]**

5 a 2 m; **[1]**
b They have measured from a crest to a trough, not to the rest position. **[1]**
20 cm; **[1]**
c Similar to the diagram, but the peaks and troughs only reach to 10 cm; **[1]**
d The bird moves up and down **[1]** but does not move in the direction of the wave; **[1]**
e These waves are in shallower water; **[1]**

6 a 300 000 000 m; **[1]**
b 3 m; **[1]**
c The longer wavelengths are diffracted round the hill **[1]**. Shorter wavelengths are not diffracted significantly; **[1]**

7 a amplitude; **[1]**
b 60 cm; **[1]**
c $v = f\lambda$ **[1]** = 60 Hz × 0.6 m = 36 m/s; **[1]**
d i transverse; **[1]**
ii longitudinal; **[1]**

8 $f = 1 / T$ **[1]** = 1 / 0.58 s = 1.72 Hz; **[1]**
$v = f\lambda$ **[1]** = 1.72 Hz × 0.22 m = 0.38 m/s; **[1]**

Chapter 15

Questions

1 Drawing of two waves, one with a longer wavelength than the other. The longer wave should be labelled red and the shorter wave violet.

2 a gamma rays, X-rays, UV, visible light, IR, microwaves, radio waves.

b radio waves, microwaves, IR, visible light, UV, X-rays, gamma rays.

3 The light is refracted but not dispersed. Monochromatic light is of only one wavelength so all the light is refracted equally.

4 5.6×10^{14} Hz

5 infrared and microwaves

6 infrared, X-rays and gamma rays

7 Microwaves carry her mobile phone signal; visible light lets her see the TV; infrared from the fire warms her and infrared is also used in the tv remote control; radio waves carry the TV signal.

8 The radiographer is working with X-rays all day so the cumulative effect would be much greater than for the patient.

9 Scientists have not proved that the microwaves used by phones are harmful, but this is not the same as proving that they are harmless.

10 a geostationary

b low earth orbit

c low earth orbit

11 Data can be transmitted at a faster rate. The signal can be regenerated.

Exam-style questions

1 C; **[1]**

2 B; **[1]**

3 C; **[1]**

4 a red light; **[1]**

b violet light; **[1]**

c infrared radiation; **[1]**

d ultraviolet; **[1]**

e Same speed in a vacuum *or* can be reflected, refracted or diffracted *or* are transverse waves *or* are part of the electromagnetic spectrum; **[1]**

f different wavelength/frequency; **[1]**

5 a gamma rays X-rays ultraviolet blue light yellow light red light infrared microwaves radio waves

All 6 correct for **[2]** or 5 correct for; **[1]**

b infrared **[1]**, microwaves; **[1]**

c gamma rays; **[1]**

d visible light **[1]**, infrared; **[1]**

6 a 700 Nm = 7×10^{-7} m **[1]** $v = f\lambda$ so $\lambda = v / f$ **[1]** = $3 \times 10^8 / 7 \times 10^{-7} = 4.3 \times 10^{14}$ Hz; **[3]**

b longer; **[1]**

Chapter 16

Questions

1 iron, cobalt, nickel

2 Unlike poles attract; like poles repel

3 See Table 16.1

4 Steel is a hard magnet and iron is a soft magnet.

5 a Diagram should be like Figure 16.8.
b The arrows point away from the magnetic north pole.
c at the poles
d Where the field lines are closest together.

6 a the Earth's magnetic field lines
b magnetic south pole
c geographic North Pole; because the field lines are closer together
d The field lines point into the Earth so the compass needle points downwards into the ground.

7 a Increasing the current flowing; through it, increase the number of turns of wire on the coil; add a soft iron core.
b The strength of an electromagnet can be changed and it can be switched on and off.
c A supply of electricity/electric current.

8 a Diagram should be like Figure 16.11
b The north and south poles would switch.

Exam-style questions

1 D; **[1]**

2 A; **[1]**

3 C; **[1]**

4 a Diagram should be like Figure 16.8; **[2]**
b You will need a bar magnet, plotting compass, pencil and plain paper.
1 Place a bar magnet in the centre of a sheet of paper and draw round it.
2 Place a plotting compass near one of the poles of the magnet. Mark dots 1 and 2 on the paper to indicate the two ends of the compass needle, as shown in the figure.

3 Move the compass away from the magnet and position it so that one end of its needle is marked by dot 2. Mark dot 3 at the other end.
4 Continue this process, until you have moved round to the other pole of the magnet or until you have gone off the page.
5 Remove the compass. The sequence of dots shows one of the field lines of the magnet's field. Draw a smooth line through the dots.
6 Repeat the process, starting at a slightly different position near the end of the magnet to obtain at least 10 field lines (including at least two from each side of the magnet); **[3]**

5 a north; **[1]**
b The magnets will move towards each other; **[1]**

6 a Student's own graph. Current plotted on *x*-axis and force on *y*-axis and labelled. **[1]** Pointed plotted correctly. **[1]** Line of best fit drawn through the points that goes through the origin; **[1]**
b The strength of the electromagnet increases with the current passing through it; **[1]**
c Increase the number of turns; **[1]** include a soft iron core; **[1]**
d When using the electromagnet to move objects such as cars in a scrapyard; **[1]**
e The weight of the steel plate exceeds the magnetic force of attraction between the steel plate and the electromagnet; **[1]**

7 a A magnetically hard material retains magnetism well but is difficult to magnetise in the first place. A magnetically soft material is easy to magnetise but readily loses its magnetism; **[1]**
b Magnetically hard materials include bar magnets; which can be used as compass needles; **[1]**
c Magnetically soft materials include soft iron cores; which can be used in electromagnets; **[1]**

Chapter 17

Questions

1 positive, negative; repel, attract

2 a Friction between the child and the trampoline causes static electricity.

b The hairs must all have the same charge.

3 Friction with the carpet causes you to become charged. The charge flows through you and into the metal handle.

4 electrons, cloth, rod; negative, positive

5 a Diagram similar to Figure 17.8, but showing that the rod has lost electrons and the cloth has gained them.

b When an acetate rod is rubbed, electrons move from the rod to the cloth. This means that the rod becomes positively charged and the cloth becomes negatively charged.

6 Polyethene is an insulator so electrons are tightly held in atoms so do not move. This means that charge can build up. Metal is a conductor so there are free electrons which will flow through the rod, then through your hand and body to Earth.

7 a Equally spaced lines with arrows pointing towards the negative charge (as in Figure 17.10b).

b Straight lines between the plates with arrows going from positive to negative (as in Figure 17.10c).

8 6.25×10^{18} electrons

Exam-style questions

1 D; **[1]**

2 B; **[1]**

3 D; **[1]**

4 A; **[1]**

5 a The strips have the same charge **[1]** and so they repel each other; **[1]**

b The rods will not move **[1]** they are conductors and so do not become charged; **[1]**

c negatively **[1]**, electrons **[1]**, cloth **[1]**, rod; **[1]**

d B;

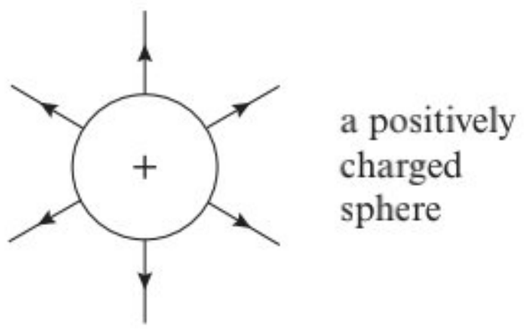
6 a Negatively charged particles are transferred **[1]** from the hair to the comb; **[1]**

b electrons; **[1]**

c All his hairs have the same charge (positive) **[1]** so they repel; **[1]**

7 a the area around a charged object in which a charge will experience a force; **[1]**

b



For each diagram, lines drawn correctly **[1]**, direction of arrows correct; **[1]**

8 a Electrons are transferred **[1]** from the balloon to the cloth; **[1]**

b It is positively charged. **[1]** It is repelling the balloon pushing it down and adding to the force on the balance; **[1]**

c The charge on the balloon is conducted away though the metal pan. **[1]** The balloon is now uncharged and so is attracted to the charged rod. **[1]** The overall force on the balance is smaller; **[1]**

9 a The droplets of paint will become positively charged. **[1]** They will be repelled by the paint gun towards the fence; **[1]**

b The paint droplets repel each other, so this gives a very fine cloud of paint. **[1]** This gives an even coating of paint on the fence; **[1]**

c negative; [1]

d When an aircraft is being refuelled, charge can build up in the fuel as it passes through the pipes; [1]

Chapter 18

Questions

1 a ammeter
b in series (in line)
c a circle containing a capital A, as shown in Figure 18.5

2 a Circuit similar to Figure 18.5, with a second ammeter on the left-hand side of the circuit.
b Arrows go from the long end of the cell, as in Figure 18.5.
c same

3 a most metals (for example, copper); graphite
b most non-metals (for example, glass, Perspex)

4 a from the positive to the negative terminal
b from the negative to the positive terminal

5 a ampere (often abbreviated to amp); symbol = A
b coulomb; symbol = C

6 a 10^3 or 1000
b 10^6 or 1 000 000

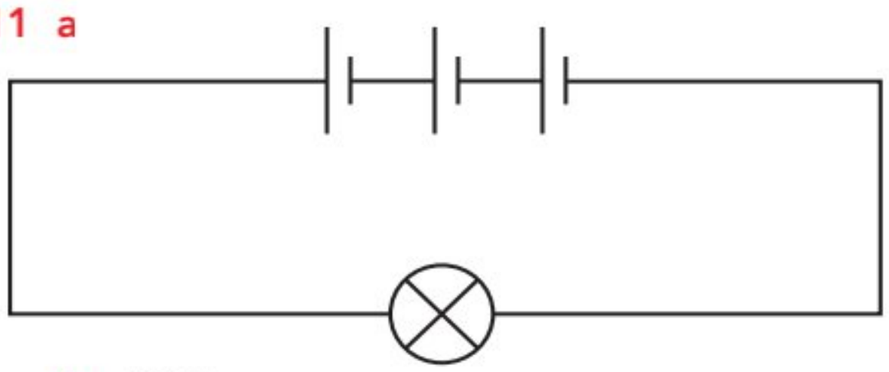
7 1 A = 1 C/s

8 a 110 s
b 5.33 mA
c 270 C
d 77.1 s

9 a potential difference
b voltmeter
c a circle containing a capital V, as shown in Figure 18.8

10 a electromotive force (e.m.f.)
b volts, V

11 a



b 36 V

12 a $E = QV$
b $Q = \frac{E}{V}$

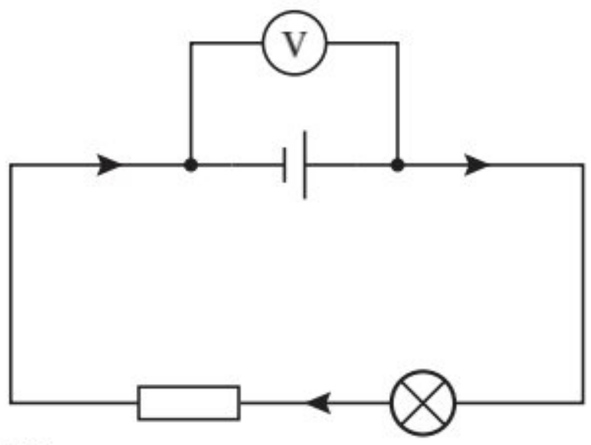
13 12 V

14 a 12 J
b 60 J
c 240 J

15 6 J

16 12 V

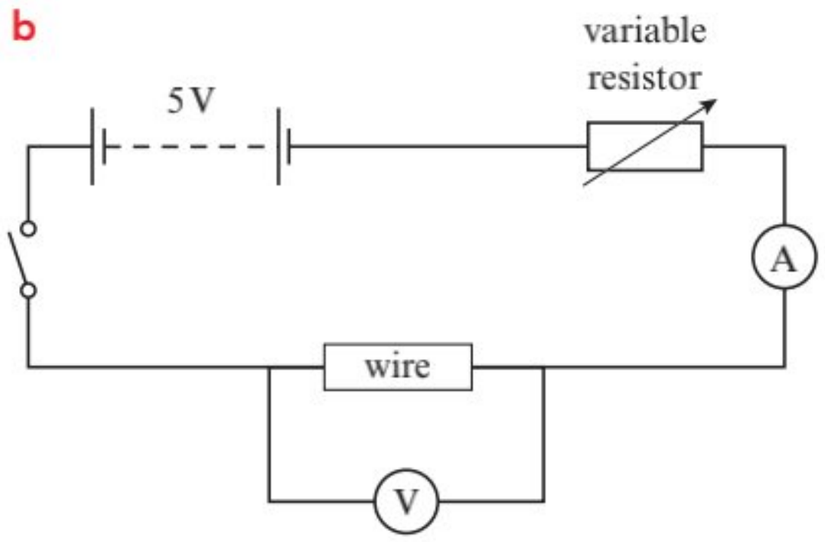
17 a



b 9 J
c 1 V
d 0.5

18 a 48 Ω
b increase

19 a long
b



20 a 120 Ω
b 4 mA
c 7.5 V
d 1.5 Ω

21 a 60 V
b double

21 a 3 kΩ
b 120 V

23 3.75 mA

24 Because the curves are both straight and pass through the origin so that current and voltage are directly proportional.

25 As you move along the p.d. axis, a given change in p.d. results in a smaller change in current so the resistance is increasing. The resistance is the reciprocal of the gradient; the gradient is decreasing, so the resistance must be increasing.

26 **a** 40 Ω

b 16 Ω

27 watts = volts × amps

28 **a** 480 W

b 5 A

c 30 V

d 9.6 kW

29 72 W

30 0.21 A

31 144 J

32 3 days

33 13 dirhams

34 **a** 433 W

b 21p

c 1 hour

d 14p

e 83 W

f 16p

g 5 hours

h 0.72p

i 0.1 unit

j 1.6p

Exam-style questions

1 C; **[1]**

2 A; **[1]**

3 B; **[1]**

4 C; **[1]**

5 **a** distance = speed × time; **[1]**

b 0.5 ms; **[2]**

c $Q = It$; **[1]**

d 15 C; **[2]**

e $V = E/Q$; **[1]**

f 495 mJ; **[2]**

g $P = VIt$ = 33 MV × 30 kA × 0.5 ms **[1]**
= 495 mJ; **[1]**

6 **a** Diagram similar to the answer for question 18.3a, but with the wire replaced by a lamp; **[2]**

b **i** 1.5 A; **[1]**

ii $V = IR$; **[1]**

ii 4 Ω; **[3]**

c Increasing the current increases the number of electrons flowing through the tungsten wire and this increases the number of collisions between the electrons and the lattice (regular arrangement of atoms in the metal). Some of the kinetic energy from the electrons transfers into thermal energy, which makes the lattice vibrate more. This increases the resistance because it increases the number of collisions between the electrons and the lattice; **[2]**

Chapter 19

Questions

1 a circuit symbol for a resistor: see Figure 19.2

b circuit symbol for a variable resistor: see Figure 19.2

2 a light dependent resistor

b circuit symbol for a light-dependent resistor: see Figure 19.2

c falls

3 a circuit symbol for a thermistor: see Figure 19.2

b thermometer

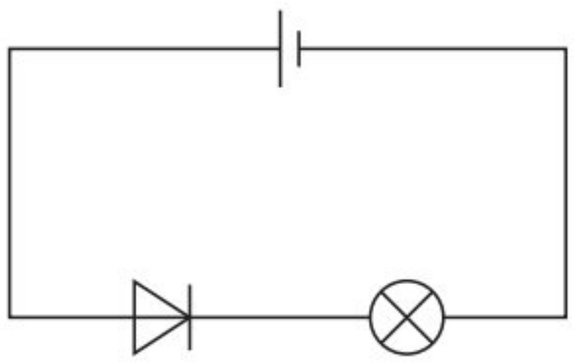
c resistance changes with temperature. For an NTC (negative coefficient thermistor), the resistance falls with temperature.

4 a Circuit diagram similar to Figure 19.8, with the thermistor replaced by an LDR and the lamp replaced by a heater.

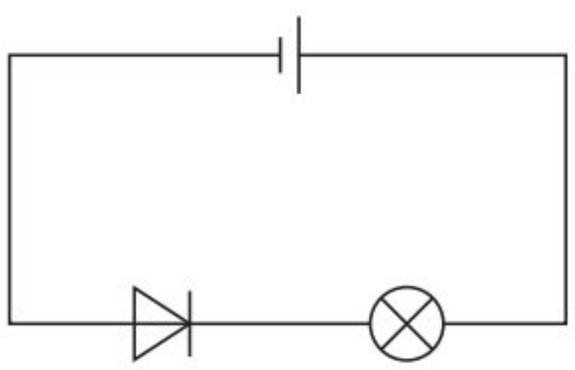
b When it is dark, the LDR has a high resistance. The current in the left-hand circuit is small, so the relay remains open. There is no current in the right-hand circuit.

c When light shines on the LDR, its resistance decreases. The current through the relay coil increases, pulling the relay switch closed. Now a current flows in the right-hand circuit and this turns on the heater.

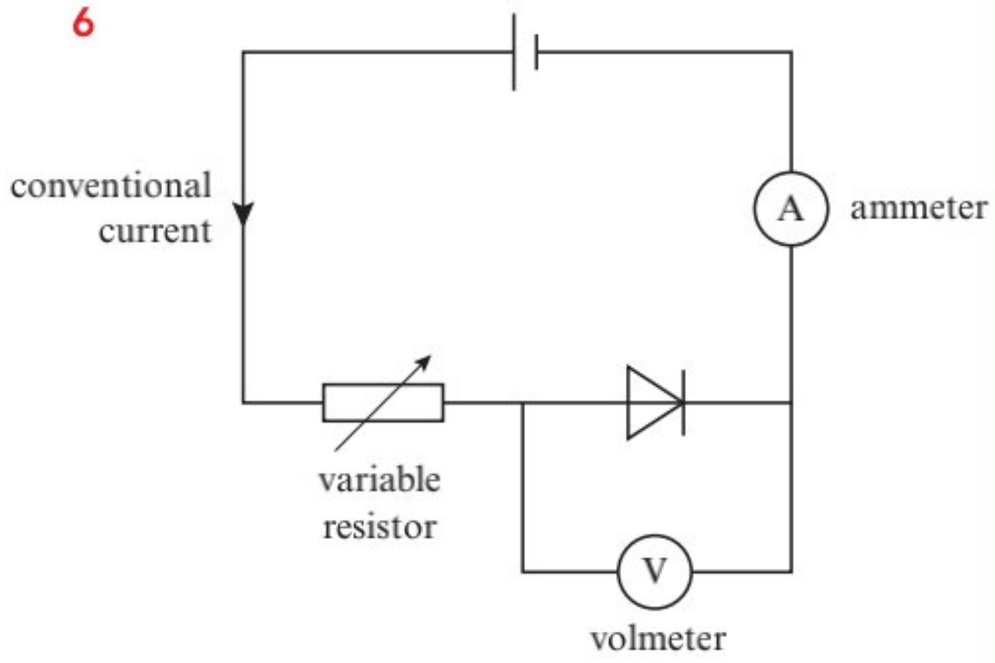
5 a



b



6



7 Each lamp can be controlled by its own switch. If one lamp breaks and does not allow current to flow, the other lamps will still work.

8 It is the same (1.4 A)

9 90 Ω

10 a 10 Ω

b 0.6 A

c 2.4 V (across 4 Ω resistor); 3.6 V (across 6 Ω resistor)

11 a series

b To obtain a smaller fixed or variable p.d. than the source e.m.f.

12 a $V_1 = 1.8$ V; $V_{in} = 9.0$ V

b $V_1 = 28$ V; $R_1 = 280$ Ω

13 Wire has resistance, like a resistor. A longer wire is like having resistors in series (i.e. a chain of resistors) whose total resistance is the sum of the resistors, so a longer wire has a higher resistance.

14 A thicker wire is like having a resistors in parallel whose combined resistance is less than the smallest resistance value.

15 a 0.33 A

b the bigger resistor (30.0 Ω)

16 a 2.4 Ω

b 1 (through 6 Ω resistor); 1.5 A (through 4 Ω resistor)

c 2.5 A

17

Bulb	source	1	2	3	4	5	6
Resistance / Ω	leave blank	9	3	6	6	3	3
Voltage / V	9.00	6.75	2.25	6.00	3.00	1.50	1.50
Current / A	1.75	0.75	0.75	1.00	0.50	0.50	0.50

18 multi-way bar extension; block adapters

19 fuse

20 It can lead to a fire.

21 **a** 5 A; a fuse of 3 A would melt every time that the hairdryer was switched on. Fuses rated higher than 5 would allow too big a current to flow before melting and breaking the circuit.

22 **a** This is to prevent too high a current entering the house where it could melt the insulation on wiring, which could give off poisonous fumes or cause a fire.

b circuit breaker

23 When the current gets too high the insulation can giving off poisonous fumes, melt or catch fire.

24 The earth wire provides a low resistance electrical path to ground and reduces the chances of a fatal electric shock.

25 If it was connected to the neutral or earth wire, a current could still pass into the appliance even with the switch open. If the appliance was faulty and the live wire touched the metal casing, then a person touching the casing would get an electric shock.

26 If it was connected to the earth or neutral wire, a person could still get electrocuted when they touch the appliance.

27 A fuse melts and breaks the circuit when the current passing through is too high.

28 Double insulation is where the electric circuit for an electrical appliance is inside a plastic case, which is inside the outer case.

Exam-style questions

1 B; **[1]**

2 A; **[1]**

3 C; **[1]**

4 **a** 7V; **[1]**

b 5V; **[1]**

c 6 mA **[1]**

d $R_1 = 7V / 17\,mA = 412\,\Omega$, $R_2 = 7V/ 6\,mA = 1167\,\Omega$, $R_3 = 5V/ 23\,mA = 217\,\Omega$, Effective resistance = 521.5 Ω (resistance of R_1 in parallel with $R_2 = 304.5\,\Omega$); **[2]**

5 **a** $A_4 = 1.9A$; **[1]** $A_5 = 2.6$ A; **[1]**

b $A_3 = 0.7A$; **[1]** $A_4 = 0.7$ A; **[1]** $A_5 = 1.4$ A; **[1]**

6 **a** thermistor; **[1]**

b 14 mA; **[1]**

c 7 V; **[1]**

d 500 Ω; **[1]**

e The current increases; **[1]**

7 **a** To prevent excessive current that could lead to the insulation giving off poisonous gases, melting or catching fire; **[1]**

b C; **[1]**

c Any two of (but one mark must be for the idea that the fuse melts or breaks the circuit): A fuse contains a thin section of wire. **[1]** As current increases, temperature increases. **[1]** When current exceeds a certain value, the wire melts, **[1]** which stops current flowing in the circuit; **[1]**

d circuit breaker; **[1]**

e Someone with wet hands could be electrocuted (injured or killed) if they touch a faulty electrical appliance. **[1]** This is because water is a conductor; **[1]**

f earth wire; **[1]**

Chapter 20

Questions

1 current, circular, right-hand grip, bar magnet

2 an iron core

3 Clockwise

4 a Current flows in the motor circuit. The electromagnet is magnetised. The electromagnet attracts the armature. The contacts close together. Current flows through the electromagnet coil.

b Iron can be magnetised.

c Soft iron loses its magnetism easily.

5 When the switch is closed current flows through the coil creating a magnetic field. This attracts the iron, pulling it down, so the signal lifts up.
When the switch is opened, no current flows. The field is lost so gravity pulls the signal back down.

6 a Energy transferred by electricity is transferred to the kinetic energy store of the motor and to the thermal energy store of the surroundings by heating and by sound.

b Energy transferred by electricity is transferred to the kinetic energy store of the loudspeaker and then by sound to the thermal energy store of the surroundings.

7 current, force, magnetic, greater, further

8 a Turn the magnet round to reverse the field. Swaop the power supply connections to reverse the current.

b The motor effect only happens when current flows across the field.

9 First finger field, second finger current, thumb force or motion

10 a right

b up

c into the page

11 Increase the strength of the magnetic field, increase the current.

12 The coil would spin one way, then after half a revolution it would reverse.

Exam-style questions

1 D; **[1]**

2 D; **[1]**

3 C; **[1]**

4 A; **[1]**

5 a Field lines going the centre of the coil with arrows pointing to the right; **[1]** lines joining up around the top and bottom of the coil with arrows pointing to the left; **[1]** south pole marked at left and north pole at right; **[1]**

b The field would reverse.

c The bars were magnetised identically so they repelled.

d (Soft) Iron because it is easy to magnetise.

6 Current flows through the coil **[1]** so it becomes a magnet. **[1]** The coil attracts the iron bar and so releases the door; **[1]**

7 Current in the wire creates a magnetic field. **[1]** This is a current flowing across a magnetic field so it experiences a force **[1]** Fleming's left-hand rule shows that the force on the wire is downwards. **[1]** So the equal and opposite force on the magnet is upwards; **[1]**

8 a Flemings left-hand rule. **[1]** If the thumb and first two fingers of the left hand are extended at right angles to each other and if the first finger points in the direction of the field and the second in the direction of current, then the thumb will give the direction of force of motion; **[1]**

b The commutator. **[1]** It reverses the connections to the battery so the motor spins continuously; **[1]**]

c Any two from: increase the current; **[1]** increase the strength of the field; **[1]** increase the number of turns on the coil; **[1]**

9 a up; **[1]**

b The beam would deflect in the opposite direction (down) **[1]** but would not deflect as much; **[1]**

c The force will always be at right angles to the direction in which the beam is travelling; **[1]**

Chapter 21

Questions

1 C

2 Move the wire.

3 The magnet could be turned round so the opposite pole is moved in, or the original pole could be moved out of the coil.

4 With the cell, the current always flows in one direction (d.c.). With the generator the current constantly changes direction (a.c.).

5 Any two of: use a stronger magnet, have more turns on the coil or increase the speed of movement.

6 Diagram similar to Figure 21.13 but with the magnet moving away from the coil, and induced south pole nearest the north pole of the magnet and the current flowing in the opposite direction.

7 a grid, pylons, voltage, reduce, transformers

b A: primary coil; B: iron core; C: secondary coil

c Step-up. It has more turns on the secondary coil than on the primary coil.

8 a step-down

b 6 V

9

N_p	N_s	V_p	V_s	Step up or step down?
10	20	**6**	12	Step up
10	**100**	1.2	12	**Step up**
2000	50	240	6	**Step down**
10 000	20	115 000	**230**	**Step down**

10 step down

11 50 turns

12 a The core carries the magnetic field created by the primary current to the secondary coil.

b The core must be able to be magnetised and demagnetised quickly.

13 With direct current the field does not change so no current is induced.

14 a i 1000 A ii 10 A

b Higher voltage means lower current so less energy is lost as thermal energy in the wires.

15 a 32 000 W

b 12.8 W

16 0.1 A. Assume the transformer is 100% efficient.

Exam-style questions

1 C; **[1]**

2 B; **[1]**

3 A; **[1]**

4 D; **[1]**

5 a conductor, magnetic, induced, circuit, current; [2 all five correct, 1 three or four correct]

b Connect the wire to the ammeter. **[1]** Move the wire between the poles of the magnet. **[1]** Observe the reading on the meter; **[1]**

c the strength of the field **[1]** the speed of movement; **[1]**

6 a The primary coil, secondary coil and soft iron core should be labelled [1 for each]. There should be more turns on the secondary coil than on the primary; **[1]**

b A transformer will not work with d.c. because the magnetic field in the transformer is unchanging; **[1]**

7 a A is a step up transformer **[1]** It increases voltage to decrease energy losses in the cables. **[1]** B is a step-down transformer. **[1]** It reduces the voltage to a safe level for use in homes; **[1]**

b 500 000 V; **[2]**

8 a The ammeter registers a current because the wire cuts through the field lines **[1]** and a current is induced; **[1]**

b i no current; **[1]**

ii The current is bigger and in the same direction; **[1]**

iii The current is the same as the first experiment; **[1]**

iv The current is bigger and in the opposite direction; **[1]**

9 a slip rings; **[1]**

b Fleming's right-hand rule; **[1]**

c The current flows from B to C, towards the slip rings; **[1]**

d The generator makes a.c. which is constantly changing. **[1]** When the coil is horizontal the current is at its peak; **[1]** When the coil is vertical no current flows; **[1]**

10 a Due to the high current; **[1]**

b 0.83 A; **[4]**

Chapter 22

Questions

1 a electrons

b positive charge

2 a he particles are deflected backwards as they are repelled by the positive charge on the nucleus.

b The particles are deflected as they are repelled by the positive nucleus, but their momentum keeps them moving.

c The particles pass straight through as they are not near enough the nucleus to be affected by the force of repulsion.

3 Only about 1 in 8000 particles bounced back.

4 electrostatic attraction.

5 nucleus, protons, neutrons, mass, protons, neutrons

6

Subatomic particle	Position	Relative charge	Relative mass
proton	in the nucleus	1	1
electron	orbiting the nucleus	−1	0 (or $\frac{1}{1836}$ or negligible)
neutron	In the nucleus	0	1

7 a 5

b 12

c 5 protons, 7 neutrons and 5 electrons.

8 a 27

b $^{60}_{27}$Co

9 1836

10 a Carbon-12 has 6 protons, 6 electrons and 6 neutrons. Carbon-14 has 6 protons, 6 electrons and 8 neutrons

b isotopes, proton, nucleon, chemical

11 a

Nuclide	Proton number Z	Neutron number N	Nucleon number A
Nu-1	6	6	12
Nu-2	7	6	13
Nu-3	7	7	14
Nu-4	6	8	14
Nu-5	5	6	11
Nu-6	6	7	13

b Nu-1, Nu-4 and Nu-6

c Nu-2 and Nu3

d carbon, boron and nitrogen

Exam-style questions

1 D; **[1]**

2 D; **[1]**

3 C; **[1]**

4 a protons **[1]** and neutrons; **[1]**

b mass number; **[1]**

c an atom that gains an electron is called an ion OR atoms are all neutral **[1]**; when it gains an electron it will have an overall negative charge / becomes negatively charged; **[1]**

5 a 4; **[1]**

b 4; **[1]**

c 9; **[1]**

d 5; **[1]**

e $^{9}_{4}$Be; **[1]**

f 4 protons, **[1]** 4 electrons **[1]** and 7 neutrons; **[1]**

g $^{11}_{4}$Be; **[2]**

6 a It was positively charged; **[1]**

b Diagram should show one alpha particle going straight through between two atoms, **[1]** one closer to an atom and being deflected by about 30° **[1]** and a third one approaching an atom directly and being deflected back on itself; **[1]**

c The nucleus is very small compared with the size of the atom **[1]** and is positively charged; **[1]**

Chapter 23

Questions

1 The radiation which we are exposed to all the time from radioactive sources.

2 Natural, any three from: materials in the ground, building materials, cosmic rays, food and drink, gases in the atmosphere.
Artificial, any three from: medical uses, weapons testing, air travel, nuclear power stations.

3 cosmic rays

4 unstable, neutrons, two protons, two neutrons, electron, electromagnetic

5 It comes from inside the nucleus.

6 gamma rays

7 The number of protons changes and this is what determines which element it is.

8 a $^{210}_{84}Po \rightarrow ^{206}_{82}Pb + ^{4}_{2}\alpha$ + energy

b $84 = 82 + 2$

c $210 = 206 + 4$

9 $^{218}_{84}Po \rightarrow ^{218}_{85}At + ^{0}_{-1}\beta$

10 a Both have high frequency, short wavelength. Both travel at the speed of light and can travel through a vacuum.

b Gamma rays are emitted spontaneously from a nucleus whereas X rays are made in machines.

11 a Beam 1 is alpha particles, beam 2 is beta particles

b Plate A is negative and plate B is positive.

c gamma rays

12 a The top third of the film would be darkened by exposure. The bottom two thirds would not as the aluminium and lead would absorb the beta particles.

b The top two thirds of the film would be darkened but not the bottom third as the lead would absorb most of the gamma rays.

c The lightproof jacket is likely to be paper which would stop alpha. Also, the range of alpha in air is only a few centimetres so it is unlikely that alpha particles would reach the badge.

13 a 800

b 200

14 38 days

15 2 days

16 11 400 years

17 a Beta particles or gamma rays would penetrate through the smoke easily.

b Alpha particles are stopped by the plastic casing or by a few centimetres of air.

c A short half-life would mean the smoke detector would need to be changed frequently.

18 More radiation would pass through the sheet, increasing the count rate on the detector. This would lead to the rollers being moved slightly further apart and the thickness would increase.

19 The radiation used is gamma which can penetrate through plastic.

Exam-style questions

1 C; **[1]**

2 C; **[1]**

3 B; **[1]**

4 a protons, **[1]** neutrons, **[1]** positively, **[1]** electron, **[1]** nucleus, **[1]** high, **[1]** electromagnetic; **[1]**

b

Radiation	Penetration	Stopped by
alpha	least penetrating	thin paper, a few cm of air
beta	in between	aluminium [1]
gamma	most penetrating [1]	lead [1]

5 a The time taken for half of the unstable nuclei to decay; **[1]**

b 5 mg; **[1]**

c Ionisation causes cells/DNA to mutate; **[1]**

d Any two from store it in a lead lined box; **[1]** store it in a labelled cupboard; **[1]** only qualified people handle it; **[1]** handle with tweezers; **[1]** do not point source at anyone; **[1]** record exposure times; **[1]**

6 a electron; **[1]**

b aluminium; **[1]**

c 2.9 days; **[1]**

7 **a** 2 protons and 2 neutrons OR identical to the nucleus of a helium atom; **[1]**

b $^{238}_{92}\text{U} \rightarrow {}^{234}_{90}\text{Th} + {}^{4}_{2}\alpha$; **[3]**

c Place paper between the rock and the detector. **[1]** If the count rate drops it is alpha; **[1]**

8 **a** Geiger counter

b The student has halved the initial count of 64 and read the time to drop from 62 to 32. They did not allow for the background count.

c Graph showing background count rate of 15 subtracted from all values on original graph/graph with similar shape to original graph with initial value at 50 counts/min; **[1]**
Half value calculated (25 counts/min) and line drawn across to the graph and line drawn down to time axis **[1]**.
Half-life = 1.3 hours; **[1]**

Chapter 24

Questions

1 Earth to spin on its axis; Moon to orbit the Earth; Earth to orbit the Sun; seasons.

2 Diagram similar to Figure 24.7, but with the northern hemisphere tilted towards the Sun. In the diagram it is summer in the northern hemisphere as it is tilted towards the Sun. The southern hemisphere is tilted away from the Sun and so it is winter there.

3 a waxing gibbous
b 27.5 days

4 1.3 seconds

5 a 200 seconds or 3.3 minutes
b 15 000 seconds, 250 minutes or 4.2 hours

6 774 million km

7 9.5×10^{12} km

8 a gravity
b elliptical
c more highly elliptical (allow more squashed)
d Approaching the Sun the comet speeds up , gaining kinetic energy and losing gravitational potential energy. Nearest the Sun it has maximum kinetic energy. This decreases at it moves away from the Sun. At its furthest point it has maximum gravitational potential energy. The total energy remains the same.

9 a 300 N
b 120 N
c 780 N

10 a 36 km/s
b 9.5 km/s

11 a As orbital distance increases, so does orbital duration.
b There is a trend that the planets with greater gravitational field strength have more moons, but there is not a clear pattern.

Exam-style questions

1 D; **[1]**

2 B; **[1]**

3 D; **[1]**

4 a In this model the Earth is central and there are six planets; now we know that the Sun is central and there are eight planets; **[1]**
b The order of the planets other than Earth is correct. The moon orbits the Earth; **[1]**
c They are rocky planets/ they are closest to the Sun; **[1]**
d They are gas planets / they are furthest from the Sun; **[1]**
e 760 seconds or 12.7 minutes; **[3]**

5 a Point X is facing away from the Sun; **[1]**
b X will be 180° round from the position shown; **[1]**
c The Moon reflects light from the Sun; **[1]**
d gravity; **[1]**
e The Moon orbits the Earth, **[1]** taking 27.5 days to do so; **[1]**
f The Moon's gravitational field strength is less than Earth's; **[1]**

6 a Pluto; **[1]**
b Venus; **[1]**
c This is generally true, **[1]** but Earth is an anomaly, having higher density than would be expected; **[1]**
d Mars and Pluto have the lowest gravitational field strength; **[2]**
e 13 km/s; **[3]**

Chapter 25

Questions

1 hydrogen (75%); helium (24%)

2 a 15×10^6 K
b 5800 K
c 2×10^{30} kg
d infrared = 50%; visible = 40%; ultraviolet = 10%

3 (thermo)nuclear fusion

4 Eyes would have evolved to see in the ultraviolet region.

5 a 144 million km
b 143 years

6 a 1.33×10^8 s
b 3.99×10^{13} km
c 18 000 years
d 107 million years

7 diagram should look like Figure 25.2

8 about 20 times

9 It must be above or below the galactic disc

10 4×10^{41} kg

11 a 6300 km
b 0.95 m
c 24 m
d 6.2 cm

12 If the Milky Way was shrunk to fit inside the distance between Earth and the Sun, the distance to Proxima Centauri would be less than the radius of the Earth, we could get to Pluto by running two laps of a 400 m running track, the Sun would be at the other end of a cricket pitch and a new pencil would be about three times as long as the distance to the Moon.

13 They are cold and dense enough to collapse.

14 a When a molecular cloud is cold and dense enough, clumps of it can collapse under the force of gravity. The clump collapses into a spinning sphere of superhot gas, which pulls in more matter from the molecular cloud. It becomes a star once nuclear fusion starts.

b In the process of collapsing the gravitational potential energy in the molecular cloud is turned into kinetic energy. Collisions between particles causes kinetic energy to be transferred to thermal energy.

15 a Nuclear fusion is where light nuclei fuse (join) together to create a heavy nucleus but some mass turns into energy.

b The nuclei all have the same positive charge so need to be moving fast enough to overcome the electrostatic repulsion.

16 a protostar: A very young star that is still gathering mass from its parent molecular cloud.

b main sequence star: A stable part of a star's life cycle when it is burning hydrogen in its core before moving onto another stage of its life cycle once it has used up 12% of its hydrogen.

c red giant: A star with a starting mass of less than eight solar masses that is burning helium in its core. Its shell of hydrogen has expanded and cooled.

d white dwarf: The final stage of a star that started with less than eight solar masses and has run out of fuel.

e supernova: An exploding star that began life with more than 8 solar masses and has run out of fuel.

f neutron star: A collapsed star composed almost entirely of neutrons when a star with more than 8 solar masses reaches the end of its life.

g black hole: This is the final stage in the life cycle of a star that started with more than 8 solar masses. It has enough mass left over after exploding as a supernova to collapse to a point where gravity is so strong that not even light can escape.

17 The flow diagram should be like Figure 25.10.

18 a 1.0 m
b i 0.5 m
ii 1.5 m
c i 600 Hz
ii 200 Hz
iii 330 Hz
d Apart from the sound getting louder and then quieter, the pitch increases and then falls and the vehicle passes me (which is called the Doppler effect). If the car is travelling slowly, the change in frequency is too small to detect.

19 a i 20 km/s per million light years
ii 2.1×10^{-18} per second
b i 4000 million light years
ii 15.1 billion years
ii 15.1 billion years

20 The Hubble redshift of distant galaxies show that the universe is expanding.

Hubble plotted the recession speed of galaxies against their distance from us (Figure 26.12) and discovered that the further away a galaxy is from us, the faster it is moving.

The fact that the universe is expanding means that galaxies were once closer together and there must have been a time when they were all in one place, implying that there was a beginning.

The reciprocal of the Hubble constant gives the age of the universe (about 13.8 billion years).

The cosmic microwave background radiation (CMBR) or microwave radiation also supports an expanding universe.

The universe became transparent (electromagnetic radiation stopped being scattered) when neutral atoms formed, when the temperature dropped to 3000 K.

It was predicted that an expanding universe would redshift this radiation.

Penzias and Wilson discovered the predicted redshift by accident using their radio telescope.

Exam-style questions

1 B; **[1]**

2 A; **[1]**

3 C; **[1]**

4 B; **[1]**

5 **a** galaxy; **[1]**

b gravity; **[1]**

c Milky Way; **[1]**

d billions; **[1]**

6 **a** The galaxies are moving away; **[1]** the wavelength is redshifted/increased/stretched; **[1]**

b correctly plotted points, **[2]** line of best fit; **[1]**

c gradient = 158 (km/s) / million light-year; **[1]** mark for showing the method; **[1]**

d $d = \frac{d}{v}$

$$= \frac{7.3\times10^{6}\times3\times10^{8}\,\text{m/s}\times365\times24\times60\times60}{1150\times10^{3}\,\text{m/s}}$$

$= 6.0\times10^{16}\,\text{s} = 1.9$ billion years; **[2]**

7 Gravity caused a molecular cloud to collapse into a protostar, which continued to pull in more matter from the cloud; **[1]**

As the cloud collapsed, its gravitational potential energy turned into the kinetic energy of the gas molecules, which turned into thermal energy. Once it got hot enough the gas turned into a plasma. Once the plasma gets hot enough, the protons (hydrogen ion) move fast enough to overcome electrostatic repulsion and fuses into helium, releasing energy; **[1]**

The radiation pressure pushing outwards is equal to weight, acting inwards and the star is stable, which is what the Sun is like now; **[1]**

Eventually, it will use up its hydrogen fuel so the radiation pressure will fall and the Sun will collapse when gravitational potential energy will turn into thermal energy. The core will get hot enough to fuse helium and the outer shell of the Sun expands and cools so that the Sun will be red giant; **[1]**

When the helium runs out, the Sun will collapse into a white dwarf; **[1]**

8 The Big Bang Theory suggests that the universe started from a point (singularity) 13.8 billion years ago and has been expanding and cooling ever since; **[1]**

The (Hubble) redshift of the galaxies/clusters; **[1]**

The microwave background or CMBR (cosmic microwave background radiation), which is redshifted light from the early Universe; **[1]**